Designing the 'Right to Mobility': a Holistic Analysis to Rethink the Public City and Fighting Heat Waves in Urban Areas

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Abstract
This study examines the relationship between urban design, walkability, and climate change, with a particular focus on the necessity for public spaces that can accommodate rising temperatures and heat waves. Using Bergamo, Italy, as a case study, the research combines GIS-based spatial analysis with stakeholder interviews to assess the impact of urban heat islands on pedestrian mobility. The findings indicate that effective urban design must balance the practical needs of mobility with the social benefits of public spaces. The paper advocates for the implementation of adaptive design strategies that enhance walkability, promote social interaction, and mitigate heat-related barriers. These strategies are expected to support the health and well-being of urban residents, particularly those who are most vulnerable.

Introduction
The future of urban areas appears to be contingent upon the implementation of sustainable and active transportation strategies. However, the effects of climate change are intensifying, particularly in relation to rising temperatures and heat waves (IPCC, 2023). Consequently, novel approaches are required to promote a soft mobility paradigm that considers the implications of climate change, while designing 'spaces for mobility'. Cities and their vitality are pivotal to societal well-being. Nevertheless, it is essential to ascertain whether these urban areas are accessible and available to all members of society. There are major differences in the mobility requirements and various degrees of social relationship needs of different street users, and public space planning must necessarily take these into account.
Henri Lefebvre identified the practice of the use of the city, describing pairs of opposing and complementary needs. These included security and openness, certainty and adventure, work organisation and fun, predictability and the unexpected, unity and difference, isolation and encounter, and independence and communication. He posited that humans need to see, hear, touch, taste, and fuse all these perceptions into a World (Lefevbre, 2013). For 75% of the European citizens (Eurostat, 2022) the concept of the World encompasses a specific urban form – cities, towns, suburbs. These needs are distributed in different ways among people and evolve over time, both in the short term (from morning to night) and in the long term (across different age groups). The importance of public space, and particularly of the sidewalk, has been widely documented in the literature. In her 1961 work, The Dead and Life of Great American Cities, Jane Jacobs identified three primary functions for this section of the street. Firstly, it serves as a form of self-surveillance, protecting residents and non-residents alike. Secondly, it provides a space dedicated to the formation of networks based on trust. Thirdly, it facilitates the assimilation of younger individuals into the urban social context (Jacobs, 1992). It is important to note that the three roles are not contingent upon mobility, even though the sidewalk was

originally designed for that purpose. The three roles that Jacobs describes are primarily social in nature, with the public walkability space serving as a conduit for interaction. It is important to recognise that urban life is not solely about the movement between spaces; it is also about the act of staying in spaces. As Cerdà observed, urban life is constituted by two fundamental elements that include all of the functions and activities that comprise human life. The human being rests and the human being moves (Cerdà, 1867).

The term 'walkability' is open to interpretation. To identify a clear definition, Ann Forsyth (2015) conducted a literature review. The outcomes can be condensed into three categories:

- Walkability is defined as a condition that favours or enables walking. This definition emphasises elements such as movement, the compactness of the urban fabric, safety, security, and the attractiveness of the pedestrian route. It is the simplest definition of walkability.
- Walkability is defined as the perceived outcome of walking. It encompasses a number of factors, including livability, sociability, sustainability, and physical exercise. It places emphasis on the secondary outcomes that pedestrians obtain in addition to the main objective of moving from one point to another.
- Walkability is defined as a proxy for the evaluation of urban environments. The conversion of pedestrian mobility into numerical values provides a means of comparing different environments or, in the case of the same environment, highlighting the results of a design intervention. In essence, it is the measurement of pedestrian mobility.

The absence of a unified accepted definition can potentially make the phenomenon challenging to comprehend and, subsequently, slow its advancement. Nevertheless, there are some similarities between the three categories. Firstly, the environment that a pedestrian must traverse and secondly, the distance to the destination. The configuration of the city, and in particular the area allocated to pedestrians, is of paramount importance. Whether it is the absence of obstacles that impede walking, the provision of adequate lighting to enhance perceived security, or even the simplicity of creating spaces conducive to social interaction, the manner in which the pedestrian aspect of the city is conceived and designed aligns with numerous of these definitions. The second factor to be considered is the distance. It is evident that pedestrians are unable to traverse distances that can be covered by other forms of transportation at fixed times. In such instances, the use of motorised or public transport is unavoidable. Nevertheless, urban compactness can positively influence the security and sociability of places. A denser city tends to offer a greater number of accessible locations and services that can be reached on foot. Consequently, an increase in the number of pedestrians will result in more opportunities for social interaction and a perception of enhanced security.

The concept of pedestrian public space can then be seen from two distinct perspectives. Firstly, it is the pathway that allows pedestrians to traverse between two points, thereby ensuring the walkability of the space. Secondly, it is a social space where public life takes shape and 'things happen' (Gehl, 2010). Mobility space, therefore, is also a part of the public city system and should fulfil both the roles of becoming a quality space and facilitating the movement of people.

Once the space of walkability has been defined, it is necessary to frame the people who move in this space. The World Health Organization (WHO) define the pedestrian as '*any person who is travelling by walking for at least part of his or her journey. In addition to the ordinary form of walking, a pedestrian may be using various modifications and aids to walking such as wheelchairs, motorized scooters, walkers, canes, skateboards, and roller blades. The person may carry items of varying quantities, held in hands, strapped on the back, placed on the head, balanced on shoulders, or pushed/pulled along. A person is also considered a pedestrian when running, jogging, hiking, or when sitting or lying down in the roadway.*' (WHO, 2013, p. 3). While this definition is comprehensive, the difficulty in identifying the characteristics of

pedestrians is considerable. The utilisation of public space is contingent upon the characteristics of the pedestrian in question. Individuals with temporary or permanent mobility impairments, the elderly, parents with children, pregnant women, and so forth, may necessitate different requirements than those that the city can provide.
The mobility behaviour of a pedestrian is influenced by internal or external factors. Internal factors include the state of health (e.g. temporary injuries), the time and objective of the journey, whether they are alone or in company, the possibility that the individual is carrying material burdens (e.g. a package) or immaterial burdens (e.g. sadness or depression), the age, etc. The external factors include physical elements – such as pavement and street width, number of people, climate, etc. – and subjective qualities of the walking environment: imageability, enclosure, human scale, complexity, etc. (Singh, 2016). The walking speed of moving pedestrians varies considerably, with a range of between 1 km/h and 5 km/h (GDCI, 2016). This fact alone should highlight the extreme differences within the usually generalized category of pedestrians.

The objective of this contribution is to propose a rethinking of the design process and organisation of public mobility space, with a particular focus on those aspects related to walkability. This is achieved by emphasising the role and impact of heat waves, a highly topical subject given climate change, in shaping the design principles of public space, which is defined here as an open and accessible space for city users. This is done trying to promote walkability, in particular for the more vulnerable people. To do so, it is necessary to apply methodologies based on complex and diverse analyses to investigate and define the main spatial critical points. These must be the basis for the definition of subsequent mitigating actions aimed at removing urban barriers to walkability, in particular the effects of heat waves and the urban heat island, so as to intercept different aspects including the personal perception of the inhabitants.
The next paragraph introduces the topic of heat waves and the urban heat island, emphasising their barrier effect on walkability in urban public space. The case study is then presented, namely the Redona district of Bergamo, a medium-sized city in northern Italy. The methodologies and materials used are then illustrated, dividing them into quantitative and qualitative. The same division is applicable to the data analysis and comments section, where both positive and negative findings regarding the effect of heat on walkability are highlighted.

Heat, public spaces and walkability
The walking practice can be reduced or limited by the design of the streets and by various public spaces' barriers, which are connected both to the space-time context and to the characteristics of the people walking. The environmental conditions can act as a limiting factor to walkability, as the utilisation of public space varies throughout the day and across different seasons. This is due to the influence of varying temperatures on human behaviour. Among the various effects that climate change is causing on human beings' daily lives, the rise in temperatures is of particular concern, with the greatest impact being felt in urban areas. Heat can be then conceptualised as a form of hidden barrier. In Italy, the average global temperature in 2020 was 1.44 °C higher than in the 1961-1990 reference period. Furthermore, the ten hottest years recorded are all positioned after 2005 (ISPRA, 2021). The projections indicate a rise in average temperatures between 1.6 °C in the case of drastic reductions in emissions and 5.1 °C in a scenario of constant emissions, over a reference period between 1990 and 2100. Additionally, the number of heat waves days is projected to increase from 10 in 1990 to a range between 75 and 250, respectively, in a scenario of strong emission reductions or constant emissions (UNFCCC, 2018). From 1960 to 2020, temperatures in urban areas increased by approximately 3 °C, with cities such as Milan, Turin, Bologna, Florence and Genoa experiencing the greatest rises (IIPH, 2022). The effects of heat waves are worsening when it

is combined with the urban heat island (UHI) effect. This is the phenomenon whereby temperatures in urban areas are higher than in rural areas (Oke, 1982). The UHI phenomenon is the result of the accumulation of heat during the initial hours of the day, followed by its subsequent release, which leads to a sharp increase in urban temperatures. This situation is potentially dangerous for people, especially those in vulnerable categories. It is not possible to generalise the impact of the UHI and heat waves on human beings. The personal thermal comfort varies based on environmental factors such as temperatures, humidity, wind, atmospheric pressure, and direct sun exposure (Yang et al., 2015). However, there are general studies about heat effects. The results of the EuroHEAT project showed that people living in areas with moderate climates are more susceptible to heat waves. Italy was identified as one of the European countries with the highest rates of morbidity and mortality associated with high temperatures, with an increase of 20.3% in mortality observed on days with average temperatures approximately 3 °C higher than the historical seasonal distribution (CCM, 2019). For example, in the city of Bologna, a 1 °C increase in temperature above 24 °C is associated with a 2% increase in mortality (IIPH, 2022). It is well documented that several physical diseases are closely linked to heat. One of the immediate effects of heat stress is dehydration, which is caused by sweating and a failure to replenish fluids (CCM, 2019). This phenomenon is particularly detrimental to individuals with a diminished capacity to perceive dehydration, such as children and the elderly. The latter are particularly susceptible to the phenomenon due to causes such as reduced perception of thirst, impaired kidney function or cognitive impairment (ASUGI, 2020). Heat-related lipothymia is a transient alteration in blood pressure balance that can manifest in a variety of ways, ranging from mild dizziness to complete loss of consciousness. (CCM, 2019). Finally, heatstroke represents one of the most serious consequences of heat exposure and, if not treated promptly, can result in death. The condition is caused by an impairment of the body's ability to thermoregulate due to a temperature that is too high. Once more, it is important to note that there are several symptoms associated with heatstroke, which can manifest in a number of ways. These include, but are not limited to, weakness, nausea, pulmonary oedema and shock. The potential for confusion regarding symptoms is a further complicating factor. For instance, the elderly may experience temporary temperature rises due to medication (CCM, 2019). In urban areas, where green spaces are scarce, the risk of mortality from elevated temperatures is elevated by 5% (UNEP, 2021). In addition to the direct effects on the human body, high temperatures are also linked to mental and psychological health problems. These include increases in suicide, anxiety, and stress, as well as decreases in personal happiness and well-being (IIPH, 2022).

Case study

To identify relationships between temperature and walkability, this paper uses as a case study a district in the city of Bergamo, a medium-sized city in northern Italy, located 50 km from Milan at the confluence of the Brembana and Seriana valleys. Over the past decade, the population of Bergamo has grown from 115.000 in 2011 to 120.000 in 2022. As is the case with the rest of Italy, Bergamo is also characterised by a progressive ageing of its residents. In 2022, the over-65s constituted 25% of the total population (ISTAT, 2024). The city was founded by the Romans and is situated on a hill. From this centre, fortified during the sixteenth century by the Venetian Republic – the walls of which are today UNESCO heritage – roads were developed, and boroughs grew up around them. Therefore, the ancient Bergamo is characterised by a hand form. At the beginning of the 20th century, the area between the boroughs was developed, resulting in an increase in population density within the city (Pagani, 2000). Following the Second World War, as was the case in many Italian cities, the urban form underwent a significant expansion, resulting in the creation of entirely new neighbourhoods or the expansion of the periphery with the establishment of small settlements, known as 'Corpi

Santi'. This rapid expansion from one side enabled the city to meet housing demands, yet on the other side resulted in a detachment from historical and cultural values, as well as from forms of mobility other than the car.

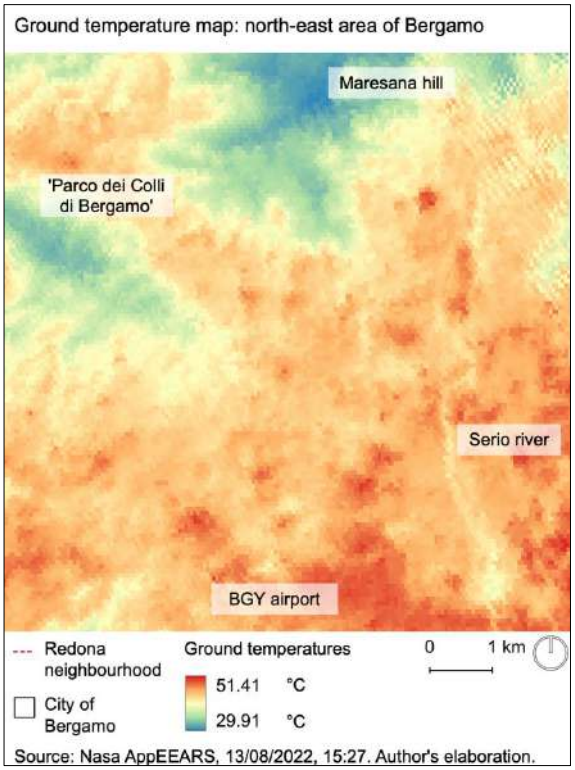
The Redona neighbourhood, which serves as a case study for this examination, was established as a 'Corpo Santo' on a road that connects Bergamo to the Seriana Valley. The district's population has increased since 1995, reaching a total of 7.041 in 2021. The proportion of the population aged 65 and above is approximately 25%, which is comparable to the citywide figure (retidiquartiere.it, 2024). During the period of urban densification, the district underwent a profound transformation, with the construction of both residential buildings and factories (which are now largely unused). The Redona neighbourhood was selected as a case study due to three key characteristics: i) it is a highly dynamic area in terms of past, ongoing, and planned urban regeneration processes. ii) It encompasses a diverse range of building types (tower blocks, single-family houses, commercial complexes, brownfields, etc.) and green features (parks, agricultural areas, nature reserves, etc.). iii) It serves as an infrastructural node for rail and road transport, both on a local and provincial scale.

Methodology ad materials

The methodology adopted for the analysis of spatial aspects is based on a combination of quantitative and qualitative approaches. The quantitative analysis is comprised of a series of investigations into the spatial aspects of the problem, primarily conducted through the use of geographic information systems (GIS). In contrast, the qualitative analysis is based on a series of semi-structured interviews with local stakeholders, which aim to gain an understanding of the perception and awareness levels regarding the problem.

The data used in the quantitative analysis was gathered from three main sources: the Regional Topographic Database (DBT) of the Lombardy Region, which was updated to January 2022. The DBT is an official geographical database of digital spatial information representing and describing the topographical objects of the territory and is the basic cartography. The data set contains information on a range of geographical features, including roads, railways, buildings, natural and artificial watercourses, altimetry, quarries and landfills, vegetation cover, and so forth. However, some geometries about recent interventions were absent. Consequently, data from Open Street Maps (OSM) were employed. The dataset was obtained from Geofabrik and updated to September 2022. To validate the data and collect new data not available from the first two sources, multiple surveys were conducted on the field in the second half of 2022. The data not officially available include the width of pavements, the type and colour of surface materials, the facilities of public transport stops and pedestrian crossings, and permanent and temporary point obstacles. The data was used to conduct four sets of analyses. The preliminary analysis included green spaces, mobility and the built environment, shop windows and abandoned businesses, neighbourhood-scale demographics, the dynamics of motorised traffic, and building heights. The pedestrian accessibility analysis considered pavement width, punctual obstacles (permanent or temporary), surface materials, facilities at pedestrian crossings and public transport stops. The pedestrian mobility analysis included walkable catchment areas from public transport stops and theoretical pedestrian flows. The UHI analysis employs data from the preceding three groups, namely building heights, public surface materials, and the location of green areas, trees, and bodies of water. These elements are among the factors that influence the urban heat island effect (Map B). Furthermore, a city-scale heat analysis was conducted utilising data from NASA-AppEars, which enables the clear delineation of urban areas (BGY airport) and rural/natural areas (natural park 'Parco dei Colli

di Bergamo', Maresana hill, Serio river) based on the temperature differences illustrated by the map (Map A).
The surface materials have particular importance when analysing the UHI because of the Albedo index. This index has a range from 0, representing a perfectly black surface that absorbs all solar radiation, to 1, representing a completely white surface that reflects all solar radiation (Moretti et al., 2021). The properties of the material itself and the colour influence the Albedo index. A low index indicates a high capacity to absorb solar radiation, which has a negative impact on the urban heat island, as is the case with asphalt (Albedo 0.10). The calculation of the Albedo index is complex and varies based on the methodology and instruments used during the survey. However, for comparative purposes, other materials with different albedo indices include marble (0.80), limestone (0.70), concrete and granite (0.50), and basalt (0.40) (Moretti et al., 2021).



Map A: ground temperatures using Nasa AppEEARS data and G.I.S. elaboration.

Qualitative analysis was conducted through four semi-structured interviews between December 2022 and January 2023. Nine people were interviewed, both as individual stakeholders and as representatives of the respective association. The objective of the dialogue

with local stakeholders was to confirm and integrate the information gathered during the initial phase of the analysis. All interviews were conducted in person, with an average duration of one hour. The associations interviewed were selected with the objective of achieving the greatest possible representation of citizens and thus of different users of public space. The first group, *Associazione Genitori Costruire Integrazione ONLUS*, is a non-profit organisation of social utility that was established in 2006 by a group of parents with children with impairments. Its objective is to create projects that will enable young people with disabilities to participate in a community and enjoy quality leisure time. The *Comitato per Redona* was established in 2001 by a group of citizens who were opposed to the municipality of Bergamo's proposal to construct a new sports hall within a local park. Their efforts were successful in preventing the implementation of this project. The *Gruppo Aquiloni* is an organisation that provides disabled young people with the opportunity to engage in leisure activities in the form of excursions, theatre, painting workshops, and so forth. The *Banca del Tempo Scambiotemporedona* is an association for social promotion founded in 2010. Its objective is to offer the residents of the area a form of service exchange that does not involve the use of money, using time as the unit of measurement. The interviews were structured by introducing the research themes (walkability, urban barriers, UHI, etc.) and leaving the interviewees free to highlight the specificities of the neighbourhood in relation to these themes. For some interviews, additional tools were used, such as paper maps – on which it was possible to write and draw – or digital maps.

Data analysis and comments

The combination of the three elements selected for analysis of the UHI effect – surface materials, building height, and green elements – has identified certain heat-susceptible areas.

The majority of the car parking areas in the neighborhood (1 on map B) are covered by asphalt, with the southern side lacking protection from the buildings' shade and generally devoid of trees. Parking areas are among the most straightforward areas to intervene in order to mitigate the heat absorption capacity. This can be achieved by improving the shade effect and changing the pavements, thereby increasing the albedo index. The main local road, via Corridoni, presents two different conditions. The northern side (2.1 on map B) is characterised by a greater presence of tall buildings and trees, which, despite the use of asphalt as a main surface material, can offer mitigating effects. In contrast, the southern side (2.2 on map B) presents an opposite situation, with a general lack of shade due to the absence of tall buildings and trees, and an abundance of asphalt. The Plorzano highway and adjacent roads can also be divided into two sections. In the southern part (3.1 on map B), pedestrian transit is rare and in certain portions forbidden. In the northern sector (3.2 on map B), this road system serves as a connection route between districts. The former Reggiani factory provides shade in a portion of the pedestrian path, but the total absence of trees and green areas, the presence of a large car park, and the use of asphalt as the sole pavement material make the stretch highly susceptible to the effects of the UHI.

However, an overall assessment of the neighbourhood indicates that the UHI effect is adequately counteracted in almost all areas. Despite the neighbourhood being strongly composed of asphalt elements (more than 87%), the large amount of greenery, whether in the form of trees or public parks within the urban area or agricultural areas surrounding the neighbourhood, offers the possibility of cooling. Furthermore, the new urban interventions are based on materials with a high Albedo index.

The results of the interviews can be classified according to the following categories: urban barriers, car traffic, and heat effects. The first category is not pertinent to the scope of this contribution. The second category, similar to the first, generates problems that are not directly related to the subject matter of this work. Nevertheless, the interviews yielded some insights

that could inform strategies to address the issue of heat. In particular, rush hours are identified as the most challenging for walkability, due to the difficulty in breathing and the accumulation of heat on asphalt and the emission of heat from car engines. The final category, heat effects, reveals that the most significant challenge in discussing heat is the bench situation in Redona. The area in question is deficient in seating facilities, which are both a source of respite and a venue for social interaction. While there are benches situated around the district, these are often combined with bus shelters. Furthermore, there are few seating areas within parks, with the notable exception of Turani Park. The park benches have recently been replaced with new ones, and their position has also been changed. Consequently, a series of problems directly related to heat have emerged. The benches were previously constructed from wood but have since been replaced with iron ones. The combination of the new position and the lack of shade results in the benches becoming uncomfortably warm, rendering them unusable for several hours, particularly during the summer months. Additionally, the benches were placed at a considerable distance from one another, which has the effect of reducing the spontaneity and complexity of social interaction. It is not uncommon for elderly individuals to visit the park with a folding chair or stool from their own homes.

Map B: triggering and mitigating elements of the UHI in Redona Neighborhood.

A discontinuity in the quality of pedestrian public space can be identified when the results of quantitative and qualitative analysis are considered. Such deficiencies can often be rectified through the implementation of relatively minor alterations. The creation of continuous and protected walkability spaces within street areas is possible through the implementation of NBSs, depaving interventions, street space redesign, green areas, and pedestrian resting points. However, there is a need to integrate mobility road design and road functions within planning tools. This can be achieved by linking mobility management and planning management, which

are often administered by different offices within the Italian context. This would facilitate the enhancement of not only the mobility role that roads fulfil but also the social function of public space that the footpath has lost.

Conclusions

To comprehend the impediments to walkability resulting from urban barriers, particularly the effects of the UHI, it is essential to adopt an analytical approach that integrates the spatial configuration of cities, the citizens' perception of streets, and the impact of heat waves in an urban context. The reduction of walkability represents a barrier to the opportunity to utilise public spaces, particularly for the most vulnerable population groups. An integrated project offers the potential to establish minimum conditions that would ensure the widest possible use of the road and pavement. This would facilitate the right to the city and the ability to walk to the widest possible number of citizens, while also enabling public space to fulfil its social function.

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