Critical Urban Infrastructure Within Concept of Chrono-Urbanism

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Abstract

Urbanization has a direct and negative effect on global problems like climate change and pandemics, which makes disasters in cities more serious. To respond these problems, the concept of 15-minute cities and critical urban infrastructures have gained prominence. The main objective of this research is to assess the accessibility of critical infrastructure in İzmir and determine the equity in the distribution of critical services throughout the city and perception of people to the concept. Reaching critical services is vital during a crisis or ensuring citizens' quality of life. The study examines the conceptualization and operation of critical urban infrastructure in the context of x-minute cities, and whether critical infrastructures were accessible in 5,10,15-minutes by walk in Karşıyaka, İzmir. The findings can contribute to urban development in terms of resilient, accessible, sustainable cities and community well-being.
Keywords: Chrono-urbanism; critical infrastructure; spatial analysis

1. Introduction

The word Anthropocene defines an era characterized by the dominance of human activity, caused by the increase in population density in urban areas. This has consequences and makes urban environments more vulnerable to chronic stresses and sudden shocks. One stress is climate change, and it causes various shocks in cities. In other words, the rapid urbanization in cities causes climate change, and climate change creates crises in cities. National governments, their coalitions, and major international organizations like the European Commission and the United Nations has become more conscious of the critical role that cities play in advancing global and regional sustainability, especially in the context of climate change (Pozoukidou and Angelidou, 2022). Therefore, numerous international policy papers prioritize the issue of climate crisis. They include the Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015), New Urban Agenda (United Nations, 2017), and the European Green Deal (European Comission, 2019). Furthermore, the Global Risk Report 2023 (World Economic Forum, 2023) indicates that climate-related risks are in the top ten long-term global risks. “Failure to mitigate climate change”, “failure of climate-change adaptation”, and “natural disasters and extreme weather events” are the first three risks in the report. One more worldwide problem which happened following 2020 is the Covid-19 pandemic. The process of urbanization worsens accessibility challenges, making individuals more vulnerable to pandemic-related crisis.

Multiple strategies and research have been discussed in order to address these concerns and mitigate their impact. The concepts of critical infrastructures and 15-minute cities are two of them. The core concept of 15-minute cities is that they are "compact, complete, and connected". Active modes of transportation like walking and cycling must gradually replace vehicular traffic as the primary source of emissions (Logan *et al.*, 2022). Furthermore, improving the level of connection and accessibility to critical products and services is of utmost importance, particularly in instances with restricted access like pandemics. The 15-minute city relies on chrono-urbanism, arguing that the quality of urban life is inversely proportional to the amount of time spent on transportation, primarily automobiles (Logan et al., 2022). Furthermore, critical infrastructure has played a vital role in the literature. Various nations and organizations own distinct policies related to critical infrastructure. Systems, facilities, and networks are all examples of critical infrastructures because of their significance

to the functioning and well-being of the people. Interdependency (Rinaldi, Peerenboom and Kelly, 2001), and scale (Theoharidou, Kotzanikolaou and Gritza-Lis, 2009; Steele and Legacy, 2017) are two approaches for critical infrastructure. Scale is an essential issue because it is crucial to study critical infrastructures at local and urban scales, which are generally seen to be handled on a national scale. However, scale is mentioned in a limited way in policy documents, and research based on local scales is rare. Therefore, this is a lack in the literature. Cantelmi and others (2021) explain the importance of scale by saying that breakdown in infrastructure can be even more critical if it causes a cascade of breakdowns that have regional, national, or international scale. Besides, Steele and others (2017) ask that "critical at what scale and for whom?". Therefore, it is imperative to carry out critical infrastructure study within the scope of the 15-minute city concept.

Considering these discussions, this study investigated whether critical infrastructures were accessible in 5, 10, 15-minutes. The main objective of this study is to examine the accessibility of critical infrastructures in Karşıyaka, and to figure out fairness in the distribution of specific critical services in the district. For the study, network analysis is conducted for transportation, and green infrastructures, and it is presented via GIS software. The paper consists of four parts. First, the theoretical framework explains critical infrastructure and the 15-minute city concept. In the methodology part, the study area, methodology, and results and discussion take part. In conclusion, results and limitations are discussed.

2. Theoretical Framework

2.1. X-Minute City Concepts

Chrono-urbanism posits that the quality of urban life is negatively correlated with the amount of time spent on transportation, particularly when relying on automobiles (Moreno *et al.*, 2021). In other words, the concept refers to "the temporal dimension of urban planning" (Moreno *et al.*, 2023). Carlos Moreno, a professor at Sorbonne University, developed this idea in 2015 (Ferrer-ortiz *et al.*, 2022). Urban and territorial proximities are facilitated by the development of polycentric cities or territories that consist of multiple "complete neighbourhoods." This approach aims to minimize daily commutes and facilitate individuals to work in close proximity to their homes (Guzman, Oviedo and Cantillo-Garcia, 2024). According to Moreno and others (2023), the concept seeks to integrate time variable along with the space in the analysis and planning of urban areas. It is important to understand "broadly how time affects urban form, infrastructure, and social interactions" (Moreno *et al.*, 2023).

The idea of x-minute cities is based on the principles of chrono-urbanism (Guzman, Oviedo and Cantillo-Garcia, 2024). In addition, it is noted that the notion of the x-minute city offers a sense of place identification through chrono-urbanism and alternative lifestyles, which reduces dependence on cars by promoting walking distances in cities (Moreno *et al.*, 2021). The x-minute city concept has received significant attention in recent years, primarily due to the urgency to address global warming and the pandemic. Those global crises require the use of different approaches to spatial organization of neighbourhoods. Accordingly, the concept of a x-minute city has a potential to provide solutions by promoting pedestrian and cycling activities to access essential goods and services. Besides, the concept has the capacity to address multiple Sustainable Development Goals (SDGs) and can be adapted to meet the

criteria specified in the United Nations-approved New Urban Agenda (Ferrer-ortiz *et al.*, 2022).

According to Allam and others (2022), 15-minute city may be valuable because of reducing car demand in cities. They indicate that most of emission in urban areas occur due to vehicular transportation. The concept may propose a solution to transportation-related problems that may contribute to climate change. In addition to reducing emissions, the concept of the x-minute city or neighbourhood concept of urban design offers a multitude of extra advantages (Logan *et al.*, 2022). Another crisis that draws attention to the 15 minutes city concept is the covid 19 pandemic. Ferrer-ortiz and others (2022) state that the COVID-19 health crisis has greatly increased interest in the 15-minute city concept. The primary cause of this phenomenon is the concentration of the people in densely populated areas, which gives rise to new challenges in urban settings. Pozoukidou and Angelidou (2022) assert that despite it was first developed in 2015, the popularity of the 15-minute city model increased significantly during the COVID-19 issue. In addition, persons in pedestrian-friendly areas tend to demonstrate a greater degree of confidence in their neighbours, thereby fostering social capital. Research has shown that neighbourhoods designed to be pedestrian-friendly have a positive impact on the well-being of both young and elderly residents (Logan *et al.*, 2022). In addition, the discussions on the concept of the 15-minute city include a fair distribution of essential services to the residents of the city. Pozoukidou and Chatziyiannaki (2021) the importance of developing a sustainable community is emphasized, which can be achieved through "equal access to facilities and opportunities, local social interaction, participation in local community activities, community stability, pride of place, sense of belonging and feeling safe and secure". Inclusiveness encompasses basic urban services and amenities, such as access to high-quality and affordable housing, mobility infrastructure that serves to people of all ages and abilities, affordable transportation choices, equal chances for employment and education, and a right to a healthy lifestyle (Pozoukidou and Chatziyiannaki, 2021). Increasing access to urban amenities may contribute to optimal consumption achieved without limiting available resources, going beyond common quotas for population and service density. This is also related with mixed used built environment, which include residential, commercial and entertainment places (Allam et al., 2022). Moreno and others (2021) also mention mixed-used development and they indicate that engagement of inhabitants to living, working, commerce, healthcare, education, and entertainment are necessary to maintain remarkable urban life and better quality of life. Briefly, the 15-minute city concept highlights the neighbourhood as the basic component of spatial and functional organization and argues that cities should be organized into neighbourhoods where every need can be met within 15 minutes by foot or bicycle (Pozoukidou and Angelidou, 2022).

The 15-minute city concept emphasizes the accessibility of basic services within a particular time and distance by means of walking or cycling. As mentioned in Allam and others (2022a), this concept enables the strategic positioning of essential urban amenities, infrastructures, and opportunities to promote accessibility. These services are described in the plans and strategies of different cities. It found its way into universal planning practice, with Paris, Portland, Oregon, and Melbourne as the forerunners (Pozoukidou and Angelidou, 2022). One example is Melbourne 2017–2050 plan. Destinations from starting point to the destination are comprised of 800 meters of walking distance (Victoria State Government, n.d.). Education, commercial,

green, open spaces, and transportation are some services accessible within 20 minutes of walking distance (Figure 1). In addition, Ferrer-ortiz and others (2022) indicate that Plan Melbourne is based on walking, cycling, or public transport, with its 20-minute neighbourhood as a chrono-urbanism practice, and Singapore and Beijing's approach combines a more extended threshold for commuting trips (45 to 60 minutes) and a reduced threshold for local daily trips (15–20 minutes).

Figure 1. Features of Melbourne 20-Minute Neighborhood (Victoria State Government, n.d.)

Another example is the Portland Plan, which was created in 2012. A "complete neighbourhood" is defined by the plan as a place where residents may conveniently and safely access essential goods and services for their everyday lives. It involves a variety of housing options, grocery stores and other commercial services, quality public schools, open public spaces, recreational facilities, affordable active transportation options, and civic amenities (Pozoukidou and Angelidou, 2022).

Density, diversity, digitalization, and proximity are four dimensions proposed by Moreno for the 15-minute city concept (Moreno *et al.*, 2021) (Figure 2). The concept aims to shift towards a city that is more polycentric and diverse in its usage. This will be achieved by emphasizing those four key dimensions. The aim is to provide a good quality of living within short distances and reduce dependence on automobiles (Gower and Grodach, 2022). Regarding density, 15-minute city concept advocates for a compact city where people are able to sustain themselves comfortably due to the availability of resources. This approach differs from conventional urban planning concept, which only considers density based on built environment quotas (Allam, Bibri, *et al.*, 2022a). Diversity refers to the mixed-use of the built environment and multiculturality, a social mix. A mixed-built environment consists of “healthy mix of residential, entertainment, and commercial elements” and aims to maximize available spaces and promote the proximity of services (Allam, Bibri, *et al.*, 2022b). The dimension of digitization is intimately linked to the components of smart cities and is crucial in realizing three other dimensions (Moreno *et al.*, 2021). Proximity is another

dimension that aims to reach basic services in 15 minutes (Moreno *et al.*, 2021). This dimension encourages the reduction of travel time and the car usage. Vehicular transportation is a major contributor, accounting for 78% of urban emissions in urban areas. Proximity provides direct ways to reduce emissions through decreased travel requirements and short distances (Allam, Bibri, *et al.*, 2022b). Furthermore, it encourages social engagement (Moreno *et al.*, 2021). This research examines the proximity dimension as a primary dimension of the concept for analysing Izmir.

Figure 2. The 15-Minute City Framework (Moreno *et al.*, 2021)

2.2. Urban Critical Infrastructure

The term "critical infrastructure" emerged in the 1990s and has subsequently been included in policy papers and legislation. A comprehensive understanding of the concept of critical infrastructure is necessary (Henten and Windekilde, 2020). Furthermore, Setola and others (2017) state that critical infrastructures do not have a standard definition, but the main idea is that they harm society when disrupted. Critical infrastructures, in a general sense, refer to assets or systems that are essential for upholding the societal and economic operations of a community (UNISDR, 2017). Serre and Heinzlef (2018) argue that the term "critical" implies a situation where the defence and economic organization could be challenged in the event of a disruption in essential infrastructure. The Organization for Economic Co-operation and Development (OECD, 2019) provides a definition of critical infrastructures as “systems, assets, facilities, and networks that provide essential services for the economy's functioning and the population's safety and well-being”. Critical infrastructures, as defined by many systems, cultures, and professional viewpoints, are responsible for providing vital goods and services that are necessary for the ongoing functioning of society and the economy (Shen, Feng and Peng, 2016).

The perception of critical infrastructure has evolved. Initially, they were viewed as concrete and stable, like physical and information and communication technologies. Nevertheless, there has been a shift in this trend towards a more all-encompassing approach. As stated by Pursiainen (2009), critical infrastructures contain all necessary societal functions. In contrast to earlier views, Mottahedi and others (2021) argue that the human factor is important and emphasize that critical infrastructure systems include the integration of individuals, engineering systems, and ecological surroundings. Furthermore, according to Steele and Legacy (2017), it can be described

as a "multidimensional and lived phenomenon" that relates to place, space, ecology, culture, pipes, wire, and concrete, among other things.

The actual events, shocks, and stresses in cities have an important role in the evolution of debates in critical infrastructure. Even while terrorist threats are discussed in relation to critical infrastructure, this one-hazard approach was insufficient to guarantee the uninterrupted operation of the system. Consequently, the European Union embraced the concept of the "all-hazards" strategy (Pursiainen, 2018). However, climate change has become an increasingly important issue when it comes to maintaining the resilience and protection of critical infrastructure (Hawchar *et al.*, 2020; Salimi and Al-Ghamdi, 2020; Kumar *et al.*, 2021; Silvast *et al.*, 2021). Besides, COVID-19 pandemic is also taking place in discussions (Clark-Ginsberg *et al.*, 2020; Derks, Giessen and Winkel, 2020; Mcphearson, 2020).

Infrastructures have played an important effect on the formation of metropolitan regions throughout the history. Furthermore, while critical infrastructures are typically discussed on a national scale, they are a part of urban development because they both affect and are affected by urban development. Given the existence of spatial difference and sociotechnical rupture, critical infrastructures have a significant impact on “governing and contesting” of urban change (Mcfarlane and Rutherford, 2008). Technological advancements, political strategies, and economic approaches have a significant impact on the development of infrastructure, which in turn affects urban growth. Today's existing political and economic circumstances necessitate new investments in urban infrastructure. Recent political and technical arrangements in cities facilitate the development of mega infrastructure projects. There, new globalized "infrastructure practices" emerge (Addie, Glass and Nelles, 2020).

2.3. Urban Critical Infrastructures in Chrono-Urbanism Perspective

Like definition of the concept, sectors of critical infrastructure also may differ from country to country. OECD (2019), according to surveys, defines 16 critical infrastructure sectors (Table 1). According to Lomba-Fernández and others (2020), cities depend on these sectors for daily life. Some countries have different categories. The "National Strategy for Critical Infrastructure Protection, Germany" report categorizes critical infrastructures into two main groups: basic technical infrastructure (such as power, ICTs, transportation, and water) and socio-economic services infrastructure (including food, public health, emergency services, disaster management, public administration, finance, media, and cultural heritage) (CIP Strategy, 2009). As mentioned, critical infrastructures studies mainly focus on technical infrastructures. The concept of "soft capital" such as human capital and knowledge, is discussed in the literature at gradually. However, it is important to examine the "dynamics of critical social infrastructure" in order to understand their impact on community capacity (O’Sullivan *et al.*, 2013). Furthermore, the discussion surrounding ecological critical infrastructure has achieved significance in recent years. The ecological perception is particularly essential, especially regarding climate change and the pandemic. In addition to OECD, recent studies focus on green infrastructure as critical infrastructure (Derks, Giessen and Winkel, 2020; Amorim, Menezes and Fernandes, 2022). Steele and others (2017) argue that in the context of urbanization, the essential interconnections between critical infrastructure and the equity of human and natural systems highlight the critical role of infrastructure. Therefore, “soft/

green/digital infrastructure (at different scales and for different reasons) qualifies as critical" (Steele et al., 2017 p.85). Because of these reasons, green infrastructure is also considered critical infrastructure in this study.

Table 1. Critical Infrastructure Sectors (OECD, 2019; Derks, Giessen and Winkel, 2020; Amorim, Menezes and Fernandes, 2022)

Critical Infrastructure Sectors
Energy
Nuclear sector
ICT
Transportation
Water
Dams & flood defense
Food supply & distribution
Health
Finance & banking
Government
Public safety
Law enforcement
Chemical industry
Space sector
Defence industry
Critical manufacturing
Green Infrastructure

As mentioned, critical infrastructure sectors consist of technical infrastructures and socio-economic sectors. Within the scope of the x minute city concept, access to various urban services is discussed on a temporal dimension. In this context, some of the services included in x-minute city applications are critical urban services or critical socio-economic services (Table 2). An inclusive and fair distribution to critical services is essential in two ways: quality of life and accessing to services in emergency situations.

Table 2. Critical Infrastructure Sectors within Concept of X-Minute City

Critical infrastructure sectors in x-minute city concept	ICT
	Transportation
	Food supply & distribution
	Finance and banking
	Health
	Green Infrastructure

The two main concepts—urban vital infrastructure and the 15-minute city concept—are examined in the context of this study. These two concepts are often examined independently in several studies, and there is a need for a broader overview of the study on both topics in the literature. Studying these two concepts together consists of an alternative evaluation of cities in the context of resilience, sustainability, and fairness in cities. Therefore, in İzmir, the critical infrastructure sectors within the 15-minute

perimeters are examined. In the study, green infrastructure and public transportation are selected to analyse.

3. Methodology

3.1. Study Area

İzmir located in the western part of Türkiye and around the İzmir bay. It is the third biggest city in Türkiye. The city has been faced with speed urbanization for since 1960s. Also, Izmir is the 3rd city with the highest population density according to 2023 population data (TSI, 2023). The has experienced significant population increase and expansion of built-up regions, resulting in increased pressure on natural resources (Tonyaloğlu, 2020). The city has many policies and projects about both critical service sectors and micro-mobility and pedestrianization. İzmir has 30 districts, and Çiğli, Karşıyaka, Bayraklı, Bornova, Buca, Konak, Balçova, Gaziemir, Karabağlar, Narılıdere and Güzelbahçe are urban areas of the city (Figure 3).

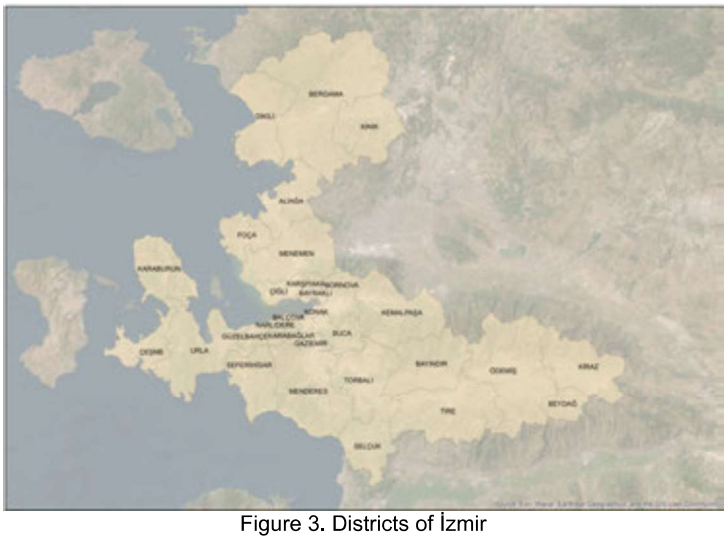

Figure 3. Districts of İzmir

İzmir is a unique city with various strategies and policies focused on sustainable development strategies, resilience, and ecological approaches. The Izmir Metropolitan Municipality has implemented a new urban development strategy in response to the rapid urban growth and its associated ecological, social, and environmental changes. This strategy focuses on a series of projects aimed at addressing climate change (Tonyaloğlu, 2020). In addition, there are various thematic plans focusing on climate change adaptation and nature-based solutions: İzmir Green City Action Plan (İzmir Metropolitan Municipality, 2020a), A Framework for Resilient Cities To Climate Change: Green Revision Guidebook (Berberoğlu, Çilek and Ünlükaplan, 2019), İzmir's Strategy for Living in Harmony With Nature 2021-2030 (İzmir Metropolitan Municipality, 2022) and Izmir Sustainable Energy and Climate Action Plan, 2020 (İzmir Metropolitan Municipality, 2020b).

Additionally, İzmir Metropolitan Municipality has strategies and projects for various critical infrastructure sectors. For instance, the "Cittaslow Neighbourhoods" initiative aims to create neighbourhoods that are both pedestrian-friendly and supportive to a high quality of life. The Cittaslow Metropolis Project is a model developed in cooperation with the Cittaslow International Union and Izmir Metropolitan Municipality to promote the Cittaslow philosophy in metropolitan areas.[4] Sustainable Urban Mobility plan is another project in İzmir. SUMP Izmir takes a holistic approach to all modes of transportation, including pedestrian, cycling, public transport, vehicular traffic, rail and other mobility-related issues such as traffic safety, urban development, climate measures, air pollution, environmentally friendly drivers, new forms of mobility and digitalization[5]. Although the city has no official 15-minute city implementation, it has projects focus on sustainable mobility modes.

In figure 4, a 15-minute accessibility service area map for critical services is demonstrated. These services are public transportation stations, food markets, green areas and Wi-Fi points. As seen in the figure, Konak and Karşıyaka have the highest accessibility level to all critical services. Especially, public transportation stations which are metro and tramway stations are highly accessible in those areas. In this study, Karşıyaka is selected as case area because of its potential to 15-minute city concept and its dense population.

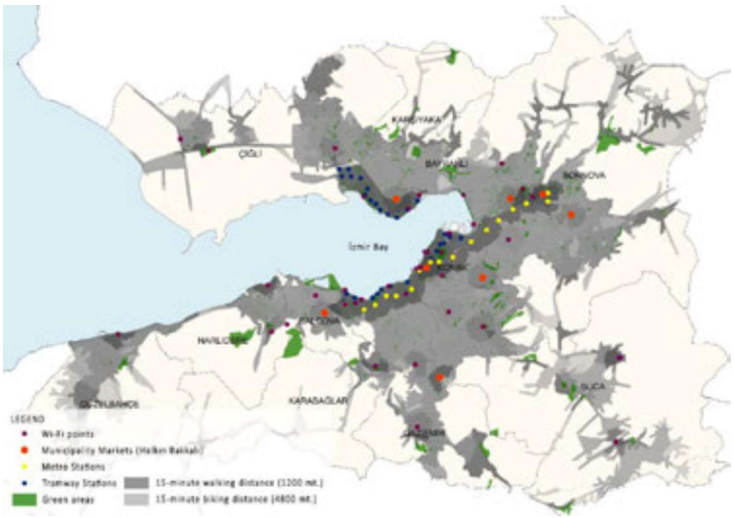

Figure 4. Green areas, metro, Wi-Fi points and tramway stations in 15-minute walking distance and biking distance (produced by authors)

Karşıyaka is located on the northern shore of Izmir Bay. The district has 341857 population, and it is the fourth district with highest population in İzmir. In Karşıyaka, the coastal road, suburban train line (Izban), Anadolu Street and İzmir Ring Road constitute the main transportation axes (Özgen and Türkseven Doğrusoy, 2020). It is

[4] https://cittaslowturkiye.org/tr/dunyanin-ilk-cittaslow-metropol-kenti-izmir/
[5] https://sumpizmir.org/#genel

observed that there are mostly residential areas in the urban structure developing between these axes (Özgen and Türkseven Doğrusoy, 2020). In Türkiye, there were a huge migration from rural to urban areas in 1950s. İzmir was also affected from this movement and urbanization rate increased in those years. As a result of this, the urban fabric in Karşıyaka also transformed, high-rise residential and commercial buildings were built instead of summer houses, the coastline was filled in and widened, the use of the sea was restricted due to sea pollution, and thus daily life changed and social life spread from the coastal area to the inland areas (Özgen and Türkseven Doğrusoy, 2020). Also, the settlement started to expand towards the north with increasing demands over time. Neighborhoods with poor quality and infrastructure problems have also become the main components of the region (Zengin Çelik and Çilingir, 2017). The district has become one of urban centres in İzmir. Easy and multi-modal transportation can be seen as one of the most important reasons for the district to create a dynamic and intense urban experience in daily life by increasing human circulation (Özgen and Türkseven Doğrusoy, 2020).

Considering these, transportation and green infrastructure are selected as critical sectors to figure out their accessibility within 15 minutes. These sectors involve publicly use services.

4. Method

The study has two parts. First, a comprehensive literature review is conducted to determine commonalities in critical urban infrastructure and the 15-minute city concept. Within the scope of this study, public transportation and green infrastructure are selected as critical sectors. Bus, tramway and İZBAN (suburban line) are analysed as public transportation stations, and parks and sport areas are analysed as green infrastructure.

This study examines the proximity component within the concept of the 15-minute city. This dimension involves to the length of travel and the accessibility to critical services. Given the objective of evaluating the accessibility of critical services within a 15-minute, the suitable dimension is proximity. Other three dimensions, density, diversity and digitalization, are not evaluated, but the case area involves them. Karşıyaka is one of high dense areas in terms of population and building. Also, it has become an attraction point in İzmir because it has various land uses such as commercial, education, health, green areas. Besides, there are some attempts for digitalization in İzmir in public transportation. These three dimensions support the research objective of the study, which is proximity. From this point of view, in the scope of the second part of this paper, the accessibility of critical infrastructure services in specific perimeters are investigated. The perimeters are based on various walking distances as 5, 10 and 15 minutes.

Various methodologies are applied throughout the accessibility analysis process. The ratio method, minimum distance model, Geographic Information System (GIS)-based spatial analysis, gravity model, and two-step floating catchment area method are common spatial accessibility methods (Song *et al.*, 2022). Network analysis in GIS refers to the examination of spatial networks, including transportation networks, utility networks, and social networks, using geographic information system (GIS) technology. Further techniques for network analysis comprise buffering and point-to-point straight-

line distance calculation. Nevertheless, these analyses oversimplify the evaluation of access by disregarding the consideration of actual access routes such as paths and roads, as well as obstacles like rivers and trains (Comber, Brunsdon and Green, 2008). In this study, GIS mapping tools and network analysis are used to generate the perimeters. Network studies have the capacity to provide answers to a diverse range of concerns regarding linear networks, including roads, railways, rivers, facilities and utilities. This method of geographical analysis involves calculating the distances between locations or nodes on a network by using network data, which often consists of linear features like roads and footpaths (Comber, Brunsdon and Green, 2008). Walking speed varies according to physical characteristics of people (i.e. age) and geographical characteristics of the area (i.e. slope and climate). Nevertheless, these characteristics are not included in this study. In the study, walking distance is assumed to be ¾ mile or 1200 meters in 15 minutes and cycling distance is assumed to be 3 miles or 4800 meters in 15 minutes (Duany and Steuteville, 2021). 5- and 10-minutes walking distances are 400 meters and 800 meters. Public transportation and green areas are important in well-being of people in their daily life or during emergency situations. Therefore, it is valuable to investigate different accessibility times to make contribution to spatial plans and decisions.

As mentioned in Fazio and others' (2023) study the use of open data can have a determinant impact in situations when resources are limited. Hence, main data source of this study is Open Street Map and İzmir Metropolitan Municipality. Data consists of the location of active green spaces metro, tramway, bus station points, and roads. İzmir Metropolitan Municipality (IMM) provides green spaces data. Public transportation stations are provided by open source of IMM. Public transportation stations are obtained from the application where the IMM shares some spatial data as open source. Roads, forests, building data are from Open Street Map. The network analysis of 5,10,15-minute periphery is based on transportation stations and green spaces as starting points.

5. Results and Discussion

In this study, the accessibility of critical infrastructure of İzmir is measured. Bus stations, metro stations, tramway stations and active green areas have been investigated by service area analysis in network analysis. Figure 5 demonstrates location of green areas (parks and sport, recreation areas, forests) and public transportation stations. Forests and recreations areas are mainly located in north side of the area, which is less dense than south part. Analyses are conducted in highly dense urban area, which is southern part of the area.

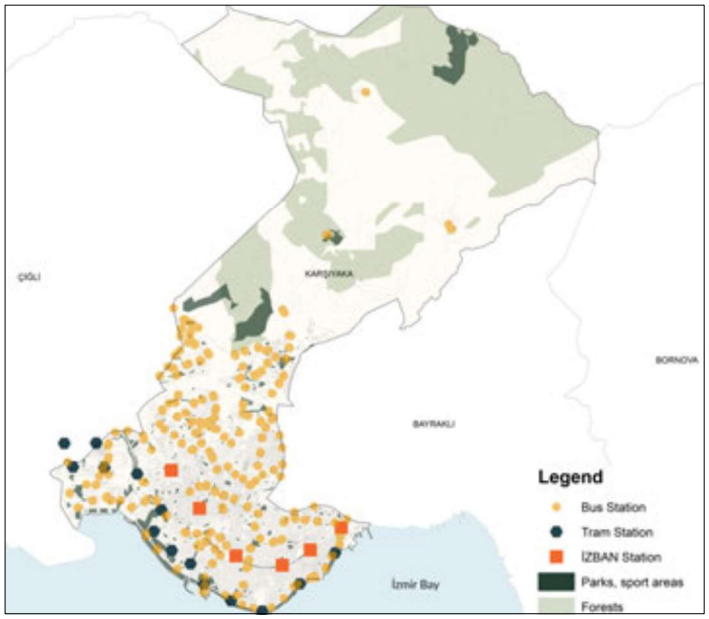

Figure 5. Locations of Green Areas and Public Transportation Stations

The first network analysis is conducted to measure green areas accessibility. In the study actively used green areas are analysed, which are parks and sport areas in 5,10, 15-minute periphery (Figure 6). As seen in the map, parks and sport areas are highly accessible in the area by walking. Most of parks and sport area are accessible in 5-minute walking distance. However, when comparing north and south parts of the area, neighbourhoods in the north have less parks and sport areas and accessibility to them. As seen in the map, shoreline has a huge potential of green areas. There is a green axis along the coast, and it serves as both parks or recreation areas and pedestrian axis. Because of uninterrupted green axis throughout the shoreline, capacity of accessibility of green areas is very high there.

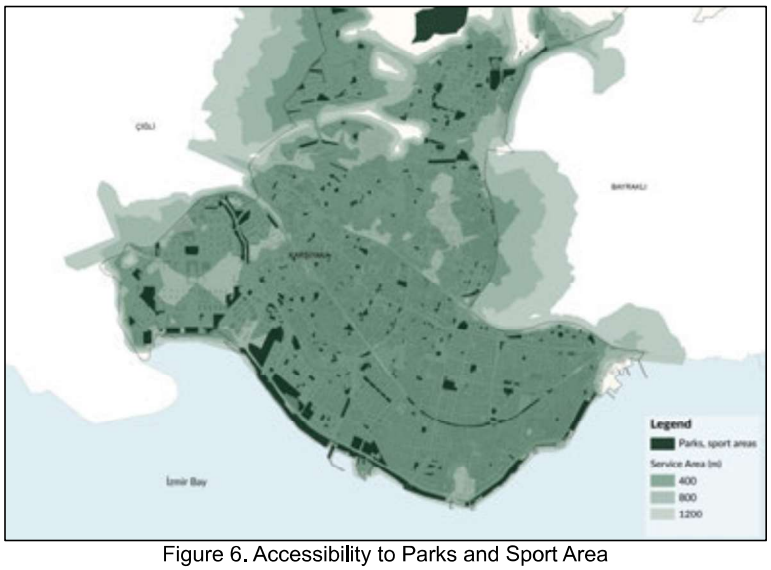

Figure 6. Accessibility to Parks and Sport Area

Compared to tram and İZBAN stations, number of bus stations is higher in the area. However as seen figure 7, they are accessible in 15 minutes, but 5-minute service is not sufficient. Some parts of the area are not served by bus station in 5-minute walking perimeter. Accessibility to bus stations is crucial in the area because public transportation is highly dependent on buses especially in inner sides.

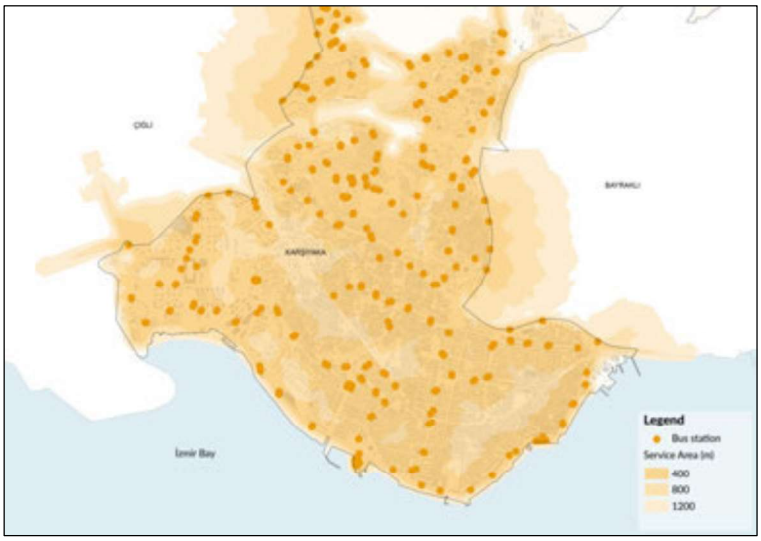

Figure 7. Accessibility to bus stations

Figure 9 demonstrates accessibility to İZBAN stations. İZBAN is a suburban line which connects the area with other parts of İzmir, therefore, accessibility to it is very important. The line connects the rural districts with urban (Figure 8). However, it serves a very limited area within walking distance. The coastal area of İzmir Bay has the most accessibility to both İZBAN and tramway stations. Those stations are accessible in 15-minute walking distance generally. Tramway stop serves along the coast north of the bay, so accessibility of them generally concentrated in these areas. (Figure 10).

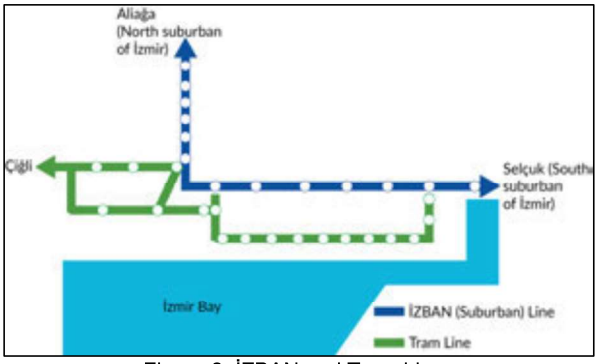

Figure 8. İZBAN and Tram Lines

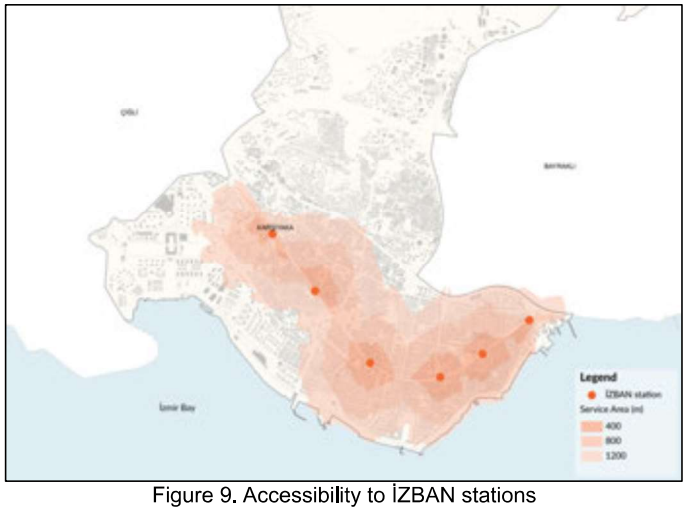

Figure 9. Accessibility to İZBAN stations

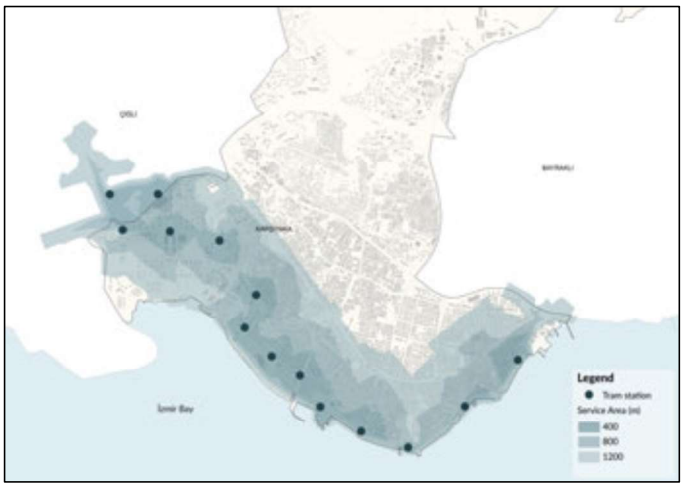

Figure 10. Accessibility and tramway stations

Figure 11 demonstrates all public transportation modes' accessibility in 5, 10, 15-minute walking distance. Coastal areas have the most accessibility for all modes of public transportation. The main reason for this is to be commercial centre of the city, and many commercial and business locates there.

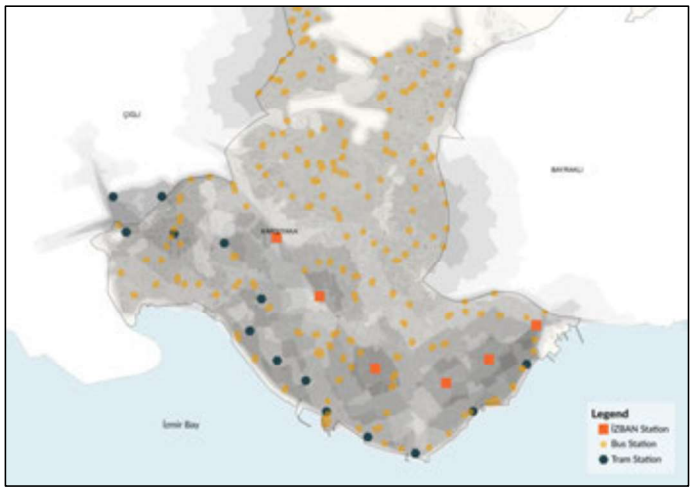

Figure 11. Accessibility to public transportation stations

Green areas and public transportation are evaluated as critical services in İzmir within the context of this study. Therefore, they need to be accessible to all. Steele and others (2017) identify criticality regarding the links between people and environments and their equality. Therefore, the study investigates the fair distribution of critical infrastructure in İzmir.

As seen in results, most of public transportation modes are in southern and coastal parts of Karşıyaka. Although, distribution of bus stations serves most of Karşıyaka district, people live in southern part have more alternatives of public transportation. Therefore, it can be said that distribution of public transportation stations is not balanced in Karşıyaka district.

6. Conclusion

Critical urban infrastructures have services sectors to ensure well-being and resilience of communities, and 15-minute cities consist of essential services accessible in 15 minutes. Critical services such as transportation, food, health, etc. should be considered in terms of accessibility. They are needed to be accessible for all within walking distance to provide resilient and fair cities. According to review on 15-minute city and critical infrastructure literature and İzmir, green areas and public transportation stations are evaluated within scope of this study.

Different approaches to critical infrastructures are necessary for more resilient and sustainable cities. While critical infrastructure studies primarily focus on technical infrastructures, it is equally necessary to include social and ecological critical sectors in cities. Reaching critical services such as education, health green spaces is necessary for quality of life of citizens. Besides, it is vital to access those services during crisis. 15-minute city concept mainly focuses on accessible to services to minimize vehicular transportation demand. However, it is also valuable considering crisis situations such as restriction in pandemics, or emergent safe places after earthquakes. Thus, critical infrastructure and 15-minute city concepts may complement each other. Also, the study of critical infrastructure on a neighbourhood scale is an important contribution to the literature because it is handled in national documents generally.

The city of İzmir does not implement the 15-minute city concept. However, this study aims to evaluate the potential to apply this concept in terms of critical services Karşıyaka. Besides, it aims to assess critical urban services in the 5, 10, 15-minute periphery by walking. Distribution of public transportation stations and parks and sport areas are evaluated. In results, especially the centre parts of Karşıyaka have accessibility in 5 and 10-minutes accessibility by walking or biking. In Karşıyaka, there is a potential to implement critical urban infrastructures in a 15-minute city concept, according to the results. However, the distribution of critical services should be more equitable through walking and biking especially in the outer ring.

The study has limitations. Firstly, geographical information such as slope is not considered, but it affects the ability and travel time of walking and biking. Also, walking infrastructure should be taken considered because there may be obstacles due to insufficient walking infrastructures. In addition, inclusive urban settings necessitate the consideration of a diverse priorities, including healthcare, education, job, and cultural and recreational amenities, during the urban planning process (Guzman, Oviedo and Cantillo-Garcia, 2024). Personal preferences are lack in the study. However, it is important to survey people their thought about accessibility to services by walking or biking.

7. References

Addie, J.P.D., Glass, M.R. and Nelles, J. (2020) 'Regionalizing the infrastructure turn: a research agenda', Regional Studies, Regional Science, 7(1), pp. 10–26. Available at: https://doi.org/10.1080/21681376.2019.1701543.

Allam, Z., Bibri, S.E., et al. (2022a) 'The "15-Minute City" concept can shape a net-zero urban future', Humanities and Social Sciences Communications, 9(1), pp. 1–5. Available at: https://doi.org/10.1057/s41599-022-01145-0.

Allam, Z., Bibri, S.E., et al. (2022b) 'The Theoretical, Practical, and Technological Foundations of the 15-Minute City Model: Proximity and Its Environmental, Social and Economic Benefits for Sustainability', Energies, 15(16), pp. 1–20. Available at: https://doi.org/10.3390/en15166042.

Allam, Z., Nieuwenhuijsen, M., et al. (2022) 'The 15-minute city offers a new framework for sustainability, liveability, and health', The Lancet Planetary Health, 6(3), pp. e181–e183. Available at: https://doi.org/10.1016/S2542-5196(22)00014-6.

Amorim, E.E.R., Menezes, M. and Fernandes, K.V. (2022) 'Urban Living Labs and Critical Infrastructure', ISC2 2022 - 8th IEEE International Smart Cities Conference [Preprint]. Available at: https://doi.org/10.1109/ISC255366.2022.9922441.

Berberoğlu, S., Çilek, A. and Ünlükaplan, Y. (2019) A Framework For Resilient Cities To Climate Change: Green Revision Guidebook.

CIP Strategy (2009) National Strategy for Critical Infrastructure Protection.

Clark-Ginsberg, A. et al. (2020) 'Maintaining critical infrastructure resilience to natural hazards during the COVID-19 pandemic: hurricane preparations by US energy companies', Journal of Infrastructure Preservation and Resilience, 1(1), pp. 1–6. Available at: https://doi.org/10.1186/s43065-020-00010-1.

Duany A. and Steuteville, R. (2021). Defining the 15-minute city. Available at: https://www.cnu.org/publicsquare/2021/02/08/defining-15-minute-city

Comber, A., Brunsdon, C. and Green, E. (2008) 'Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups', Landscape and Urban Planning, 86(1), pp. 103–114. Available at: https://doi.org/10.1016/j.landurbplan.2008.01.002.

Derks, J., Giessen, L. and Winkel, G. (2020) 'COVID-19-induced visitor boom reveals the importance of forests as critical infrastructure', Forest Policy and Economics, 118(April), p. 102253. Available at: https://doi.org/10.1016/j.forpol.2020.102253.

European Comission (2019) The European Green Deal. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

Fazio, M. et al. (2023) 'The "15-minutes station": a case study to evaluate the pedestrian accessibility of railway transport in Southern Italy', in Transportation Research Procedia. Elsevier B.V., pp. 536–543. Available at: https://doi.org/10.1016/j.trpro.2023.02.205.

Ferrer-ortiz, C. et al. (2022) 'Barcelona under the 15-Minute City Lens: Mapping the Accessibility and Proximity Potential Based on Pedestrian Travel Times', Smart Cities, 5(1), pp. 146–161. Available at: https://doi.org/10.3390/smartcities5010010.

Gower, A. and Grodach, C. (2022) 'Planning Innovation or City Branding? Exploring How Cities Operationalise the 20-Minute Neighbourhood Concept', Urban Policy and Research, 40(1), pp. 36–52. Available at: https://doi.org/10.1080/08111146.2021.2019701.

Guzman, L.A., Oviedo, D. and Cantillo-Garcia, V.A. (2024) 'Is proximity enough? A critical analysis of a 15-minute city considering individual perceptions', Cities, 148(February), p. 104882. Available at: https://doi.org/10.1016/j.cities.2024.104882.
Hawchar, L. et al. (2020) 'A GIS-based framework for high-level climate change risk assessment of critical infrastructure', Climate Risk Management, 29(May), p. 100235. Available at: https://doi.org/10.1016/j.crm.2020.100235.
Henten, A. and Windekilde, I. (2020) 'Critical infrastructure - What is it, and what are the implications?', 13th CMI Conference on Cybersecurity and Privacy - Digital Transformation - Potentials and Challenges, CMI 2020 [Preprint]. Available at: https://doi.org/10.1109/CMI51275.2020.9322690.
İzmir Metropolitan Municipality (2020a) İzmir Green City Action Plan.
İzmir Metropolitan Municipality (2020b) Izmir Sustainable Energy and Climate Action Plan, 2020.
İzmir Metropolitan Municipality (2022) İzmir's Strategy for Living in Harmony With Nature 2021-2030.
Kumar, N. et al. (2021) 'A novel framework for risk assessment and resilience of critical infrastructure towards climate change', Technological Forecasting and Social Change, 165(September 2020). Available at: https://doi.org/10.1016/j.techfore.2020.120532.
Logan, T.M. et al. (2022) 'The x-minute city: Measuring the 10, 15, 20-minute city and an evaluation of its use for sustainable urban design', Cities, 131(January), p. 103924. Available at: https://doi.org/10.1016/j.cities.2022.103924.
Lomba-Fernández, C., Labaka, L. and Hernantes, J. (2020) 'Urban critical infrastructure's governance framework for climate resilient cities', European Journal of Sustainable Development, 9(3), pp. 145–156. Available at: https://doi.org/10.14207/ejsd.2020.v9n3p145.
Mcfarlane, C. and Rutherford, J. (2008) 'Political infrastructures: Governing and experiencing the fabric of the city', International Journal of Urban and Regional Research, 32(2), pp. 363–374. Available at: https://doi.org/10.1111/j.1468-2427.2008.00792.x.
Mcphearson, T. (2020) 'Parks are Critical Urban Infrastructure: Perception and Use of Urban Green Spaces in NYC During COVID-19 Sustainable Cities View project Social media activity in parks View project', (September). Available at: https://doi.org/10.20944/preprints202008.0620.v1.
Moreno, C. et al. (2021) 'Introducing the "15-minute city": Sustainability, resilience and place identity in future post-pandemic cities', Smart Cities, 4(1), pp. 93–111. Available at: https://doi.org/10.3390/smartcities4010006.
Moreno, C. et al. (2023) The 15-minute City model : An innovative approach to measuring the quality of life in urban settings 30-minute territory model in low-density areas. WHITE PAPER N°3. IAE Paris - Université Paris 1 Panthéon- Sorbonne.
Mottahedi, A. et al. (2021) The resilience of critical infrastructure systems: A systematic literature review, Energies. Available at: https://doi.org/10.3390/en14061571.
O'Sullivan, T.L. et al. (2013) 'Unraveling the complexities of disaster management: A framework for critical social infrastructure to promote population health and resilience', Social Science and Medicine, 93, pp. 238–246. Available at: https://doi.org/10.1016/j.socscimed.2012.07.040.
OECD (2019) Good Governance for Critical Infrastructure Resilience. Available at: http://www.oecd.org/governance/good-governance-for-critical-infrastructure-resilience-02f0e5a0-en.htm%0Ahttps://www.oecd-ilibrary.org/governance/good-governance-for-critical-infrastructure-resilience_02f0e5a0-en.

Özgen, A.İ. and Türkseven Doğrusoy, İ. (2020) 'İzmir-Karşıyaka'da Çevresel Algıyı Çözümlemeye Yönelik Bir Araştırma', Tasarım Kuram, 16(29), pp. 153–167. Available at: https://doi.org/10.14744/tasarimkuram.2020.85057.
Pozoukidou, G. and Angelidou, M. (2022) 'Urban Planning in the 15-Minute City: Revisited under Sustainable and Smart City Developments until 2030', Smart Cities, 5(4), pp. 1356–1375. Available at: https://doi.org/10.3390/smartcities5040069.
Pozoukidou, G. and Chatziyiannaki, Z. (2021) '15-minute city: Decomposing the new urban planning Eutopia', Sustainability, 13(2), pp. 1–25. Available at: https://doi.org/10.3390/su13020928.
Pursiainen, C. (2009) 'The challenges for european critical infrastructure protection', Journal of European Integration, 31(6), pp. 721–739. Available at: https://doi.org/10.1080/07036330903199846.
Pursiainen, C. (2018) 'Critical infrastructure resilience: A Nordic model in the making?', International Journal of Disaster Risk Reduction, 27(653390), pp. 632–641. Available at: https://doi.org/10.1016/j.ijdrr.2017.08.006.
Rinaldi, S.M., Peerenboom, J.P. and Kelly, T.K. (2001) 'Identifying, understanding, and analyzing critical infrastructure interdependencies', IEEE Control Systems Magazine, 21(6), pp. 11–25. Available at: https://doi.org/10.1109/37.969131.
Salimi, M. and Al-Ghamdi, S.G. (2020) 'Climate change impacts on critical urban infrastructure and urban resiliency strategies for the Middle East', Sustainable Cities and Society, 54(November 2019), p. 101948. Available at: https://doi.org/10.1016/j.scs.2019.101948.
Serre, D. and Heinzlef, C. (2018) 'Assessing and mapping urban resilience to floods with respect to cascading effects through critical infrastructure networks', International Journal of Disaster Risk Reduction, 30(February), pp. 235–243. Available at: https://doi.org/10.1016/j.ijdrr.2018.02.018.
Setola, R., Luiijf, E. and Theocharidou, M. (2017) 'Critical Infrastructures, Protection and Resilience', in R. Setola et al. (eds) Managing the Complexity of Critical Infrastructures: A Modelling and Simulation Approach, pp. 1–18. Available at: https://doi.org/10.1007/978-3-319-51043-9.
Shen, S., Feng, X. and Peng, Z.R. (2016) 'A framework to analyze vulnerability of critical infrastructure to climate change: the case of a coastal community in Florida', Natural Hazards, 84(1), pp. 589–609. Available at: https://doi.org/10.1007/s11069-016-2442-6.
Silvast, A. et al. (2021) 'Critical infrastructure vulnerability: a research note on adaptation to climate change in the Nordic countries', Geografisk Tidsskrift - Danish Journal of Geography , 121(1), pp. 79–90. Available at: https://doi.org/10.1080/00167223.2020.1851609.
Song, G. et al. (2022) 'Improving the Spatial Accessibility of Community-Level Healthcare Service toward the "15-Minute City" Goal in China', ISPRS International Journal of Geo-Information, 11(8). Available at: https://doi.org/10.3390/ijgi11080436.
Steele, W. and Legacy, C. (2017) 'Critical Urban Infrastructure', Urban Policy and Research, 35(1), pp. 1–6. Available at: https://doi.org/10.1080/08111146.2017.1283751.
Steele, W., Hussey, K. and Dovers, S. (2017) 'What's Critical about Critical Infrastructure?', Urban Policy and Research, 35(1), pp. 74–86. Available at: https://doi.org/10.1080/08111146.2017.1282857.
Theoharidou, M., Kotzanikolaou, P. and Gritza-Lis, D. (2009) 'Risk-based criticality analysis', in International Conference on Critical Infrastructure Protection, pp. 35–49. Available at: https://doi.org/10.1007/978-3-642-04798-5_3.

Tonyaloğlu, E.E. (2020) 'Spatiotemporal dynamics of urban ecosystem services in Turkey: The case of Bornova, Izmir', Urban Forestry and Urban Greening, 49. Available at: https://doi.org/10.1016/j.ufug.2020.126631.
TSI. (2023). Turkish Statistical Institute. https://biruni.tuik.gov.tr/medas/?kn=95&locale=tr
UNISDR (2017) 'Cross-Sectoral and Multi-Risk Approach to Cascading Disasters'.
United Nations (2015) Sendai Framework for Disaster Risk Reduction.
United Nations (2017) New Urban Agenda. Available at: https://habitat3.org/the-new-urban-agenda/.
Victoria State Government. (n.d.). 20-minute neighbourhoods. Available from: https://www.planning.vic.gov.au/guides-and-resources/strategies-and-initiatives/20-minute-neighbourhoods
World Economic Forum (2023) Global Risks Report 2023.
Zengin Çelik, H. and Çilingir, T. (2017) 'Parsel Bazındaki Dönüşüm Uygulamalarının Kentsel Maliyetleri, Karşıyaka-Bostanlı Mahallesi Örneği', Planlama, 27(3), pp. 329–346. Available at: https://doi.org/10.14744/planlama.2017.73745.