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Post-Earthquake Urban Planning in Türkiye: Evaluating Disaster Refuge Systems in Hatay and Istanbul

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Abstract

Countries prone to significant earthquakes often develop disaster refuge and relief urban park systems to enhance urban open green spaces, which serve as temporary shelters for evacuation after seismic events. This paper examines the disaster refuge sites and urban open green space system in the center of Hatay following the February 6, 2023 earthquake. The findings provide insights into the resilience of Turkish cities after seismic events. Subsequently, the refuge sites and green space systems in Istanbul, a metropolis expected to experience a major earthquake, were analyzed in light of the Hatay example. Using ArcGIS, the service areas of shelter sites and urban open green spaces (within a 15-minute walking distance) were calculated and compared. Results indicate that the service areas for emergency shelters in the center of Hatay and Istanbul's Fatih district are insufficient. This highlights the need for better-planned urban open green spaces for evacuation purposes. This study makes significant contributions to improving shelter and evacuation processes after earthquakes in the fields of disaster management and urban planning.

Keywords: *Earthquake, resilient cities, green space systems, urban planning, emergency shelter.*

Türkiye’de Deprem Sonrası Kentsel Planlama: Hatay ve İstanbul'daki Afet Sığınak Sistemlerinin Değerlendirilmesi

Öz

Büyük depremlerle karşılaşan ülkeler, kentsel açık yeşil alanları güçlendirmek amacıyla, afet sığınakları ve yardım parkı sistemleri geliştirmekte; bu alanlar, sismik olaylar sonrasında tahliye için geçici sığınaklar olarak hizmet etmektedir. Bu çalışma, 6 Şubat 2023 tarihinde meydana gelen depremin ardından Hatay merkezindeki afet sığınakları ve kentsel açık yeşil alan sistemini incelemektedir. Elde edilen bulgular, Türkiyey'deki şehirlerin sismik olaylar sonrasındaki dayanıklılığına dair önemli bilgiler sunmaktadır. Ardından, büyük bir depreme maruz kalması beklenen İstanbul'daki sığınak alanları ve yeşil alan sistemleri, Hatay örneği dikkate alınarak analiz edilmiştir. ArcGIS kullanılarak, sığınak alanlarının ve kentsel açık yeşil alanların (15 dakikalık yürüme mesafesindeki) hizmet alanları hesaplanmış ve karşılaştırılmıştır. Sonuçlar, Hatay merkezindeki ve İstanbul'un Fatih ilçesindeki acil sığınaklar için hizmet alanlarının yetersiz olduğunu göstermektedir. Bu durum, tahliye amacıyla daha iyi planlanmış kentsel açık yeşil alanların gerekliliğini vurgulamaktadır. Bu çalışma, afet yönetimi ve şehir planlaması alanında, depremler sonrası sığınma ve tahliye süreçlerinin iyileştirilmesine yönelik önemli katkılar sağlamaktadır.

Anahtar kelimeler: *Deprem, dayanıklı şehirler, yeşil alan sistemleri, kentsel planlama, acil toplanma alanları.*

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1. Introduction

Cities are shaped by the history, culture, and geography inherited from the past by civilizations (Ilgar, 2008). However, because of natural disasters, the structure of cities is significantly disrupted. One of the most destructive natural disasters in cities is earthquakes. Earthquakes originate from movements within the Earth's crust. These movements have the potential to devastate villages, towns, and even cities, causing effects such as fires and flooding (Altun, 2018). Earthquakes that cause loss of life and property are particularly impactful in countries located in earthquake-prone zones, and researchers are increasingly focusing on disaster risk assessment and mitigation planning (Mabon, 2019; Uehara et al., 2022). Türkiye, one of these countries, has seen tens of thousands of people lose their lives due to earthquakes, and cities have suffered destruction.

Türkiye is located at a geographical junction between the continents of Europe and Asia, where two major fault lines exist. Researchers are closely examining the aftermath of the 7.7 and 7.6 magnitude earthquakes that struck the eastern part of Türkiye on February 6, 2023. The substantial loss of life and property has underscored the importance of Türkiye taking crucial steps in creating safe living spaces before earthquakes and addressing the essential needs of survivors afterward. In Türkiye, measures related to earthquakes primarily focus on constructing more resilient buildings and post-disaster intervention, with only a few detailed provisions. According to the Spatial Plans Construction Regulation dated 2014, goals, strategies, and implementation principles related to making the building stock more resilient and secure against disasters such as earthquakes, floods, landslides, fires, rockfalls, and similar events will be determined during the preparation of protection-oriented zoning plans (SPCR, 2014). The Türkiye Building Earthquake Regulation of 2018 outlines the principles for designing buildings under the influence of earthquakes (TBER, 2018). In 2022, revisions were made to the Türkiye Disaster Response Plan. The purpose of the plan is to define the roles and responsibilities of working groups and coordination units involved in disaster and emergency response efforts, as well as to establish the fundamental principles of intervention planning before, during, and after disasters (TDRP, 2022). However, there is no specific approach to the development of an urban green space system for creating a city resilient to disasters.

In urban areas, disruptions in the physical environment post-earthquakes pose challenges in meeting vital needs such as transportation, housing, food, and healthcare. Post-earthquake housing is a significant requirement, initially addressed in Türkiye through temporary shelters (Uzuner & Akıncıtürk, 2020). However, the insufficient number and functional features of these facilities contribute to various issues during disasters. Survivors not only grapple with economic and psychological consequences but also face deprivation of necessities like food, shelter, and healthcare. Therefore, cities need to be made resilient to earthquakes in all aspects. However, one of the most crucial components needed during and after an earthquake, especially in risk-prone cities, is the presence of emergency shelter sites. Despite numerous disasters in Türkiye, the significance of urban green spaces as a refuge system remains underappreciated. Current earthquake-related measures primarily emphasize building resilient structures and focus on post-disaster interventions. There is a lack of planning approaches and legal provisions specifically addressing the design, implementation, and utilization of urban green spaces for this purpose.

In this context, the authors believe that the data and experience obtained from Hatay, one of the places with the highest loss of life and property during the earthquake on February 6, provide valuable information for improving cities against other potential earthquakes and natural disasters in Türkiye. The temporary shelter needs that arose after this earthquake (tent cities spreading across various parts of the city and even temporary shelter sites consisting of a few tents in the rural areas of the city) are a scenario that could occur in cities located in Türkiye's first-degree earthquake zone, and precautions need to be taken. Especially after this earthquake, experts unanimously agree that there is a high probability of a major earthquake occurring in Istanbul, which is not only Türkiye's largest metropolis but also its cultural capital, located along the North Anatolian Fault (Erdik et al., 2003; Erberik, 2010). However, unlike Hatay, Istanbul has a dense urban structure and limited open spaces in its immediate vicinity that could be used as refuge sites. The city's only assurance in this regard is the urban open green space system.

Therefore, in this study, considering the data obtained from the earthquake on February 6, 2023, the city's emergency shelter sites and urban open green space system in Istanbul were examined to better understand the opportunities the city offers as a refuge in the event of an earthquake. In the study area in Hatay (study area 1), the spatial data of the emergency shelter sites designated by DEMA (Disaster and Emergency Management Authority), open green spaces, and temporary shelter cities (tent cities) used after the earthquake were collected, and the service areas of these locations were calculated using the Network Analyst tool of ArcGIS. Similarly, in the designated study area in Istanbul (study area 2), the service areas of the emergency shelter sites designated by DEMA and the Istanbul Metropolitan Municipality, as well as the city's open green spaces, were calculated. These data were compared with the populations of the study areas. In both study areas, it was observed that the service areas of emergency shelter sites did not cover all neighborhoods (as they were not within a 15-minute walking distance). Furthermore, in study area 2, it was revealed that the urban open green spaces were not designed as a system and were not within a 15-minute walking distance for everyone, making them insufficient to meet the refuge and evacuation needs in the event of a major earthquake. According to these results, suggestions were presented to decision-makers to create cities that are more resistant to earthquakes.

This study highlights the importance of developing the urban open green space system to meet the refuge and evacuation needs encountered after disasters. The information obtained from this study provides valuable insights for developing disaster-resilient cities based on lessons learned from past experiences.

2. Study Area

In this article, which focuses on research related to post-earthquake refuge sites, the study areas include Hatay and Istanbul. Hatay, which includes study area 1, is a constant crossroads where Eastern and Western cultures intersect, fostering continuous cultural exchange (Hatay Governorship, 2023). Hatay province is located between the latitudes of 35° 52' and 37° 4' and the longitudes of 35° 40' and 36° 35' (Figure 1). Hatay is situated on the eastern coast of the Gulf of Iskenderun in the southern part of Türkiye. It is bordered by the Mediterranean Sea to the west, Syria to the south and east, Adana to the northwest, Osmaniye to the north, and Gaziantep to the northeast (Hatay Governorship, 2023). The province experiences a Mediterranean climate, characterized by hot and dry summers, and mild and rainy winters. Although the province's natural vegetation primarily consists of forests, many forested areas have been depleted over time, and have been replaced by shrubland types, in line with its climatic conditions.

A significant portion of the city is situated in a geomorphologically unsuitable area and is exposed to natural risks (Tonbul & Sunkar, 2008; Özşahin, 2010). In the center of Hatay, there is a risk of floods and mass movements due to geomorphological features, as well as earthquake risk arising from ground characteristics (Hatay Governorship, 2023). The study area 1 is primarily located within the Eastern Anatolian Fault, the Dead Sea Fault, and the Hellenic-Cyprus Arc. In connection with these fault lines, this region has experienced significant earthquakes in its history, resulting in significant loss of life and property (Korkmaz, 2006; Özşahin, 2010). Based on the city's structural development, during its initial establishment, a grid plan was implemented, with main streets running in a southwest-northeast direction to take advantage of the prevailing winds, and between these main streets, building blocks were formed (Demir, 1996; Kaypak, 2010). The study area 1 encompassing these features consists of 61 neighborhoods covering an area of 116 km^2 in the center of Hatay that were most affected by the earthquake that occurred in Kahramanmaraş on February 6, 2023. It includes the regions where buildings collapsed and refuge sites were used. According to the data from the year 2002, the study area 1, identified before the major earthquake, was determined to have a population of 419490 (TSI, 2022).

Study area 2 is the Fatih district of Istanbul, which has a population of 368227 and consists of 57 neighborhoods. The Fatih district covers an area of 15 km^2. Istanbul is the only metropolis in the world that spans two continents, Europe and Asia (Istanbul Governorship, 2023). One of the districts on the European side of Istanbul, Fatih, is known as the Historic Peninsula, encompassing the Byzantine walls, the Golden Horn, and the area surrounded by the Sea of Marmara. The area also suffered damage in the devastating earthquake known as the "1894 Istanbul earthquake," commonly referred to as the "Three Hundred and Ten Earthquake" among the locals. Based on research conducted by various scholars, a consensus has been reached on the most significant fault line that could trigger an earthquake affecting Istanbul and its surroundings. This potential earthquake source is the fault line that extends east-west within the Marmara Sea, following the northern branch of the North Anatolian Fault, originating from the North Marmara region (Bianet, 2020).

Fatih, Eyüp district to the north, the Golden Horn to the northeast, the Sea of Marmara to the south, Zeytinburnu to the west, and Bayrampaşa to the northwest are its neighboring districts, giving it the appearance of a peninsula surrounded by the sea on three sides (Fatih Governorship, 2023). The district is situated between 41° 1' 3.7740" north latitude and 28° 56' 25.4220" east longitude (Figure 1).

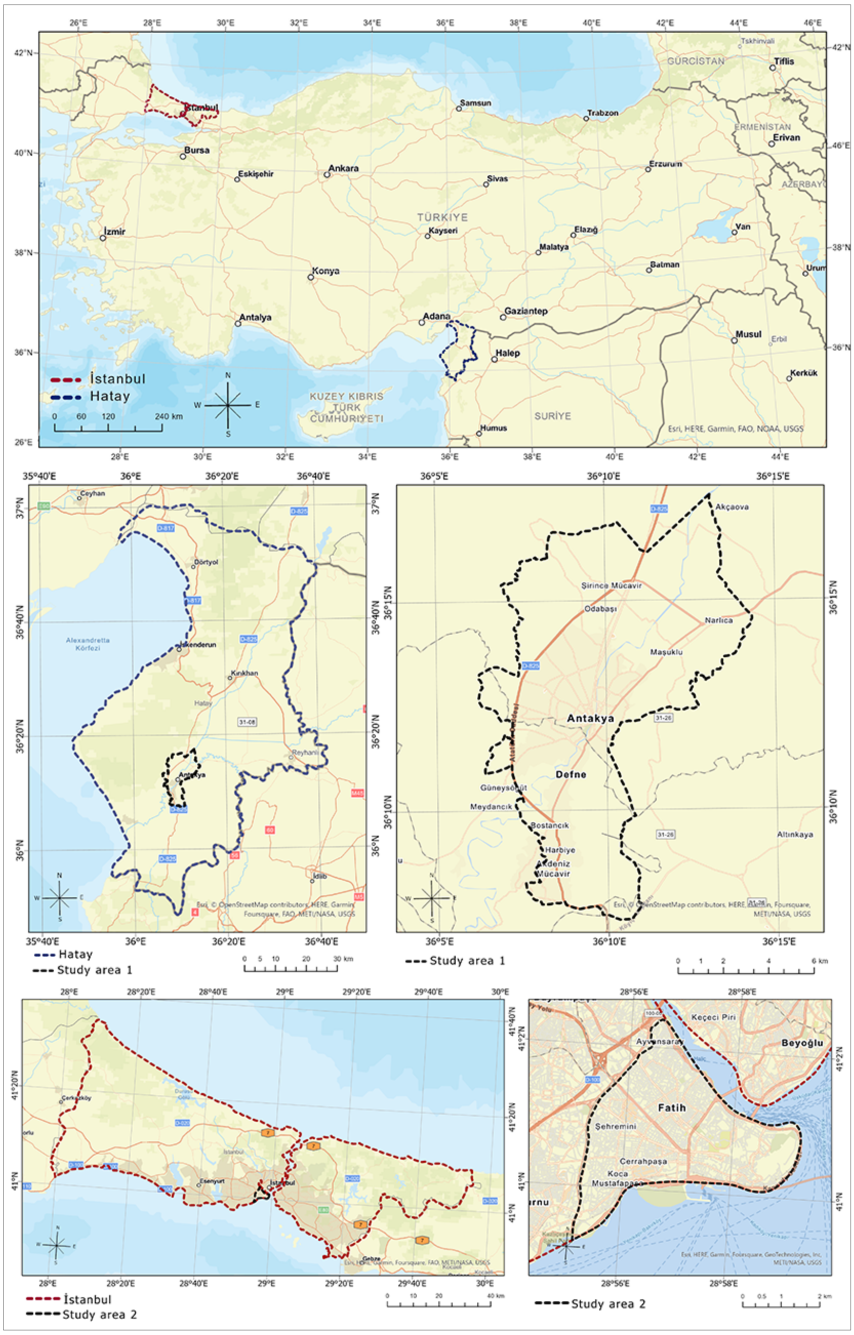

Figure 1 . Study area 1 and study area 2

Fatih district is located at an elevation of 60 meters above sea level (IMM, 2020). Fatih is influenced by a transitional type of climate known as the Marmara climate, which combines Mediterranean, Black Sea, and continental characteristics. Summers are hot and dry, while winters are mild and rainy. The coastal areas have higher humidity levels. The vegetation in the region resembles Mediterranean climate plants. The most observed plant species in the area is maquis, which is adapted to the long and dry summer season. Forested areas are sporadically present in the region (Istanbul Governorship, 2023).

The selection of these areas was based on the idea that, after the earthquake on February 6, earthquake survivors in central neighborhoods in Hatay started living in tent cities and tents in the rural areas of Hatay due to the inadequacy of shelter sites. This was because, as revealed by satellite imagery examined after the earthquake, it became evident that the city's open green space system was not sufficient to serve as a shelter site for earthquake survivors. Consequently, they had to move away from the city center to more rural areas around the city to meet their housing needs in tent cities and tents. However, in the designated area in Istanbul, the urban fabric would not allow for such a situation, primarily due to population density. Therefore, evaluating these two areas together serves to provide a clearer understanding of the potential problems related to refuge and evacuation in the event of an earthquake in Istanbul.

3. Methodology and Data Collection

In this paper, three different spatial datasets related to Hatay province have had their service areas measured. The first dataset covers Hatay's open green spaces, the second includes emergency shelter sites determined by DEMA, and the third encompasses all temporary shelter sites. These datasets were analyzed using the Network Analyst tool in ArcGIS software to determine service areas within a 5, 10, and 15-minute walking distance.

The three different datasets mentioned above were imported as facilities in the Service Area Analysis. Hatay's urban road system also served as the walking network. Similarly, service areas for open green spaces in Istanbul Fatih and DEMA's designated emergency shelter sites were calculated. These two datasets were used as facilities, and the urban road system served as the walking network. The data used in the research, the conducted analyses, and the data sources are listed in Table 1. nThe data related to roads and green spaces were obtained from the OpenStreetMap (OSM) open-access database. Data regarding emergency shelter sites in Türkiye were obtained from AFAD's open-access database. Additionally, for Istanbul data, the Istanbul City Map database provided by the Istanbul Metropolitan Municipality was used. Data on temporary shelter sites or tent cities used in Hatay after an earthquake were identified from satellite images obtained from Google Earth. Data related to buildings and water surfaces were obtained from OSM. After collecting these data, they were organized and analyzed using the ArcGIS software to compare the refuge sites in study area 1 and study area 2.

Table 1. Data and analysis table

Data	Spatial analysis	Dataset
Roads	Servis area(network)	OSM
Green areas	Servis area(facilities)	OSM
Emergency shelter sites	Servis area(facilities)	DEMA, Istanbul City Map
Temporary shelter sites	Servis area(facilities)	DEMA, Gooogle earth
Buildings	Buffer (3.5m)	OSM
Water surfaces	Buffer (100m)	OSM

The primary analysis method used the Service Area calculation tool in ArcGIS. To do this, a pedestrian network dataset was first created, considering the routes pedestrians could use to reach refuge sites in the event of an earthquake. As the OSM data provided road connectivity, road segments that pedestrians cannot use, such as the primary, trunk, and their links, were not considered. Subsequently, through a literature review, road segments with a high probability of becoming impassable due to earthquakes, such as those near riverbeds and coastlines, were excluded (Table 2).

Table 2. Areas are not suitable for walking after an earthquake

	Not walkable	Reference
Road class of OSM data	Primary, trunk, and their links	Gaglione, Gargiulo & Zucaro, 2019
Riverside	0–100 m	Walker et. al., 2024
Coastline	0–100 m	Mague, McFarland & Borrelli, 2020; Masuda, 2014
Building collapse zone	0-3.5m	Golla, 2020

In urban areas, primary roads, trunk roads, and their connecting links are typically not well-suited for pedestrian movement. These types of roads are generally designed to prioritize vehicular traffic, focusing on efficiency and high-speed transit, rather than providing safe or comfortable environments for pedestrians. Such roads often lack features that enhance pedestrian safety and comfort, such as wide sidewalks, pedestrian crossings, and adequate signage (Gaglione, Gargiulo & Zucaro, 2019).

It is stated that residential areas located within 100 meters of riverbeds in cities show higher vulnerability to flood risks (Walker et al., 2024). Additionally, riverbeds can experience displacements or flooding effects during earthquakes. For example, in the urban axis along the Asi River in Hatay, there is significant damage from the riverbank towards the embankments (KHER, 2023). This results in a greater impact on the structures around the riverbed compared to the earthquake itself. Coastal areas also have a high probability of collapses or flooding events due to earthquakes. The 9.0 magnitude earthquake that occurred in the northeastern Sea of Japan in 2011 is a good example of this. The large earthquake raised the seawater level by as much as nine meters and caused a Tsunami with a wave height of 40.5 meters in some areas (Masuda, 2014). Some of these coastal areas may be filled lands, and being in these areas poses a considerable risk in the event of a tsunami caused by an earthquake. The Massachusetts Coastal Resilience Program report states that a 100-meter buffer zone has been applied in certain cases to protect coastal areas. This measure aims to reduce the risks of environmental changes, such as flooding and erosion(Mague, McFarland & Borrelli, 2020). Therefore, these areas have been designated as unsuitable for walking after an earthquake. Additionally, building debris reduces the capacity of roads, significantly impacting post-earthquake emergency operations, especially in situations with low resilience (Golla, 2020). After the earthquake in Hatay, 215,255 heavily damaged or collapsed, 25,957 moderately damaged, and 189,317 slightly damaged structures were identified (KHER, 2023). The second study area is generally comprised of 4 or 5-story buildings. However, many of these structures are old, and in this historically settled area, the roads are narrow and surrounded by buildings. Therefore, if structures closer to the road collapse, there is a high probability of rendering the road unusable. Additionally, even if the road is not blocked by debris, buildings that suffer damage from the earthquake may collapse after some time, and pedestrians may encounter collapsing moments while walking. It is emphasized that especially on single-lane roads, the designated width is 3.5 m, and even the slightest debris extending onto the road can cause complete closure (Golla, 2020). Even if the road is wide, pedestrians are likely to prefer walking in the middle, away from buildings. Therefore, areas with debris risk extending within 3.5 m of structures are designated as non-walkable areas due to the high risk. Moreover, in the event of an earthquake, there is a possibility of roads being damaged due to the quake itself, as well as factors such as panic-induced traffic and chaos created by people, which may affect the usability of roads. For example, according to the Kahramanmaraş and Hatay Earthquakes Report (2023), the assessment of road damage, including highways, roads, tunnels, viaducts, and other road infrastructure, revealed a total of 12.2 billion Turkish liras in damages.

After these processes, source features and attributes have been organized for the walking network. During this process, walking time has been calculated according to Formula 1.

$$t_{min} = 60 * \frac{d}{s} \qquad (\mathbf{1})$$

Here, $s = 5\,km/h$ (equivalent to approximately 1.39 m/s) represents the walking speed, and d represents the distance in kilometers. Using this formula, service areas accessible within 5, 10, and 15 minutes were determined in the network analysis. After creating the walking network, service areas for the identified facilities were calculated with the service area tool. The findings were then presented in maps and tables, and finally, these data were interpreted in relation to the population.

4. Results

Emergency shelter sites, temporary shelter sites, and service areas of the urban open green space system were determined, and maps were created for study area 1 and study aea 2. In study area 1, where 419490 people reside in Hatay, 74 emergency shelter sites were identified by DEMA. According to the service area analysis, the service area of these emergency shelter sites is 118 km² (Figure 2).

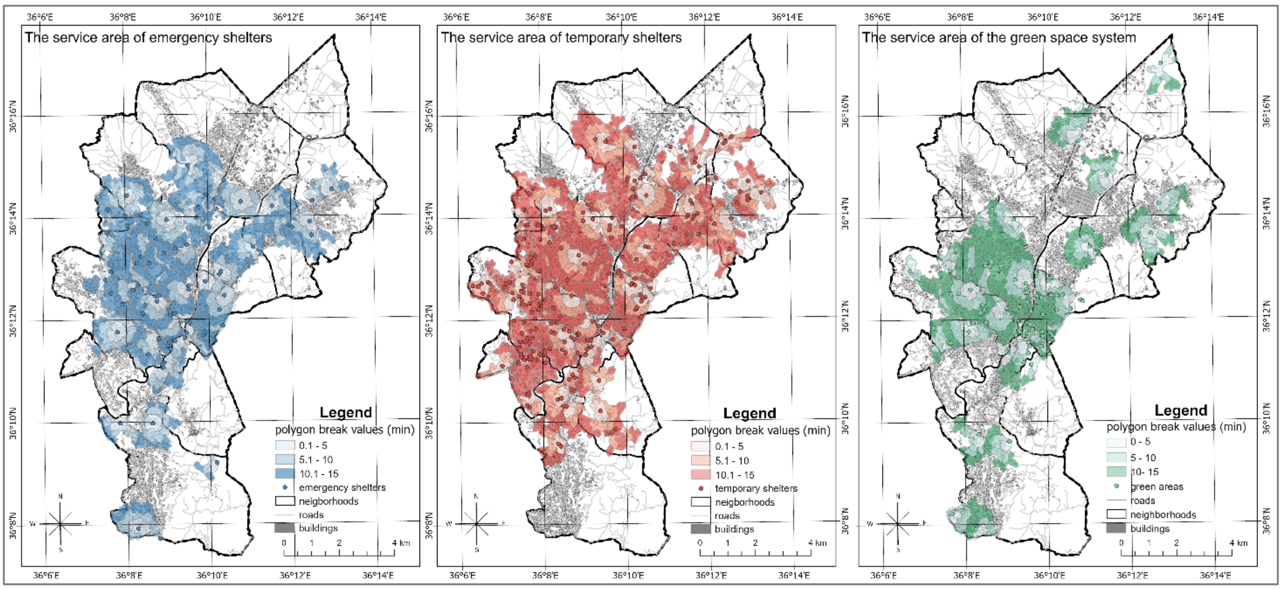

Figure 2. The service area of emergency shelters, temporary shelters, and green space system (study area 1)

In some areas of the study region, there is no emergency shelter site within a 15-minute walking distance. In other words, in certain neighborhoods, emergency shelter sites are not strategically located to serve the entire neighborhood. For instance, the Dursunlu neighborhood with a population of 8773, the Subaşı neighborhood with a population of 6001, and the Hasanlı neighborhood with a population of 44 have no emergency shelter sites. Additionally, in Harbiye, Kuzeytepe, Narlıca Güzelburç, Maşuklu, Ekinci, and Küçükdalyan neighborhoods, the service area of emergency shelter sites does not cover the entire neighborhood.

In study area 1 located in Hatay, a total of 221 temporary shelter sites have been identified. These areas encompass tent cities containing facilities for shelter and areas where 2 or 3 tents are clustered together but lack other necessary amenities for housing. Some of these tent areas are situated in emergency shelter sites, some in the yards of undamaged residences, some in open areas where debris has been cleared, and some are located along the roadsides. Simultaneously, these temporary shelter sites show an increasing trend as they move away from the city center, spreading more towards the surrounding rural areas, and staying away from riverbeds. In study area 1, a total area of 1106249 m^2 is utilized as tent space (temporary shelter site). The service area covered by this tent area is 321 km^2 (Figure 2). This indicates that in study area 1, with a population of 419490, there is a need for 1106249 m^2 of temporary shelter area after an earthquake.

The city's open green space system is observed to consist of patches. In the event of a natural disaster, there is no green road network that could provide evacuation to shelter sites by avoiding collapsed structures and roads. These patches cover an area of 1968887 m^2, with a service area of 116 km^2. Many of these areas have not been used as temporary shelter sites (Figure 2). Some of these areas may not have been utilized due to their distance from the city center or topographical conditions.

In study area 2, there are 191 emergency shelter sites covering an area of 1167484 m^2. The service area of these emergency shelter sites encompasses a 10 km^2 area (Figure 3). Similar to study area 1, emergency shelter sites in some neighborhoods of study area 2 are not appropriately located. In certain neighborhoods, there are no shelter sites at all, and residents of these neighborhoods do not have access to any shelter sites within a 15-minute distance. These neighborhoods include Sururi, Tahya Hatun, Muhsine Hatun, Tahtakale, Mimar Hayrettin, and Katip Kasım. Emergency shelter sites largely overlap with the open green space system in the Fatih district (study area 2). The 212 open green areas in the Fatih district cover an area of 983863 m^2, and the service area of these green areas is 683725 m^2 (Figure 3).

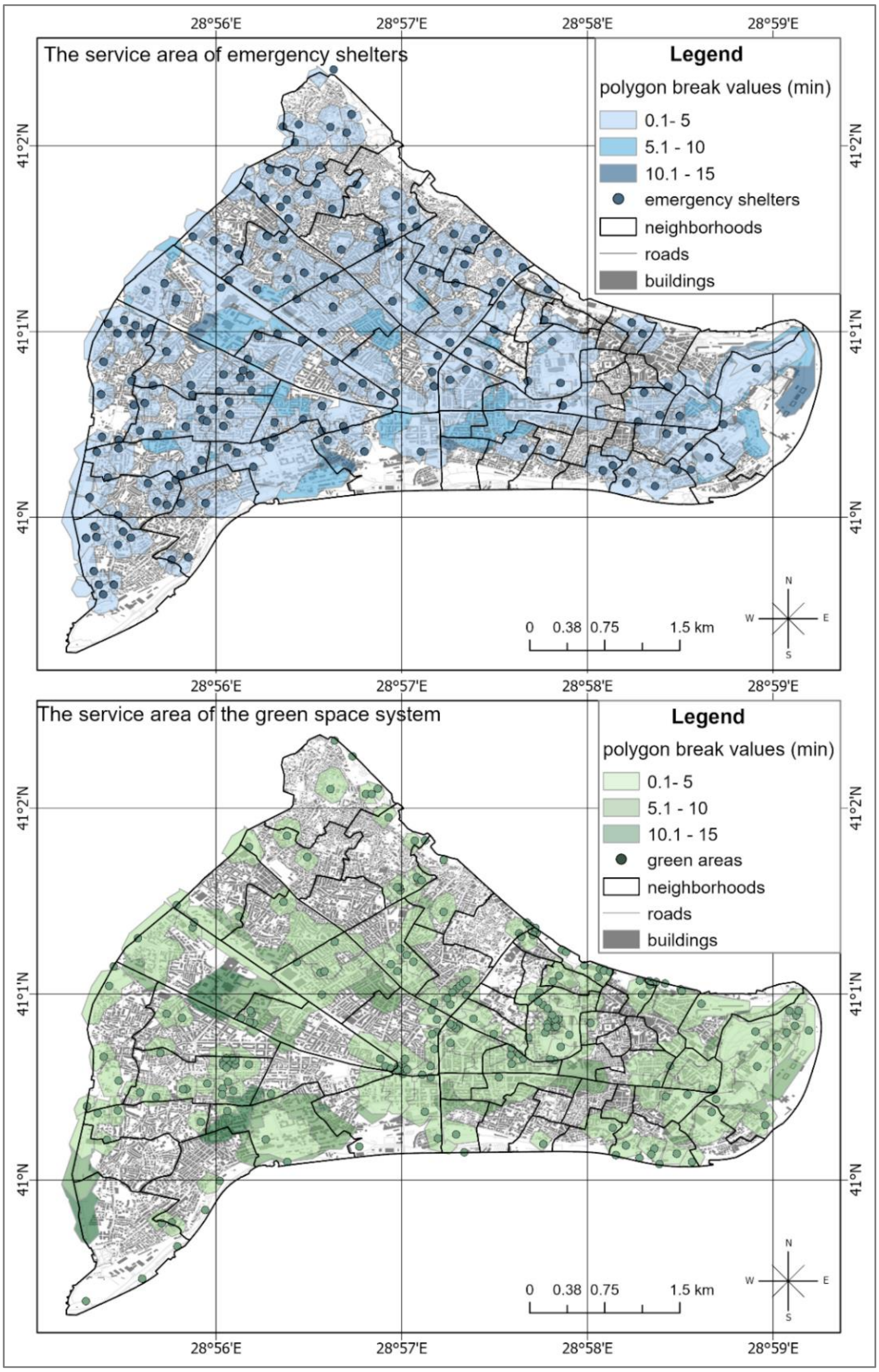

Figure 3. The service area of emergency shelters and the green space system (Study Area 2)

5. Discussion

According to the findings of the study, in Study Area 1 in Hatay, where 419490 people live, neighborhoods are spread over an area of approximately 116 km². In these neighborhoods, there are 74 emergency shelter sites covering a service area of 118 km². However, it has been observed that the service area of emergency shelter sites does not cover the entire neighborhood or there are no emergency shelter sites in some neighborhoods. After the earthquake on February 6th, which caused significant loss of life and property in Hatay, there emerged a need for approximately 1.1 km² of temporary shelter sites, covering a service area of 321 km². Temporary shelter sites are generally located far from the city center. No available data indicates that these temporary shelter sites were pre-determined. The green spaces cover approximately 1.9 km², with a service area of 116 km². Some of these areas have not been used as temporary shelter sites after the earthquake.

With a population of 368227, the area of Istanbul's Fatih district is approximately 15 km². The emergency shelter sites identified by DEMA are spread over an area of approximately 1.2 km². The service area of these sites covers an area of 10 km². Similarly, in some neighborhoods, there is no emergency shelter site within a 15-minute distance. The open green spaces in the study area cover an area of approximately 0.9 km², with a service area of approximately 0.7 km².

In this context, it is evident that a much more challenging process would emerge in Istanbul's Fatih district, where the population is much denser, after a major earthquake compared to the scenario in Hatay. Reaching the designated emergency shelter sites in Istanbul on foot after a major earthquake may be hindered due to population density and the lack of evacuation routes. Additionally, there is not enough open space in Fatih that the population could use as temporary shelter sites after a major earthquake.

Urban open green space systems cannot provide secure evacuation routes in either city. In this context, it has been observed that in Türkiye, temporary shelter sites and secure evacuation routes are not predetermined before disasters. The Türkiye Disaster Response Plan includes the responsibility of the operation service pre-improvement sub-service working groups to establish the infrastructure of temporary shelter and care units (TDRP, 2022). However, there is no law or regulation determining the necessity of pre-determining where these temporary shelter sites will be in cities at risk of disasters.

Worldwide documented responses to earthquakes indicate that a sufficient and consistent amount of open space surrounding buildings holds significant value during and after seismic events (Godschalk, 2003). Open space becomes a shelter and temporary home for thousands of people who must quickly adapt to new environments for days, months, or even years after an earthquake. Following a major earthquake, the open space network becomes almost a "second city," fulfilling a series of complex functions, including gathering and shelter, distribution of goods and services, re-establishment of trade, temporary residence, memorial ceremonies, and storage of dirty or hazardous materials (McGregor, 1998, Middleton, 2007). The network overflows with new meanings; its areas and components are reevaluated in terms of their capacities to support survival and recovery. However, information regarding the amount of open space per person required for evacuation or shelter is limited (Uyar & Özkan, 2023), and there is almost no research on its quality (Allan & Bryant, 2010).

In the literature, many studies focus on the risks of loss of life and property in urban centers, the structural integrity of buildings, and the effectiveness of disaster preparedness, but places where effective recovery occurs, such as open green spaces, are rarely addressed (Allan & Bryant, 2010; Masuda, 2014). Researchers emphasize the importance of planning and designing open green spaces in a disaster-sensitive manner, but even studies based on disaster sensitivity or resilience focus on specific aspects, highlighting the lack of comprehensive studies that address these standards or criteria (Şenik & Uzun, 2021).

It can be argued that many people in Hatay who have a chance of survival after an earthquake have gone through a challenging process to reach emergency shelter sites. In Istanbul, there is still an opportunity to find solutions to these problems. After the earthquake in Hatay, earthquake survivors had the opportunity to move away from the collapsed areas due to the semi-rural structure of the city. On the other hand, the Fatih district is enclosed by seas and dense urban fabric, and without precautions, there is a high probability of significant loss of life and property in the event of an earthquake. The possibility of earthquake victims encountering an environment that makes it difficult for them to adapt to life again is high. In a metropolis like Istanbul, the only option the community can rely on for shelter and evacuation in emergencies is an adequate urban open green space system. Therefore, decision-makers need to take precautions against a major earthquake in Istanbul, as expected by many researchers.

Results emphasize the need for strategic planning to integrate the urban open green space system with disaster resilience efforts. It is crucial to enhance accessibility and expand the coverage of emergency shelter sites, especially in neighborhoods with limited access. Research and planning efforts should focus on optimizing open green spaces as shelters and evacuation areas during and after disasters.

There are various initiatives to increase urban resilience against disasters and to be prepared for a potential earthquake in Istanbul. The Ministry of Interior, General Command of the Gendarmerie, Disaster and Emergency Management Authority, and district municipalities are actively involved in these efforts. Identified emergency and temporary shelter sites and scenarios have been transferred to databases using Geographic Information Systems. Necessary risk analyses (tsunami, ground conditions, etc.) have been conducted and incorporated into the study. Considering the December 2020 population data from the Turkish Statistical Institute (TSI), a neighborhood-focused disaster action plan has been prepared, and capacity analyses have been carried out. As a result of the study, temporary shelter and emergency shelter sites have been planned. According to the data from the Istanbul Metropolitan Municipality, a total of 5599 emergency shelter sites covering 4840.7 hectares have been identified in the 39 districts of Istanbul, with a per capita emergency shelter sites of 3.13 m^2 (UTBD, 2022). In addition, earthquake parks have been constructed in Istanbul since 2020. Earthquake parks with capacities of 500-700 and 5000 have been built in the Ataşehir and Topkapı districts, respectively. These parks are designed to provide short or medium-term shelter for citizens after a disaster and to support rescue efforts (Bianet, 2020). However, for these shelter sites to be effective, planning a comprehensive urban open green space system that includes evacuation routes and areas requires a nationwide approach. With this approach, the urban park system can be incorporated into the urban design process at the national, provincial, and local levels for management and distribution in emergencies.

The authors propose the development of urban green space systems in these cities by taking an example from Japan's earthquake-resistant urban green space approach. This would make access to emergency shelter sites much easier and safer. Additionally, it would be possible to create much more coordinated and appropriately scaled areas for both emergency shelter sites areas and temporary shelter sites. The urban green space system should be planned to meet post-disaster needs in the fastest and most coordinated manner possible. Therefore, the importance of the open green network system stands out more prominently as both shelter and evacuation areas. When the urban green system is appropriately planned, it not only provides a safer evacuation environment for pedestrians but also ensures interconnected refuge sites. This is crucial for the continuous flow of essential needs, even when other transportation routes are closed, providing a secure temporary shelter for earthquake survivors. Li et al. (2013) conducted a study where they explained the suitability assessment of green spaces in parks as shelter areas with three main criteria: availability (providing enough open space to accommodate an appropriate shelter population), accessibility (the shortest route to a hospital, fire station, and a safe water source), and safety (minimum distance in terms of faults, dangerous points, slope, and the width of surrounding roads) (Şenik & Uzun, 2021).

After numerous earthquakes in Türkiye and since Türkiye is an earthquake-prone region, the goal of creating disaster-resistant cities should be embraced nationwide, and detailed laws regarding its implementation should be established. Particularly in cities located in first-degree earthquake zones, while structures are being strengthened, certain decisions should also be made regarding the implementation of an earthquake-resistant approach for disaster refuge and relief urban park systems or urban open green space systems.

This study focuses on the development of green spaces as evacuation and shelter sites in the face of natural disasters, particularly earthquakes. In this context, it provides significant analyses and findings, contributing to the literature. Moreover, it emphasizes the necessity of increasing research in this field, highlighting the importance of the subject and offering a crucial roadmap for future studies. However, factors such as infrastructure conditions, topographic slope, road accessibility, and proximity to critical services, including hospitals and schools, were not analyzed due to data constraints and the defined scope of this study. Similarly, the assessment of green space quality, encompassing attributes such as capacity, design, and available facilities, was not conducted, as the requisite data were not accessible.

Addressing these limitations in future research could enable a more comprehensive understanding of the role of green spaces in disaster preparedness and contribute significantly to advancing knowledge in this domain.

5. Conclusion

Urban open green space systems are one of the most significant tools in the hands of experts to create disaster-resistant cities. Carmona (2010) emphasizes that a network of public open spaces connected by green corridors is the key to creating a sustainable environment in cities and integrating the natural environment with the built environment. Researchers even suggest that the city's open spaces have the potential to become a 'second city' by making simple contributions to complex services such as gathering, sheltering, distributing goods and services, and temporary settlement after a major disaster (Allan & Bryant 2010; Masuda, 2014; Jayakody, Amarathunga & Haigh, 2018). Many large cities that have faced earthquake disasters shape their planning approaches, accordingly, recognizing the importance of the urban open green space system as post-disaster refuge sites.

Recent studies highlight the necessity of incorporating the location, capacity, and usage strategies of post-disaster shelter sites in the hierarchical planning approaches implemented in Türkiye (Çınar, Akgün & Maral, 2018). Apart from a few studies emphasizing the importance of urban open green space systems in creating disaster-resistant cities (Şenik & Uzun, 2021), there is not enough research on this topic. By addressing this gap, this study has made a significant contribution to improving the quality of life in cities and creating earthquake-resistant cities. These results emphasize the importance of integrating urban planning, disaster preparedness, and open green space management to enhance cities' overall resilience to natural disasters. Consequently, it is crucial for the concept of urban open green spaces as a key element in creating disaster-resistant cities to receive more attention and application beyond research.

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Author Contribution and Conflict of Interest Declaration Information

The authors declare no conflict of interest.

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