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ORIGINAL PAPER

Assessment of emergency gathering points and temporary shelter areas for disaster resilience in Elazıg, Turkey

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Abstract
Cities are profoundly vulnerable to the impacts of disasters due to their densely populated nature. Consequently, strategies are being formulated to optimize resource utilization within urban areas and their immediate surroundings. Resilient cities constitute a key facet of these strategies, capable of adapting to and enduring the pressures arising from social, economic, and environmental adversities. The establishment of resilient cities often involves the identification of emergency gathering and shelter sites to mitigate the potential aftermath of disasters and emergencies. In Turkey, such sites are designated by the Provincial Directorates under the aegis of the Disaster and Emergency Management Presidency (AFAD). These designations are guided by specific criteria. The present study focused on the suitability and selection of 95 emergency gathering points and 4 temporary shelter locations in Elâzığ, situated within Turkey's East Anatolian Fault Zone. For this analysis, the ArcGIS Pro software (ESRI 2021) was employed to assess the distribution, area sizes, and accessibility of open and green spaces earmarked as emergency gathering points across the city. Additionally, the Service Area Analysis was leveraged to delineate the utility of these sites during and following disaster scenarios. The findings of the analysis unveiled several noteworthy insights. It was evident that in Elâzığ, a city with a population of 381,153, meeting areas were deficient in terms of both quantity and size across 38 neighborhoods. Furthermore, almost half of the designated assembly points fell short in terms of optimal location and accessibility. Moreover, the study revealed inadequacies in the number, capacity, and accessibility of disaster shelter locations. These revelations underline the imperative for more comprehensive and effective planning to bolster the resilience of cities in the face of potential disasters.

Keywords Emergency assembly point · Temporary shelter area · Disaster risk reduction

1 Introduction

Cities exhibit diverse physical and human attributes contingent upon their geographical positioning. These attributes entail inherent risks that have the potential to engender both physical and social losses. For instance, Southeast Asia faces the peril of tsunamis,

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while cities situated along tectonic plate boundaries are susceptible to seismic earthquakes. Tropical regions are prone to destructive weather phenomena. Moreover, certain disasters emerge from human activities, including epidemics, fires, and pollution of air, soil, and water.

Cities bearing substantial populations are particularly vulnerable to the impact of both natural and anthropogenic disasters. This susceptibility is exacerbated in urban centers characterized by excessive resource consumption, deficient geographical planning, inadequate infrastructure services, and rapid urbanization. In such locales, the ramifications of these disasters are markedly amplified. Unfortunately, in cities grappling with these deficiencies, the requisite urban functions often falter, and resilience to disasters is profoundly compromised.

Urban areas, where intensive human activities are concentrated, necessitate comprehensive preparedness strategies to effectively manage potential disasters given their substantial population sizes. The foundation of this preparedness lies in the domain of disaster management, encompassing a spectrum of activities such as analysis, planning, decision-making, and evaluation. This process involves harnessing existing resources to facilitate readiness, risk reduction, response, and safeguarding against an array of hazards (Kadıoğlu 2008).

To ensure swift recovery and bolster resilience against disasters, it becomes imperative to conduct thorough risk analyses and formulate risk reduction plans within urban centers (Balta 2013). Resilient cities are an integral facet of these strategies. Such cities possess the capacity to adapt and withstand the strains arising from negative impacts associated with social, economic, and environmental challenges. As part of these initiatives, establishing emergency gathering points and erecting temporary shelters in the aftermath of disasters significantly enhances a city's resilience (Bektaş and Sakarya 2020).

Green spaces, a fundamental component of sustainability and urban resilience, exert multifaceted effects encompassing social, economic, and environmental dimensions. These open and verdant areas emerge as the prime choices for secure urban zones for congregation and shelter, both during and in the aftermath of disasters (Şenik and Uzun 2021; Fan et al. 2012; Anhorn and Khazai 2015; Zhu et al. 2016).

In fact, during the Chilean earthquake of 2010, Allan et al. (2013) observed that the network of open areas in the city primarily served as venues for squares, parks, temporary shelters, and aid distribution points. These areas swiftly transformed into safe havens. Furthermore, the significance of public green spaces, initially established for leisure and entertainment amidst China's rapid urbanization, acquired an additional role as emergency gathering points during earthquakes in 1923, 1976, and 2008 (Şenik and Uzun 2021). These instances underscore the crucial role of green spaces not only in daily urban life but also in fostering urban resilience during times of adversity.

Open and green spaces are crowded populations' emergency assembly and sheltering areas after a disaster. The main question here is whether the urban available and green space system used as an "emergency assembly point" is at a level to meet the needs after the earthquake (Gerdan and Şen 2019). Because; Determination of open and green spaces within the existing urban fabric as emergency assembly points should be according to specific standards. Çınar et al. (2018) Five factors are taken into account when establishing the criteria for determining emergency assembly points (Gerdan and Şen 2019; JICA 2002; Tarabanis and Tsionis 1999).

- *Accessibility* The maximum walking distance that each individual can easily reach, as the going distance from the building blocks to the assembly points, should be 500 m/15 minutes and less.
- *Connection with road axles* The links of the collection areas with the main arteries should be established (considering the roads at risk of closing), and other gathering areas and continuity should be ensured.
- *Usability and multi functionality* Children's playgrounds, sports fields, pocket parks, neighborhood parks, small parks, and district parks from existing active green spaces; Passive green spaces, carpet fields; building gardens, school gardens, mosques, and hospital gardens; Empty spaces and open parking lots can be recommended as an emergency assembly point. The area should not be 500 m^2 (JICA 2002).
- *Ownership* Public lands should be preferred as a priority. Empty areas and open car parks that are privately owned can be selected considering the accessibility, usability, continuity, and spatial size it creates together with road axes and other assembly points. Structures such as public schools and mosques in all neighborhoods can also be used as assembly areas if they are seismically sufficient (JICA 2002).
- *Spatial dimensions* In the (JICA 2002) report, it has been suggested that the places referred to as "Preliminary Evacuation Areas" should be in each neighborhood unit, with a minimum gross allocation of 1.5 m^2/person. The study of Tarabanis and Tsionis (1999) suggested that the net usable area per capita in the assembly points be determined as a /minimum of 2 m^2 based on the building block.

The uncontrolled expansion stemming from escalating urban populations and pressures has sparked a surge of interest in research concerning emergency gathering points and temporary shelter sites, which prove crucial both during and following disasters. Scholars have sought to address these vital aspects through comprehensive investigations. Spyridaki et al. (2009), for instance, devised a multi-stage analysis employing ArcGIS tools to delineate the road network offering the fastest and most accessible routes to open and green spaces following earthquakes.

In 2021, Aşıkkutlu et al. (2021) delved into an evaluation of the adequacy of the Emergency Assembly Point in Burdur, Turkey. Meanwhile, Çınar et al. (2018) conducted an assessment of the emergency assembly points established by the Disaster and Emergency Management Presidency (AFAD) in Izmir, analyzing their adequacy and alignment with international standards through the Izmir Disaster Response Plan (IZAMP) and the Turkey National Disaster Response Plan-Izmir (TAMP).

In the same year, Şenik and Uzun conducted a detailed analysis of emergency assembly points and temporary shelter locations in Düzce, a region that experienced a magnitude 7.2 earthquake in 1999. Similarly, Bektaş and Sakarya conducted an assessment in 2020 focusing on the sufficiency and management of emergency assembly points in Istanbul, renowned as one of the world's most densely populated metropolises, and across Turkey. These collective endeavors underscore the critical importance of well-organized and accessible emergency response infrastructure in densely populated urban centers.

An observation of recent studies pertaining to the suitability and management of emergency assembly points and temporary shelter sites reveals a notable prevalence of research originating in Turkey. This prominence can be attributed to Turkey's seismic activity, as the nation is situated in a seismically active region. Over the past century, Turkey has experienced 16 earthquakes with magnitudes reaching 7, with a tragic toll of 120,000 lives lost. These seismic events have underscored the urgency of formulating disaster plans both during and after such occurrences.

Consequently, there has been a growing emphasis on studies addressing the resilience of cities in geographies prone to disasters. Such studies hold the potential to mitigate the adverse impacts of calamities. The present study delves into the significance of utilizing urban open and green spaces as emergency gathering points in Elâzığ, a city located in eastern Turkey and positioned atop the East Anatolian Fault Zone. The focus is on augmenting urban resilience. Additionally, an examination was undertaken to evaluate the dimensions, quantities, and accessibility of temporary shelter areas capable of providing short-term refuge following a disaster.

Within this framework, the study aims to assess the integration of open and green spaces into the existing urban fabric, as well as the designated emergency assembly points and temporary shelter locations designated by the Disaster and Emergency Management Presidency (AFAD). The evaluation takes place on a neighborhood scale, emphasizing their applicability and effectiveness both during and after disasters. This comprehensive analysis endeavors to contribute to the enhancement of urban resilience in the face of potential disasters.

2 Study area

The city of Elazig is situated in the eastern part of Turkey, specifically within the Upper Euphrates Section of the Eastern Anatolia Region, as depicted in Fig. 1. The city's geographical characteristics, found within the Elazig Plain, have played a pivotal role in its establishment and growth. Elâzığ is a relatively young urban center that emerged as a continuation of a historical settlement known as Harput. The city experienced rapid expansion,

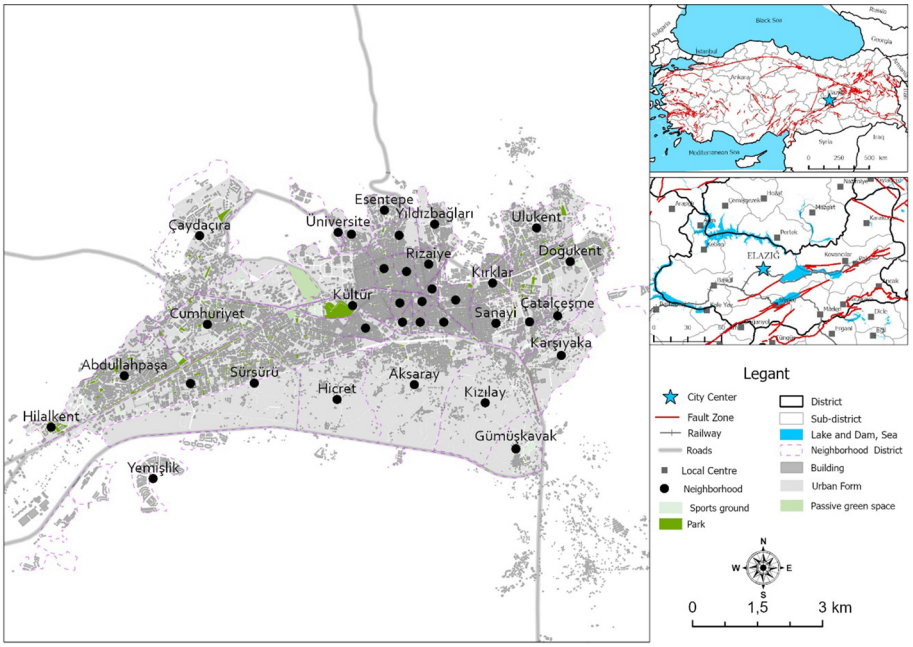

Fig. 1 Elazig city and its surrounding's fault zone

particularly after the 1950s. What initially started with 5 neighborhoods has progressively increased over time, culminating in a total of 38 neighborhoods. Presently, the population of Elazig stands at 381,153 people, contributing to the city's dynamic urban landscape.

Throughout its historical timeline, the region encompassing Elâzığ and its vicinity, positioned atop the Eastern Anatolian Fault Zone, has borne witness to numerous seismic events. Among these, an earthquake of magnitude Mw 6.8 transpired on January 24, 2020, at 08:55 pm Turkish time. The epicenter of this earthquake was located in Sivrice (Elâzığ). With a depth of 8.06 km below the surface, this seismic event profoundly impacted nearby settlements, including Elazig (36.47 km), Malatya (65.55 km), Tunceli (92.15 km), Adıyaman (96.4 km), and Diyarbakır (112.62 km) cities (Earthquake Department 2020).

In the aftermath of this earthquake, the Ministry of Environment and Urbanization spearheaded damage assessment endeavors within Elazig's city center. As part of these assessments, a total of 51,792 buildings underwent examination. The findings of these evaluations revealed that 45% of the buildings remained undamaged, 27.4% suffered slight damage, 2.7% were moderately damaged, and 11.8% experienced substantial damage (Demirtaş et al. 2021). These statistics underscore the substantial impact of seismic events on the built environment and the need for comprehensive disaster preparedness and management strategies in earthquake-prone regions.

Following the earthquake, a total of 132 shelter sites were established to accommodate the citizens impacted by the seismic event. These facilities encompassed a range of venues, such as school buildings, public guesthouses, sports facilities, and collective tent areas, as coordinated by AFAD (2023). Moreover, the city's open and green spaces played a significant role in offering communal tent sites and container cities to house those affected.

In addition to these provisions, 95 emergency assembly points were designated for use after the earthquake. These assembly points were strategically located at safe distances from structural hazards and potential risks, thereby enhancing their effectiveness in times of crisis (Fig. 2). This coordinated effort in utilizing various spaces underscores the critical importance of flexible and adaptable disaster response plans, leveraging a diverse array of resources to support affected populations.

3 Materials and methods

Public green spaces serve as places of exercise, leisure, entertainment, education, and culture for the general public, including urban parks, green squares, and other open green spaces (Dai 2011). At the same time, these areas are the emergency assembly and sheltering areas of the people during disaster periods.

The study focuses on the analysis of emergency gathering locations that are strategically distanced from structural vulnerabilities and potential hazards, as identified by the local government of Elâzığ to serve urban residents. Within this scope, several potential sites were excluded from consideration, including areas like the front of mosques, the gardens within complexes, bus station gardens, junction points, and unused land parcels. Following this refinement, a total of 95 emergency assembly points were identified within the city center.

The acquisition of pertinent information regarding these areas relied on the collection of two types of data. The first entailed a list of city parks and green spaces compiled by the Municipality of Elâzığ, while the second consisted of spatial data pertaining to these areas within the urban landscape. To integrate and correlate these datasets, the Spatial Join

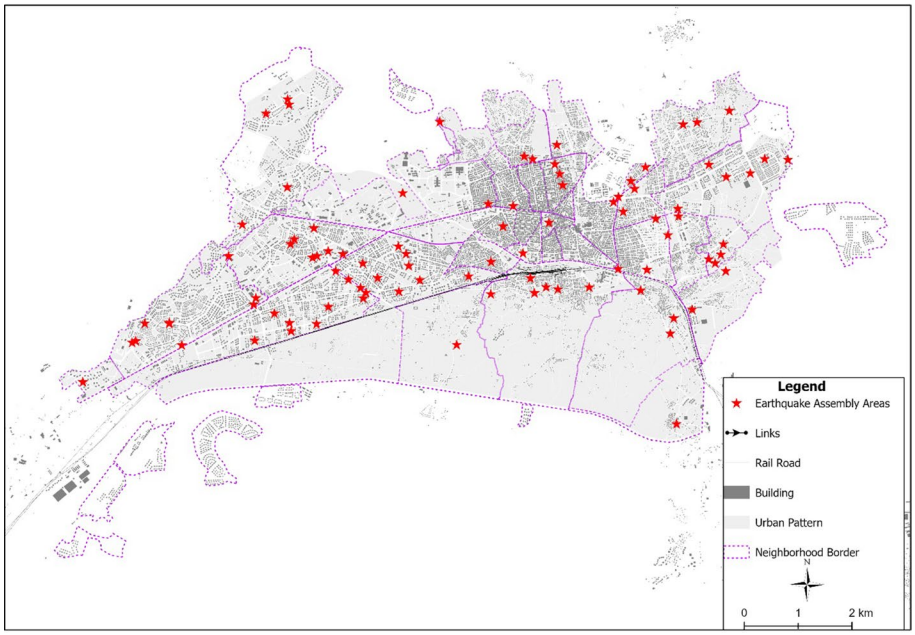

Fig. 2 Emergency assembly points in the city of Elazig

tool available in ArcGIS Pro 2.9.3 was employed. This process facilitated the amalgamation of information, ultimately furnishing comprehensive spatial data concerning open and green assembly locations designated for emergencies and disaster response. This meticulous approach underscores the importance of precision in data collection and analysis for effective urban disaster management planning.

To assess the impact of the designated open and green spaces as emergency assembly points on urban resilience, various criteria were taken into account, including accessibility, connectivity to road networks, usability, and area dimensions. In pursuit of this evaluation, the ArcGIS Pro software (ESRI 2021) was harnessed to ascertain the spatial distribution of the identified open and green spaces designated as emergency assembly points within the city. Furthermore, the software enabled an examination of the accessibility of these areas.

In this endeavor, the Service Area Analysis functionality was employed to ascertain the reach and accessibility of these spaces both during and in the aftermath of a disaster scenario (Fig. 3). By utilizing this analytical approach, the study sought to gauge how effectively the selected open and green areas could be accessed and utilized as gathering points during emergency situations, thereby contributing to the overall resilience of the urban environment. This data-driven methodology aligns with the goal of leveraging geographic information systems to enhance disaster response planning and urban resilience.

The initial phase of the service area analysis involves the incorporation of Elazig's primary and secondary road networks into the database, followed by the computation of travel times predicated on these roadways. In contemporary literature, it is generally recommended that a healthy individual's walking time to urban green spaces should average around 15 min (Özdede et al. 2021). Nevertheless, specific accessibility standards for areas designated as assembly points during disasters and emergencies remain to be clearly defined.

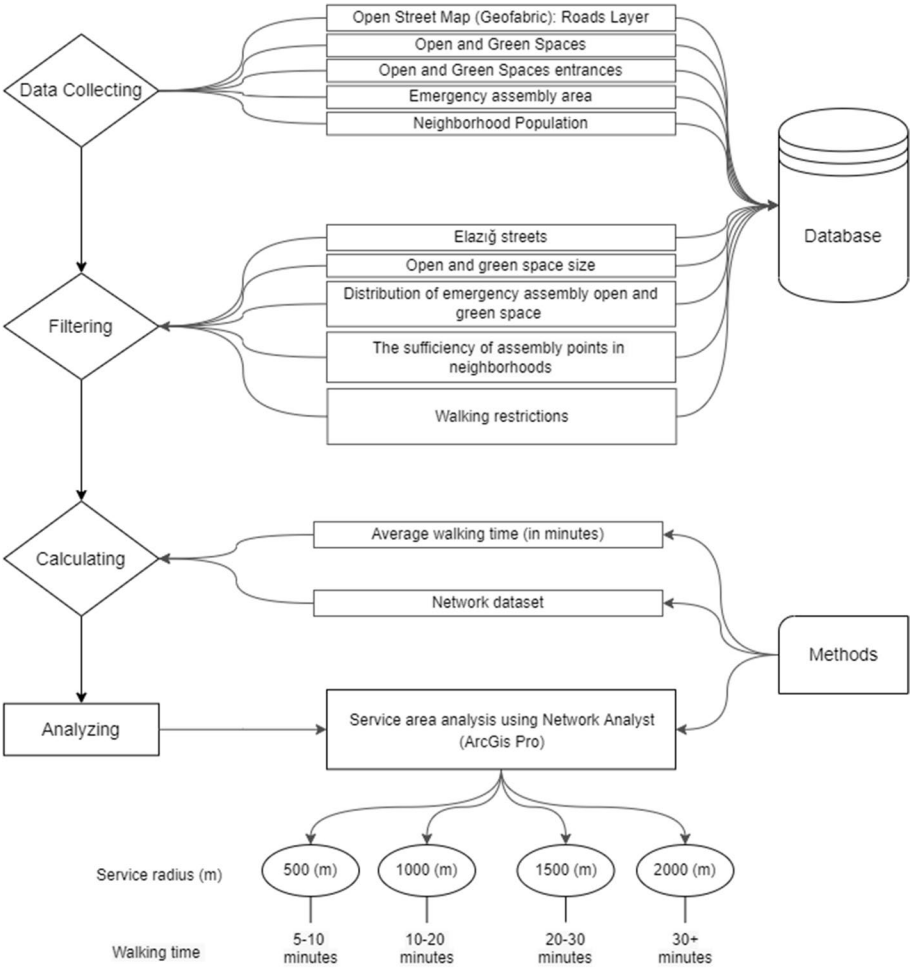

Fig. 3 Method and stages of the study

Furthermore, the size of the site designated for post-disaster utilization holds crucial importance. For instance, Shere (Sphere Association 2018) has underscored that the living area per person (excluding spaces like cooking areas, bathrooms, and WC) should amount to a minimum of 3.5 square meters. In colder climates or densely populated urban settings, this figure should be elevated to approximately 4.5–5.5 square meters per person. These dimensions provide a framework for ensuring adequate living conditions in such scenarios (Table 1).

Prior research endeavors have also yielded comprehensive criteria encompassing aspects such as area size, scope (ranging from neighborhoods to cities and regions), coverage area, and population capacity (Şenik and Uzun 2021). By consolidating such considerations, these studies have contributed to the development of a robust set of standards aimed at enhancing the effectiveness and resilience of emergency assembly points during and following disasters.

Table 1 Shelter types and standards for open green space occupancy in disasters (Developed based on Zhu et al. 2016; Liangxin et al. 2012; Sphere Association 2018; Şenik and Uzun 2021; Tong et al. 2012)

Shelter type	(m^2 per person)	Service radius (m)	Walking time	Population	Area (m^2)
Emergency (Neighborhood scale)	1.5	300–500	5–15	300–500 houses, 1500–2000	100–5000
Temporary (urban scale)	3.5	500–2000	15–30	–	5000–20.000
Long term (region scale)	9–10	> 2000	30–60	–	> 20.000

An index has been devised based on the outlined criteria. Using ArcGIS Pro version 3.0.2, the study classified the 95 emergency assembly points and 4 shelter areas into a comprehensive data network set. The analysis considered walking distance as the primary transportation mode, establishing service radii of 500 m for emergency assembly points at the neighborhood level and varying service radii (500 m, 1000 m, 2000 m, and 5000 m) for temporary shelter areas at the city level. These radii define the effective reach of these sites, ensuring their suitability for emergency gathering and shelter needs.

4 Results and discussions

4.1 Adequacy of emergency assembly points

The identification of suitable gathering areas for people in the event of a disaster is crucial for swiftly and efficiently organizing individuals to address their response needs. This includes facilitating rapid communication, locating missing persons, and coordinating essential search and rescue operations (Gerdan and Şen 2019). Within this context, information regarding emergency assembly points, which were updated after the Elazig earthquake on January 24, 2020, has been compiled in Table 2. This compilation aligns with the criteria and components detailed in the methodology section.

The spatial arrangement and adequacy of the designated emergency assembly points are graphically presented in Fig. 4. This visualization underscores the distribution of these areas and their capacity to fulfill their intended roles in emergency scenarios. The comprehensive approach employed in this study seeks to enhance disaster preparedness and response strategies, ultimately contributing to the resilience of urban environments.

The emergency assembly points encompass a diverse array of locations, with parks comprising a significant portion, alongside other spaces like city squares, market areas, green spaces, and educational zones. Notably, the distribution analysis revealed that 48.9% ($f=45$) of these points are situated in proximity to the main street, while the remaining 51.1% ($f=47$) are positioned away from the main street and connecting nodes (Table 3). This division underscores that approximately half of the city could face transportation challenges following a disaster event. While all assembly points are accessible by foot, the study highlights a conqueringly low percentage (14%, $f=13$) in which necessary measures for transportation of disabled individuals have been taken. The available infrastructure for accommodating disabled individuals is found to be deficient.

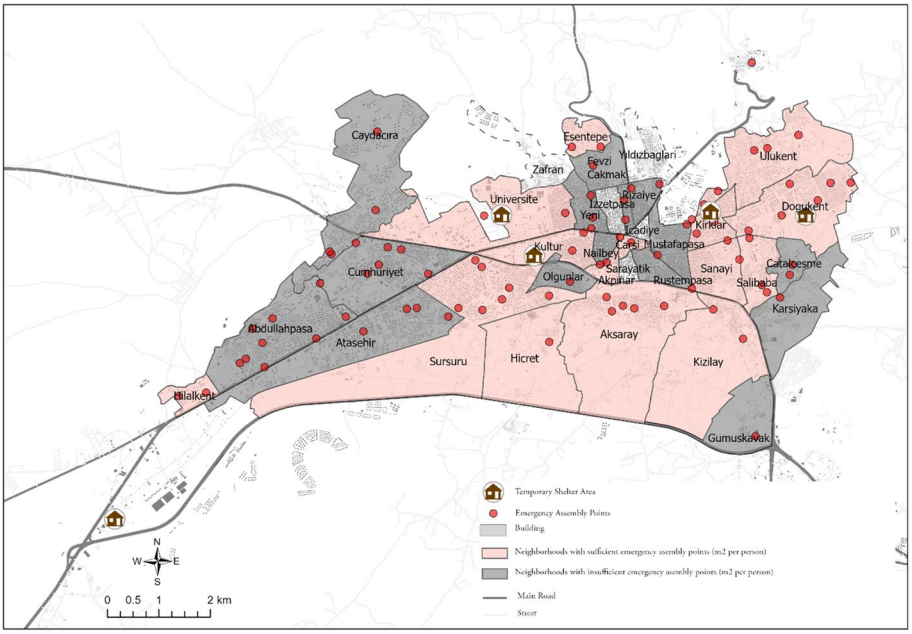

Fig. 4 Spatial distribution and adequacy status of areas designated as emergency assembly points

Nevertheless, a resilient and sustainable city should aim to provide equitable services for all stakeholders. All the designated assembly points are equipped with electricity and water lines, and 32.6% ($f=30$) of these locations include restroom facilities. However, the limited number of restrooms could potentially lead to challenges in addressing both immediate physical needs post-disaster and the potential outbreak of epidemic diseases. Addressing this concern, the study emphasizes the necessity of increasing the number of restrooms in Elazig's assembly points to ensure hygienic conditions for survival. This comprehensive evaluation underscores the importance of creating inclusive and well-equipped assembly points to enhance disaster response and overall urban resilience.

In accordance with international standards set by various organizations, the recommended area per person for emergency assembly points is 2 square meters. In Elazig, 67.4% ($f=62$) of the designated disaster and emergency assembly points fall short of this requirement. Specifically, 31.5% ($f=29$) of these sites offer a mere 0 to 0.99 square meters per person, while 35.9% ($f=33$) provide 1 to 1.99 square meters per person. Conversely, 32.6% ($f=30$) of the emergency assembly points exceed the 2 square meter standard.

Notably, neighborhoods boasting the highest number of open and green spaces per capita include Akpinar, Aksaray, Carsi, Dogukent, Hilalkent, Kizilay, Kultur, Salibaba, and University neighborhoods. This prevalence is attributed to the presence of two sheltering areas in the Dogukent District and a recreational space within the University District's boundaries. Conversely, neighborhoods with the lowest area per capita tend to be densely populated. The observation that only one-third of Elazig's emergency assembly points meet the recommended width standard is a concerning aspect with regard to resilience. Insufficient space could lead to disorder and heightened panic in the aftermath of a disaster.

To bolster the city's resilience, it is imperative to rectify the inadequacy of emergency assembly points by increasing their size to the international standard of 2 square meters per

Table 2 Information on emergency assembly points, which were updated after the Elazig earthquake

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Abdullahpaşa district	Saraybosna Street, Botanical Park	Green space	17,192	Park	Public	Available	Available	Available	Available	Available	36,973	22,193	0.6	Not available
	Tofas Junction	Open area	1043	Intersection	Public	Available	Available	Available	Available	Not available				
	Malatya Street	Green space	1527	Walking Path	Public	Available	Available	Available	Available	Not available				
	272. Street, Karanfil Street	Green space	3092	Park	Public	Available	Available	Available	Available	Not available				
	322. Street	Green space	2388	Park	Public	Available	Available	Available	Available	Available				
	Fethi Ahmet Baba Boulevard, Market Area	Open area	6130	Marketplace	Public	Available	Available	Available	Available	Available				
	300th Street	Open area	1798	Open area	Public	Available	Available	Available	Available	Not available				
	247. Street, Lokman Tasalı Park	Green space	3803	Park	Public	Available	Available	Available	Available	Not available				
Akpınar district	Susam Street	Green space	1701	Sports Field	Public	Available	Available	Available	Available	Not available	1701	3495	2.1	Available

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Aksaray district	K.Tuncel Sokak, Shht. Omer Ozdemir Park	Green space	10,758	Park	Public	Available	Available	Available	Available	Available	28,159	7107	4	Available
	Gazi Haci Sukru Al Park	Green space	1982	Park	Public	Available	Available	Available	Available	Available				
	Ceylan Street	Green space	1448	Park	Public	Available	Available	Available	Available	Not available				
	Kuvai-Milliye Caddesi, Çitlenbik Park	Green space	3266	Park	Public	Available	Available	Available	Available	Not available				
	Nakkaşlar Street	Green space	2813	Park	Public	Available	Available	Available	Available	Not available				
	Nakkaşlar Street	Green space	3286	Park	Public	Available	Available	Available	Available	Not available				
	Nöbettci Street	Green space	4606	Park	Public	Available	Available	Available	Available	Not available				

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Cumhuriyet district	Selim Hazardagli Street, Mimoza Park	Green space	4720	Park	Public	Available	Available	Available	Available	Not available	41,024	28,718	1.4	Not available
	170th Street	Green space	1498	Park	Public	Available	Available	Available	Available	Not available				
	Gazi Osmanpasa Street, Feslegen Park	Green space	1749	Park	Public	Available	Available	Available	Available	Not available				
	Menderes Street, City. Police Faruk Demir Park	Green space	10,270	Park	Public	Available	Available	Available	Available	Not available				
	Vedat Dolakay Street	Green space	7933	Green spaces	Public	Available	Available	Available	Available	Available				
	Zarif Street, Azerbaijan Park	Green space	5345	Park	Public	Available	Available	Available	Available	Available				
	Ahmet Asya Street, Chingiz Aitmatov Park	Green space	2259	Park	Public	Available	Available	Available	Available	Not available				
	Beyzade Efendi Street, Edip Cengiz Eker Park	Green space	2372	Park	Public	Available	Available	Available	Available	Not available				
	Malatya Street, Next to Elazig Municipality	Open area	4878	Open area	Public	Available	Available	Available	Available	Available				
Çarşı district	Hürriyet Street, Post Office Square	Open area	3597	Town Square	Public	Available	Available	Available	Available	Not available	4543	1020	4.5	Available
	Tüfenkciler Street	Open area	946	Town Square	Public	Available	Available	Available	Available	Not available				
	Aksaray Street	Green space	0	Park	Public	Available	Available	Available	Available	Not available				

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Çatalçeşme district	Dogukent Street	Green space	1866	Park	Public	Available	Available	Available	Available	Available	3073	4623	0.7	Not available
	Cennet Street	Green space	1207	Park	Public	Available	Available	Available	Available	Not available				
Çaydaçıra district	Haciomer Bilgin Boulevard	Green space	11,490	Park	Public	Available	Available	Available	Available	Not available	18,299	32,170	0.6	Not available
	Adnan Kahveci Boulevard	Open area	6809	Open area	Public	Available	Available	Available	Available	Available				
Dogukent district	Prof. Dr. Mustafa Temizer Boulevard	Green space	26,119	Sports Field	Public	Available	Available	Available	Available	Available	151,399	21,569	7	Available
	Istiklal Street	Green space	14,451	Park	Public	Available	Available	Available	Available	Available				
	Itri Street	Green space	6019	Park	Public	Available	Available	Available	Available	Available				
	Seyyah Sokak, Under Selimiye Mosque	Green space	12,611	Green space	Public	Available	Available	Available	Available	Not available				
	Atmaca Street	Green space	2295	Park	Public	Available	Available	Available	Available	Available				
	Prof. Dr. Mustafa Temizer Boulevard	Housing Area	87,145	Open area	Public	Available	Available	Available	Available	Not available				
	Ahmet Yesevi Street, Hanedan Wedding Hall	Open area	2759	Wedding hall	Public	Available	Available	Available	Available	Available				
Esentepe district	Dogus Street	Green space	1821	Park	Public	Available	Available	Available	Available	Not available	1821	1064	1.7	Available

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Fevzi Çakmak district	Tunc Street	Open area	1428	Open area	Public	Available	Available	Available	Available	Not available	2362	6333	0.4	Not available
	Dogus Street	Open area	934	Open area	Public	Available	Available	Available	Available	Not available				
Gümüş Kavak district	Kazim Karabekir Street	Green space	1167	Green space	Public	Available	Available	Available	Available	Not available	1167	1651	0.7	Not available
Harput district	Harput District, Meydan	Open area	3051	Town Square	Public	Available	Available	Available	Available	Available	3051			
Hicret district	Şehit Yarbay Ruşen Sağlamlı Sokak, Özge Park	Green space	2626	Park	Public	Available	Available	Available	Available	Not available	8617	5010	1.7	Available
	Irmak Street	Open area	3117	Open area	Public	Available	Available	Available	Available	Not available				
	Tadım Yolu Street	Green space	2874	Park	Public	Available	Available	Available	Available	Not available				
Hilalkent district	400th Street, Walkway	Green space	5824	Sports Field	Public	Available	Available	Available	Available	Not available	17,159	4325	4	Available
	405th Street	Open area	11,335	Marketplace	Public	Available	Available	Available	Available	Available				
Karşıyaka district	Infinitive Street	Open area	1538	Open area	Public	Available	Available	Available	Available	Not available	1538	3562	0.4	Not available

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Kırklar district	Bahaeddin Element Street, Wednesday Market	Open area	1084	Marketplace	Public	Available	Available	Available	Available	Not available	14,464	16,967	0.9	Not available
	Ela Street	Open area	2096	Open area	Public	Available	Available	Available	Available	Not available				
	Dogukent Grand Junction	Open area	6826	Intersection	Public	Available	Available	Available	Available	Not available				
	Yatir Street	Green space	4458	Park	Public	Available	Available	Available	Available	Not available				
	Ulukent Street	Housing Area	0	Sports Field	Public	Available	Available	Available	Available	Available				
Kızılay District	Gökkusagi Street	Green space	1369	Park	Public	Available	Available	Available	Available	Not available	6119	2810	2.2	Available
	Kazım Karabekir Street, Under the water tank	Open area	4750	Water tank	Public	Available	Available	Available	Available	Not available				
Kültür District	Dal Street, Hamit Aydın Park	Green space	1183	Park	Public	Available	Available	Available	Available	Not available	171,303	9923	17.3	Available
	Gazi Street	Open area	15,426	Town Square	Public	Available	Available	Available	Available	Available				
	Vali Fahri Bey Street	Housing Area	154,694	Recreation Area	Public	Available	Available	Available	Available	Available				
Mustafapaşa District	Fikret N. Street, Mustafa Temizer park	Green space	5472	Recreation Area	Public	Available	Available	Available	Available	Available	7043	11,138	0.6	Not available
	Ali Riza Septioglu Boulevard	Open area	1571	Open area	Public	Available	Available	Available	Available	Not available				

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Nailbey District	Şehir İdris Doğan Street, Pamukkale Park	Green space	382	Park	Public	Available	Available	Available	Available	Not available	382	7428	0.1	Not available
Olgunlar District	Adali Sokak, Bal Park	Green space	1073	Park	Public	Available	Available	Available	Available	Not available	1073	11,824	0.1	Not available
Rızaiye District	Mehmet Akif Ersoy Street	Green space	3421	Park	Public	Available	Available	Available	Available	Not available	16,647	12,036	1.4	Not available
	İnönü Street	Open area	5077	Car park	Public	Available	Available	Available	Available	Not available				
	Star Street	Open area	5907	Car park	Public	Available	Available	Available	Available	Not available				
	Borat Street	Open area	2242	Car park	Public	Available	Available	Available	Available	Not available				
Salı Baba District	Yaşar Doğu Street	Green space	4684	Park	Public	Available	Available	Available	Available	Not available	8636	2886	3	Available
	Umran Street	Open area	2021	Open area	Public	Available	Available	Available	Available	Not available				
	Dogan Cay Street	Green space	1931	Park	Public	Available	Available	Available	Available	Not available				
Sanayi District	Cahit Dolokay Boulevard	Open area	1844	Intersection	Public	Available	Available	Available	Available	Not available	20,290	12,966	1.6	Available
	21st Street	Green space	14,287	Green space	Public	Available	Available	Available	Available	Not available				
	Ali Riza Septioglu Boulevard	Green space	4159	Intersection	Public	Available	Available	Available	Available	Not available				

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Sürsürü District	Mustafa Uygur Boulevard	Green space	5703	Park	Public	Available	Available	Available	Available	Available	47,419	26,749	1.8	Available
	Çaydaçıra Junction Public Garden	Green space	28,988	Recreation Area	Public	Available	Available	Available	Available	Available				
	Yaşam Street	Green space	1879	Park	Public	Available	Available	Available	Available	Not available				
	Halit Hoca Efendi Bulvarı, Shht. Hasan Yıldır Park	Green space	2405	Park	Public	Available	Available	Available	Available	Not available				
	Halit Hoca Efendi Boulevard	Green space	4584	Park	Public	Available	Available	Available	Available	Not available				
	Sokullu Street	Green space	3440	Park	Public	Available	Available	Available	Available	Not available				
	Salur Street, Defne Park	Green space	420	Park	Public	Available	Available	Available	Available	Not available				
Ulukent District	Veysel Karani Street, Next to Mehmet Gülaçtı School	Green space	32,821	Education Area	Public	Available	Available	Available	Available	Available	38,167	19,806	1.9	Available
	Tahir Şaşmaz Street	Green space	2218	Park	Public	Available	Available	Available	Available	Available				
	Tahir Şaşmaz Street	Green space	2403	Park	Public	Available	Available	Available	Available	Not available				
	Ugurlu Street	Green space	725	Park	Public	Available	Available	Available	Available	Not available				

Table 2 (continued)

District	Location	Usage type	Area (m^2)	Zoning situation	Ownership	Transport		Infrastructure			Total area (m^2)	District population	Area per person > $2m^2$	Compliance with standards
						Highway	Pedestrian (500 m)	Electric	Water	WC				
Üniversite District	Recreation Area	Green space	186,283	Recreation Area	Public	Available	Available	Available	Available	Available	194,382	16,237	12	Available
	Kenar Street	Open area	1023	Open area	Public	Available	Available	Available	Available	Available				
	Firat University Rectorate Campus	Housing Area	7076	Education Area	Public	Available	Available	Available	Available	Available				
Yemişlik District	Malatya Road	Housing Area	81,356	Open area	Public	Available	Available	Available	Available	Available	81,356			Available
Yeni district	Gazi Caddesi, Oz. Har. Police Abu Bakr Durmus Park	Green space	6838	Park	Public	Available	Available	Available	Available	Not available	9065	16,958	0.5	Available
	Namik Farmer Street	Green space	1786	Park	Public	Available	Available	Available	Available	Not available				
	Architect Faruk Street	Open area	441	Open area	Public	Available	Available	Available	Available	Not available				

Table 3 Availability of assembly points

	Convenient assembly point		Inconvenient assembly point	
	f	%	*f*	%
Transport				
Facade by main street	45	48.9	47	51.1
Highway			92	100
Sidewalk (500 m)			92	100
Disabled road	13	14.1	79	85.9
Infrastructure				
Electric			92	100
Water			92	100
WC	30	32.6	62	67.4
Area per capita (m^2)				
0–0.99 m^2			29	31.5
1–1.99 m^2			33	35.9
2–2.49 m^2	1	1.1		
2.50 m^2 high	29	31.5		

person. This approach ensures a more effective response to emergencies, mitigating potential chaos and enabling a calmer and more organized disaster response.

4.2 Analysis of accessibility of emergency assembly points using the neighborhood scale travel mode

Given that transportation to emergency assembly points post-disaster would primarily rely on foot, the imperative is to ensure swift and efficient access to these locations. Figure 5 illustrates the accessibility radius of the service area reachable by foot, juxtaposed with the designated emergency assembly points within the city center of Elazig. In this analysis, a walking distance of 500 m was utilized to gauge accessibility within the study area during and after a disaster event. The results reveal that the closest assembly points are strategically positioned near residential areas dispersed throughout the city, enhancing their accessibility during emergencies and disasters.

However, the analysis also highlights the challenge of low accessibility in densely populated neighborhoods. Notably, Çaydaçıra Neighborhood, accommodating a population of 32,170, features only two assembly points. With a total area of 18,299 square meters, the existing assembly points suffer from limited accessibility. Furthermore, a shortage of gathering areas is evident in the outskirts of the city. To address this issue and enhance accessibility, there is a pressing need to establish additional assembly points. This strategic intervention would involve reducing the distance between assembly points within the city to less than 500 m, thereby ensuring that a greater number of residents have access to safe gathering areas during critical times.

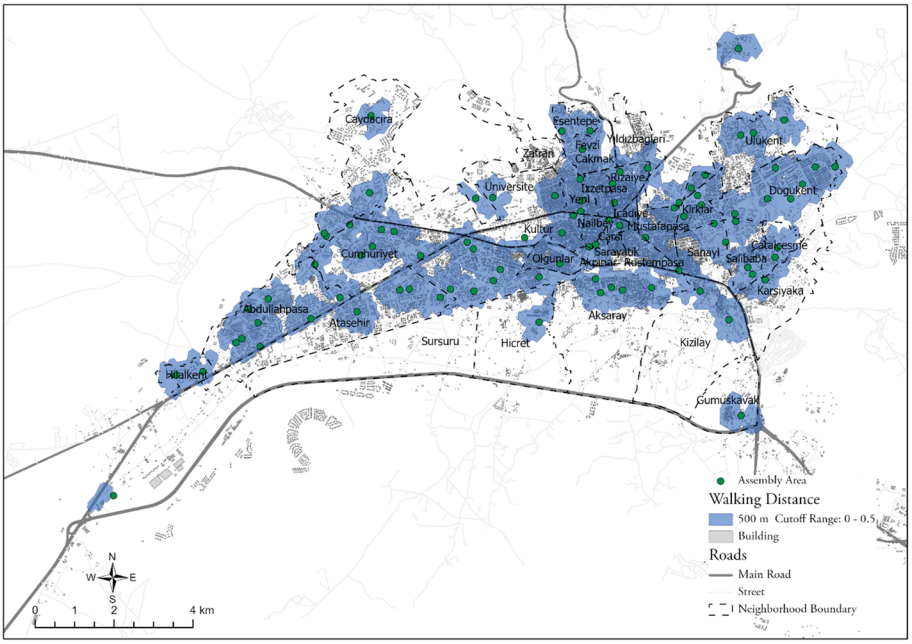

Fig. 5 Accessibility radius of service area accessible on foot and emergency assembly points in Elâzığ city center

4.3 Accessibility analysis of temporary shelter areas

Currently, the study area encompasses four designated temporary shelter areas, situated in and around the city. Based on the latest data from TUIK in 2023, the city center is home to a population of 381,158 individuals. The aggregate area of the existing temporary shelter locations in the city totals 344,420 square meters (Table 4). However, city-wide temporary shelter standards stipulate a requirement of 3.5 square meters per person. In the current context, this ratio stands at 0.90 within the established temporary shelter areas.

Conversely, to fulfill the city's temporary shelter needs, a substantial area of 982,557 square meters is necessary. Consequently, there arises a crucial necessity to augment both the number and size of shelter areas. Expanding the provision of temporary shelters holds immense significance, particularly as these shelters can offer enhanced protection against shifting climatic conditions in the aftermath of a disaster. Furthermore, the inadequacy of shelter facilities could precipitate negative psychological consequences alongside the evident

Table 4 Accessibility analysis of temporary shelter areas

Temporary shelter area	Neighborhood	Area (m^2)	Urban population	Situation
Doğukent temporary shelter area	Doğukent	87,145	381,158	Insufficient
Kırklar temporary shelter area	Kırklar	21,225		Insufficient
Kültür Tent city	Kültür	154,694		Insufficient
Yemişlik temporary shelter area	Yemişlik	81,356		Insufficient
Total area		344,420		

physical hardships for those displaced from their homes. To address these challenges, a comprehensive strategy should involve increasing both the quantity and scale of temporary shelter areas, affording greater resilience and psychological well-being for the affected populace.

The city of Elazig encompasses an approximate area of 80 square kilometers. For the purpose of evaluating access to existing temporary shelters and tent cities, a service area analysis was conducted using the criteria of 500 m, 1000 m, 2000 m, and 5000 m (Table 5). The outcomes of the analyses demonstrate the extent of accessibility based on these radii.

Within a radius of 0-500 m from the temporary shelter areas, access is provided to a total area of 2.22 square kilometers. This coverage expands to a larger area of 6.97 square kilometers within a radius of 500–1000 m, further increasing to 31.05 square kilometers within a radius of 1000–2000 m. The greatest coverage is observed within a radius of 2000–5000 m, encompassing a substantial area of 119 square kilometers from which temporary shelters can be accessed.

This analysis offers insights into the spatial distribution and extent of accessibility to temporary shelters and tent cities across varying distances. It serves as a valuable tool for informing disaster preparedness and response strategies within the city, ensuring that a comprehensive and effective network of accessible shelter areas is in place to address the needs of the population during critical times.

The design considerations of an evacuation site plan take into account crucial factors such as the evacuation time required during various disaster scenarios, whether natural (e.g., earthquakes, floods, landslides) or artificial (e.g., terrorist attacks, accidents, fires) (Coutinho-Rodrigues et al. 2016). Examining Fig. 6 reveals the distribution of access to temporary shelter areas based on different walking distances in Elazig.

In areas within a 5 to 10-min walking distance from temporary shelter areas, access covers 2.4% of the city's area. This coverage expands to 8.2% within distances of 10–20 min, and further to 36.3% for distances between 20 and 30 min. For areas requiring more than 30 min of walking, access is available to the Doğukent temporary shelter

Table 5 Access to existing temporary shelters and tent cities (m/min)

Temporary shelter area	Neighborhood	Service radius (m)	Accessible area (m^2)	Walking time
Doğukent temporary shelter area	Doğukent	0–500	645,269	5–10
		501–1000	2,280,483	10–20
		1001–2000	8,043,520	20–30
		2001–5000	46,706,608	30+
Kırklar temporary shelter area	Kırklar	0–500	352,267	5–10
		501–1000	1,532,770	10–20
		1001–2000	8,547,977	20–30
		2001–5000	50,613,597	30+
Kültür Tent city temporary shelter area	Kültür	0–500	632,389	5–10
		501–1000	2,350,242	10–20
		1001–2000	10,480,962	20–30
		2001–5000	62,092,298	30+
Yemişlik temporary shelter area	Doğukent	0–500	295,598	5–10
		501–1000	403,590	10–20
		1001–2000	1,990,410	20–30
		2001–5000	19,798,079	30+

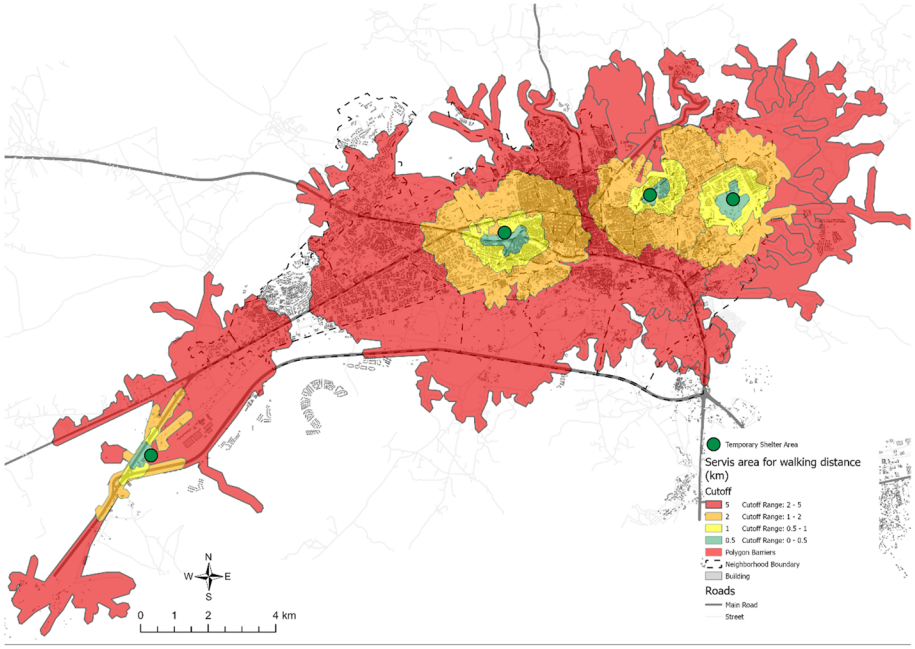

Fig. 6 Access to temporary shelters and tent cities (km/min)

area from 58.3% of the city, and to the Kırklar temporary shelter area from 63.25%. Notably, the Culture Tent City, situated centrally, emerges as the most accessible area, with 77.6% of the city within a 30-min walking distance. Conversely, the Yemişlik temporary shelter area, located outside the urban confines, proves to be the least accessible, with only 24.62% of the urban area reachable even after a 30-minute walk.

Considering that European Commission Urban Inspection Report (2000) recommends an average walking time of 15 min to urban green spaces, it becomes evident that measures need to be taken to enhance the accessibility of shelter areas. Increasing the number and capacity of these areas while reducing their accessible distances is crucial. Moreover, the selection of suitable locations for these areas should prioritize smooth and level terrain, accounting for the topographic conditions of the city. By aligning design choices with these principles, the city can enhance its disaster resilience and ensure that citizens have swift and safe access to shelter during critical times. According to the European Commission Urban Inspection Report (2000), the average walking time to urban green spaces should be 15 min. The most suitable transportation and walking distances according to the types of green areas; 400 m–10 min for kindergartens and playgrounds, 800 m–20 min for neighborhood-neighborhood parks, and 1200 m–30 min for city parks (Manlun 2003; Altunkasa 2004; Aydemir 2004; Önder and Polat 2012).

5 Conclusion

This study focused on assessing the suitability of emergency assembly points and temporary shelter areas within Elazig, a city situated in a high-risk area for various

disasters, particularly earthquakes, due to its location on the Eastern Anatolian Fault Zone. Recognizing the potential hazards, the examination aimed to mitigate potential damage by scrutinizing 95 emergency assembly points and 4 temporary shelter areas in the city. By conducting this analysis, the study successfully identified existing deficiencies in these critical zones, and subsequently proposed recommendations to enhance their effectiveness and resilience.

The analysis conducted has revealed significant shortcomings in the availability of disaster and emergency assembly points within Elazig. It was observed that more than half of these assembly points are situated away from main streets and connection points. Furthermore, the accessibility of disabled individuals to these crucial sites appears to be severely limited, which contradicts the principle of equitable distribution in resilient cities. The width of assembly points should ideally correspond to the population density of the neighborhoods they serve; yet, this alignment was found to be deficient in the research area. The insufficiency is also apparent in terms of the number and size of temporary shelter areas. Similar to the challenges faced by disaster and emergency assembly points, there are also issues related to access to temporary shelter areas. To ensure the development of a truly resilient city, it is imperative to increase both the quantity and capacity of these shelter areas, thereby addressing the current deficiencies.

The comprehensive study results indicate that no single neighborhood in Elazığ fulfills all the criteria pertaining to emergency assembly points and temporary shelter areas. Consequently, city administrators are urged to address this issue by prioritizing the enhancement of these critical facilities, especially in a city like Elazığ, which is prone to high seismic activity. In order to effectively mitigate the extent of destruction following a disaster and ensure long-term sustainability, it is imperative to adhere to the requisite standards and criteria for such essential infrastructure. By doing so, the city can better prepare itself to minimize the impact of disasters and ensure the safety and well-being of its residents.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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