



Analysis of emergency assembly points for post-earthquake disaster management: a case study of Erzincan, Türkiye

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Abstract

The selection of emergency assembly points within the urban area holds significant importance for ensuring swift and effective intervention in the aftermath of a potential disaster until temporary shelter areas are prepared. In both historical and instrumental periods, Erzincan (Türkiye) has experienced major earthquakes resulting in significant loss of life and property. The likelihood of similar earthquakes occurring in Erzincan in the future remains high. Therefore, it is necessary to identify safe areas where people can assemble after an earthquake, moving away from hazardous zones. The aim of this study is to analyse the capacities and adequacies of emergency assembly points, which constitute a step in disaster management and enhance the earthquake resilience of the city, using Geographic Information Systems (GIS) based on selected criteria (accessibility, spatial distribution, proximity to healthcare facilities, size, capacity adequacy, and proximity to fault avoidance zones), and to propose solutions. The assessment revealed that the available assembly points are not homogeneously distributed throughout the city and are inadequate to meet the available building and population density. Therefore, in addition to the available 38 emergency assembly points, 67 new alternative emergency assembly points have been identified. The proposed emergency assembly points (in the 75–100% range) increased the number of neighborhoods within the 250 m service area by 43.75% and 42.5% for 500 m. The findings underscore the necessity for more comprehensive and effective planning for Erzincan in the event of a potential disaster or emergency.

Keywords Emergency assembly points · Disaster management · Disaster resilience · Geographic information system

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1 Introduction

Disasters are events, whether natural or human-made (Bakhshian and Martinez-Pastor 2023; Makwana 2019; Noji 2005), that can affect entire communities or specific segments, resulting in physical, economic, and social losses, disrupting or halting normal life and human activities, damage to the environment and where the affected community's coping capacity is insufficient (AFAD 2023; Abid et al. 2021; Rambha et al. 2021; Yu et al. 2018). Various natural events such as earthquakes, tsunamis, hurricanes, floods, landslides, volcanic eruptions, and droughts constitute different types of disasters. Türkiye is frequently exposed to disasters due to meteorological, geological and topographic conditions (Gerdan and Şen 2020). Earthquakes, which are among the most catastrophic natural disaster (Xenidis and Kaltsidi 2022; Shrestha et al. 2018), are defined as complex elastic wave movements caused by the sudden release of energy accumulated in fractures in the Earth's crust, known as faults. Türkiye, located in one of the significant tectonic regions within the Alpine-Himalayan belt, is influenced by the displacement movements of the Eurasian, Arabian, and African plates due to its geographical location (Chang et al. 2024). Türkiye encompasses important and active tectonic structures such as the North Anatolian Fault Zone, East Anatolian Fault Zone, Aegean extensional region, and Bitlis-Zagros thrust belt (Bayrak 2022). Throughout history, large-scale earthquakes have occurred along these fault lines in Türkiye, resulting in significant loss of life and property in the aftermath of severe earthquakes (Çınar et al. 2018; Erdik et al. 2004; Steinberg and Cruz 2004; Karanci and Rüstemli 1995). One of these fault zones, the North Anatolian Fault Zone (NAFZ), which is a right-lateral strike-slip transform fault system separating the Eurasian and Anatolian plates, is one of Türkiye's active tectonic fault zones due to its exceptional morphological features and generation of destructive earthquakes. The NAFZ spans approximately 1400 km along the east–west part of Anatolia from Karlıova to the northern Aegean Sea (Şengör and Kidd 1979). NAFZ was first revealed with the Erzincan earthquake on December 27, 1939, and research on this fault zone has continued since then until today (Kıranşan 2022).

The Erzincan Plain, situated on the NAFZ, is a tectonic plain formed due to the movement of this fault. The fact that the city center is within this plain and close to this fault zone increases the risk of disasters. Therefore, earthquakes are the foremost concern in terms of natural disasters throughout the plain. According to the literature, the earthquake that occurred in Erzincan on December 27, 1939 ($M_s > 7.9$) is considered the largest earthquake to have occurred in Anatolia from the nineteenth century to the present day (Koçbulut 2023; Haçin 2014). This earthquake caused surface ruptures along an approximately 360 km-long line from Erzincan to Ezinepazar in Amasya (Koçbulut 2023; Dündar 2019; Gürsoy et al. 2013). The earthquake resulted in the loss of 32,968 lives and the collapse of 116,720 buildings (KOERI 2017; Haçin 2014). Additionally, another earthquake with a magnitude of M_s 6.8 occurred in Erzincan on March 13, 1992 (Aktar et al. 2004; Grosser et al. 1998; Fuenzalida et al. 1997). As a result of this earthquake, 653 people lost their lives, and 8,057 buildings were damaged or destroyed (Kurtuluş 1993).

The impact and magnitude of disasters are measured by the human losses, injuries, structural damages, and socio-economic losses they cause. It is not possible to prevent natural event. However, by being prepared through natural hazard perception, awareness and education, these events can be prevented from turning into disasters or their damages can be minimized (Chaudhary and Piracha 2021; Öztürk and Şahinöz 2018). One of the crucial tasks within the scope of pre-disaster precautions is the spatial identification of assembly

points during disasters and emergencies, and announcing these arpoints the public (Şirin and Ocak 2020).

One of the frequently observed behaviours during disasters is people's attempts to exit enclosed spaces and buildings due to the shock they experience. After any earthquake, it is observed that people instinctively move away from areas with dense building stocks, driven by the need for safety, and begin to gather in the nearest open and green spaces. (Partigöç 2023; Yıldız 2023; Nogami 2022; Zengin Çelik et al. 2018; Özyavuz et al. 2016). These areas serve as assembly or shelter zones during and after earthquakes, thus contributing to the establishment of safe urban spaces (Anhorn and Khazai 2015). Examples of such open green spaces include parks, playgrounds, recreational areas, sports facilities, squares, marketplaces, educational, and official facilities. Assembly points are spaces where disaster victims can safely reach and gather during disasters and emergencies without posing additional risks. Therefore, it is essential to select points that do not pose disaster risks and have the infrastructure to meet basic needs (Maral et al. 2015). However, the fundamental question here is whether the open green spaces used as emergency assembly points are adequately equipped to meet the needs after a disaster or emergency.

In Türkiye, there is no legislation regarding the criteria to be used in determining emergency assembly points (Uyar 2021). However, when examining the studies conducted, it is generally observed that five important criteria are taken into account for the identification and planning of these points (JICA and IMM 2002).

These criteria are as follows: (1) Accessibility: The maximum walking distance for individuals to reach assembly points from building blocks should be 500 m/15 min or less; (2) Connectivity with road axes: Assembly points should be connected to main arteries (taking into account the risk of closure of roads), and continuity with other assembly points should be ensured; (3) Usability and Multifunctionality: Existing active green spaces such as playgrounds, sports fields, pocket parks, neighborhood parks, small parks, and district parks; passive green spaces, turf fields; building gardens, schoolyards, mosque and hospital gardens; vacant lots, and open parking lots can be proposed as assembly points. The area should not be smaller than 500 m²; (4) Ownership: Public lands should be preferred. Vacant lots and open parking lots owned by private individuals can be preferred, taking into account accessibility, usability, road axes, continuity with other assembly points, and spatial size. Structures such as public schools, mosques, etc., present in all neighborhoods, can also be used as assembly points if they are seismically adequate; (5) Spatial Sizes: According to this criterion, emergency assembly points should be determined with a minimum gross area of 1.5 m² per person.

In Türkiye, when determining disaster and emergency assembly points by AFAD (Disaster and Emergency Management Presidency), attention is paid to selection criteria such as: (1) Population density; (2) Accessibility and ease of evacuation; (3) Accessibility for people with disabilities and the elderly as much as possible; (4) Being away from secondary hazards such as fire, flooding, tsunami, infrastructure, and others, and being located in areas not affected by liquefaction and away from fault lines; (5) Being as flat as possible without obstacles; (6) Being close to residential areas but not affected by structural and non-structural elements; (7) Proximity to facilities where basic needs such as electricity, water, toilets, etc. By paying attention to these criteria, suitable public places are selected to the greatest extent possible (Doğan 2023).

When examining the criteria for assembly points, it becomes evident that spatial characteristics are the most influential factor in determining these points. This result underscores the importance of basic infrastructure services in the area to enable disaster victims to quickly and easily reach these points and to meet their needs adequately. Following this

criterion, transportation and accessibility criteria are crucial for disaster victims and for the delivery of necessary assistance to the area. Additionally, the proximity of assembly points to residential areas and healthcare facilities is also important (Gökgöz et al. 2020). (Table 1).

This study aimed to evaluate the adequacy of available emergency assembly points and propose alternative assembly points for areas that are deemed inadequate and unable to meet the criteria, with the goal of enhancing the earthquake resilience of the city. The geographical coordinates of these assembly points are shown in Appendix Table 2. For this purpose, in case of a disaster or emergency that may occur in Erzincan, it has been investigated where suitable emergency assembly points can be located so that people living in the city center can gather quickly and accurately and be in safe areas until temporary shelters are prepared.

2 Study area

Erzincan is located in the northwest part of the Eastern Anatolia Region in the upper Fırat basin, between 39° 02' 40 05" north latitude and 38° 16' 40 45" east longitude (Fig. 1). Erzincan is bordered by Erzurum to the east, Sivas to the west, Tunceli to the south, Bingöl to the southeast, Elazığ and Malatya to the southwest, Gümüşhane and Bayburt to the north, and Giresun to the northwest. It has an area of 11,903 km², and the altitude of the city center is 1185 m above sea level (Erzincan Governorship 2024).

Erzincan and its surrounding areas are entirely within the boundaries of the first-degree earthquake zone. Therefore, both historical and instrumental periods have witnessed numerous earthquakes in the province of Erzincan. Throughout the instrumental period, seismic activity has persisted in Erzincan, with the most severe earthquakes with magnitude 5 and above occurring in 1939 (Ms: 7.9) and 1992 (Ms: 6.8) (Özşahin and Eroğlu 2019). These earthquakes in Erzincan and its surrounding areas indicate the potential for similar disasters in the future (Şengezer 1993). In this regard, to prevent panic among the affected population and to mitigate potential chaos following an earthquake, it is necessary to evacuate people from hazardous areas. For this reason, in collaboration with municipalities and AFAD (Disaster and Emergency Management Presidency), safe zones where the public can gather by moving away from hazardous areas should be identified to prevent panic and ensure healthy information exchange during the period until temporary accommodation centers are ready after disasters and emergencies.

Table 1 Number (*f*) of neighborhood for 250 m, and 500 m service area

	Available		Proposed	
	250 m service area <i>f</i>	500 m service area <i>f</i>	250 m service area <i>f</i>	500 m service area <i>f</i>
%0–24	57	47	32	22
%25–49	7	6	12	5
%50–74	2	3	13	6
%75–100	7	17	16	40

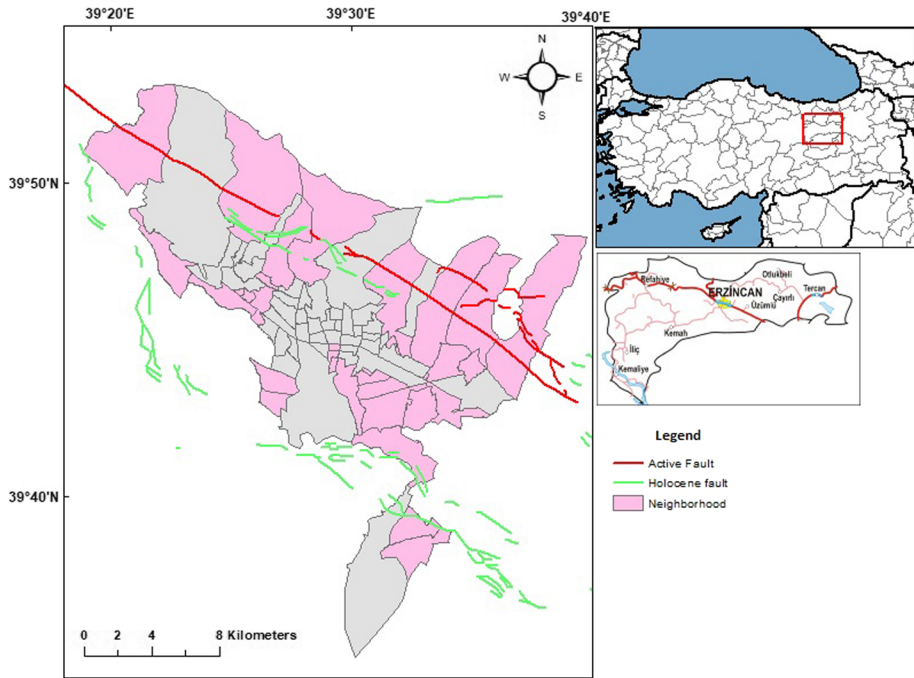


Fig. 1 Study area

In the central district of Erzincan province, an examination was made to assess the adequacy of the emergency assembly points determined by AFAD for this purpose and whether they meet the needs, and solutions were proposed for the points where deficiencies were identified.

3 Materials and methods

In the study, the suitability and adequacy of 38 emergency assembly points designated by AFAD in the central district of Erzincan for evacuation in the event of disasters and emergencies were analysed according to selected criteria. After conducting the analysis, deficiencies were identified, and solutions were proposed. The analysis and evaluation processes in the study were conducted using Geographic Information Systems (GIS). Figure 2 shows the workflow of the study.

Geographic Information Systems is a computer-based system that allows for the storage, processing, analysis, and visualization of spatial data. In GIS, non-spatial qualitative and quantitative data pertaining to the study area are added to attribute tables within the system and stored in the database (Reddy 2018; Wiczorek and Delmerico 2009; Wise 2002). GIS also enables querying and analysis of the stored data.

GIS software, which is widely used by various professional groups today, is utilized either as professionally licensed or open-source free software. In this study, QGIS, a completely free, most popular and open-source GIS software (Rosas-Chavoya et al. 2022), was used to integrate, relate, and analyse datasets within a database. This

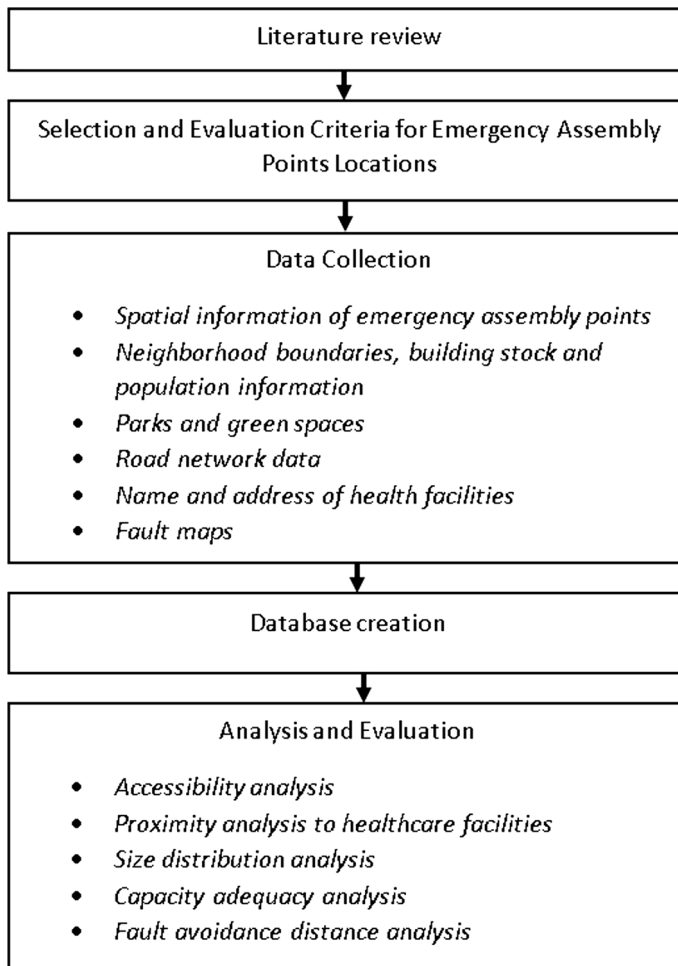


Fig. 2 A methodology schema

software was born under the name Quantum GIS in 2002 and was developed by Gary Sherman. The main purpose of the software is to provide an interface to visualize geo-spatial data (Moyroud and Portet 2018; Hugentobler 2008).

The involvement of developers and the process of adding code has transformed QGIS from being solely a spatial information viewer into a powerful Geographic Information System tool used by a wide range of users not only for visualization but also for organizing and performing complex spatial analyses (Khan and Mohiuddin 2018; Moyroud and Portet 2018). The program has facilitated the merging of data with different characteristics, ultimately resulting in the acquisition of new and comprehensive spatial data.

The first step of the study involved scanning the literature to identify criteria (accessibility, spatial distribution, proximity to healthcare facilities, size, capacity adequacy, proximity to fault zones) that would be used in the analysis of the suitability and adequacy of available emergency assembly points.

Following the determination of criteria, efforts were made to establish an up-to-date database. During the database creation process, data of different structures (vector, raster, and attribute information) and formats were converted into formats compatible with the QGIS program. The establishment of an updated database allowed for spatial analyses of the emergency assembly points in question, leading to the production of thematic maps. The data used in the database creation phase, including available and created data, is as follows:

- Vector data containing the emergency assembly points designated by the Erzincan Provincial Directorate of Disaster and Emergency Management,
- Vector data showing neighborhood boundaries, building stock within neighborhood boundaries, and neighborhood population information,
- Vector data produced as a result of digitizing the parks and green areas located throughout the city on the QGIS program and the attribute information (area, park name, etc.) of these points,
- Vector data containing urban road network. This data is divided into 4 classes (intercity roads, urban main roads, urban connector roads, and urban access roads) according to road widths,
- Vector data created by digitizing the healthcare facilities located throughout the province in the QGIS software,
- Vector data created by digitizing the raster map showing the fault lines passing through the city center in QGIS.

After the database was established, an analysis and evaluation study was conducted. Initially, the 38 emergency assembly points located in the city center, whose locations were known, were qualitatively and quantitatively examined through GIS, and their current status was assessed. Spatial distribution, size, capacity and adequacy, accessibility, access to healthcare facilities, and proximity to fault zones were analysed for emergency assembly points based on queries made in the database. Evaluations were conducted both on a neighborhood basis and for the service area of walking distances of 250 m and 500 m. Capacity and adequacy assessments were queried using building stock and population data in residential areas. As a result of the evaluations, alternative emergency assembly points were proposed using pre-selected criteria for areas identified as deficient or inadequate.

4 Result and discussion

In urban planning today, spatial data is utilized to quickly and accurately address potential problems that may arise. The processing of geographical data used in urban planning and development is carried out through GIS technology. Spatial analyses conducted with GIS aid in developing effective strategies for decision-making and determining available conditions.

GIS plays a crucial role in disaster management, as it is essential for predicting the community's response during disasters and interpreting how social life will be affected after events like earthquakes. Analysing the adequacy of assembly points from a geographical perspective included in disaster intervention plans for cities, as in the case of Erzincan, which has experienced significant earthquakes, is extremely important.

For this purpose, various types of data (raster, vector, tabular attribute data) were obtained in the study, and subsequently, new data and thematic maps to be used in analysis and evaluation were created using these data. Within the scope of the methodology determined in accordance with the objectives of the study and using the acquired data, GIS-based analyses were conducted. During the geographical analysis of emergency assembly points, criteria deemed suitable for the study area and previously established in other studies were utilized.

As a result of the obtained data and reviewed studies, it has been determined that there are numerous criteria and standards for determining assembly points. Standards and criteria vary according to countries or regions and are sometimes left to the discretion of local authorities. In order to make an objective evaluation, criteria were established based on the geographical and topographical conditions of the study area, and the results were obtained accordingly.

4.1 Accessibility analysis for emergency assembly points

It is of utmost importance for earthquake survivors to be able to reach emergency assembly points quickly and easily in the event of an earthquake. Following an earthquake, search and rescue, as well as first aid activities, need to be carried out rapidly. The condition of roads is crucial for people to communicate with each other and reach assembly points easily amidst the panic and anxiety that ensues after an earthquake. The availability of all kinds of essential supplies for the affected people from earthquake depends on the active operation of transportation systems. Therefore, accessibility is particularly crucial in the planning of site selection for these points.

Within the scope of the study, the connectivity of the assembly points to urban roads was determined through proximity analysis. As a result of the analysis and evaluation, it was found that the majority of emergency assembly points are distant from main urban roads. It was determined that five assembly points in the Cumhuriyet, Ergenekon, Mengüceli, Yavuz Selim, and Yunus Emre neighborhoods are connected to main urban roads. Additionally, the 5 emergency assembly points located in Atatürk, Gülabibey, İnönü, Karaağaç and Yavuz Selim neighborhoods have access to both main urban roads and connecting roads. The remaining 28 emergency assembly points can be accessed via urban access roads.

In the study, proximity analysis was conducted for the proposed 67 emergency assembly points as well. As a result of the evaluation, it was determined that the emergency assembly point in the Mustafa Kemal Paşa, Bahçelievler, Gölçük and Halitpaşa neighborhoods, which previously did not have emergency assembly points, can be accessed via main roads. It was determined that the remaining 63 emergency assembly points can be accessed via urban access roads.

Attention should be paid to the possibility of partial blockage of evacuation routes due to the collapse of buildings along the roadsides after an earthquake. The designated emergency assembly point should ideally be connected to at least two evacuation routes with width of no less than 7 m (Chu and Su 2012). Additionally, according to a study conducted, the probabilities of road closure are as follows:

- 98% for roads with widths ranging from 2 to 6 m,
- 11% for roads with widths ranging from 7 to 15 m,
- 0.3% for roads wider than 16 m (JICA and IMM 2002).

Considering the urban access road mostly with a width of 7 m found within the neighborhoods affiliated with Erzinçan city center, emergency assembly points have been selected in open green areas. Taking all these factors into account, it is believed that the connectivity of emergency assembly points to urban access roads, including those in possible earthquake scenarios, will not create restrictive or challenging situations in terms of accessibility for disaster survivors.

4.2 Proximity analysis to healthcare facilities of emergency assembly points

In order for people injured due to building collapses after a potential earthquake to receive medical intervention as quickly as possible, emergency assembly points should be located as close as possible to healthcare facilities (Soltani et al. 2015). Healthcare facilities should be located within 1–3 km from designated emergency assembly points (Anhorn and Khazai 2015). Therefore, proximity analysis of emergency assembly points and healthcare facilities (family health centers, hospitals, etc.) was conducted for both the lower limit of 1 km and the upper limit of 3 km service radius.

As a result of the analysis, for the 1 km service radius, out of the total of 105 designated emergency assembly points, 25 are located outside the service area. When the upper limit of the service radius is taken as 3 km, all of the designated 105 emergency assembly points are located within the service area (Fig. 3).

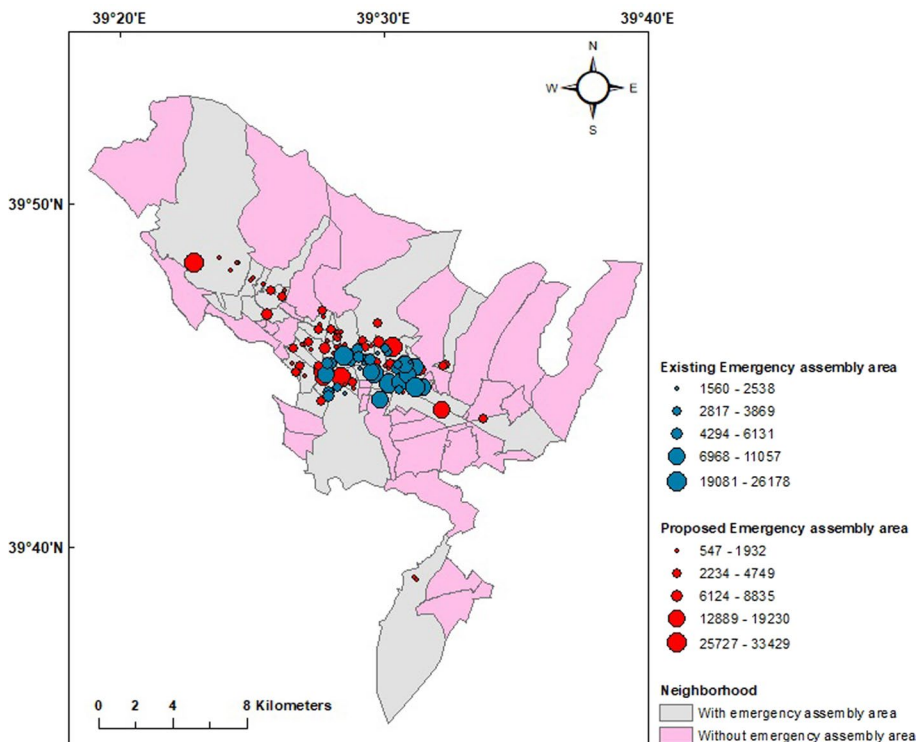


Fig. 3 Proximity to healthcare facilities of emergency assembly points (1–3 km)

4.3 Size distribution analysis

In order for emergency assembly points to be designated by relevant institutions and organizations and therefore be able to provide services when needed, they should have a size capable of serving a specific population. Therefore, the sizes of available assembly points are directly related to the population they will accommodate during and after disasters and emergencies. There are many studies defining different threshold values in terms of size. According to the most widely accepted standards, the minimum size of an emergency assembly point is 500 m², with no limitation on the maximum size.

The sizes of the 38 emergency assembly points previously determined by AFAD within the study area have been analysed. The capacity of emergency assembly points to be used in disasters and emergencies varies depending on the neighborhood or region they are located in. In the current situation within the city, the total area of emergency assembly points is approximately 25 hectares (254,185 m²). The smallest area among the emergency assembly points is a park area of 1560 m² located in the Arslanlı neighborhood. The largest area among the emergency assembly points is an open area of 26,178 m² located in the Karaağaç neighborhood (Fig. 4).

In addition to the available 38 emergency assembly points within the city, 67 more emergency assembly points have been proposed. The total area of these proposed 67 emergency assembly points is approximately 28 hectares (281,261 m²). Thus, with the addition of the proposed emergency assembly points, the total area of emergency assembly points has increased by twofold, calculated to be approximately 54 hectares (535,446 m²). The smallest area among the emergency assembly points is a park area of 547 m² located in the Osmangazi neighborhood. The emergency assembly point with the largest area is the Kaan Murathan Demir park located in the Yalnızbağ neighborhood, with an area of 33,429 m² (Fig. 4).

4.4 Capacity adequacy analysis

The most important factor in determining the number and size of emergency assembly points is the population living within neighborhood boundaries. Planning studies at the neighborhood or district level after an earthquake calculate the amount of assembly points per population. These calculations are carried out by both local authorities and public institutions such as AFAD. Strategies and plans should be prepared to safely direct the population to assembly points in areas where urbanization is heavily felt. In this study, neighborhood populations were used as data for the adequacy analysis of assembly points at the neighborhood scale. The distribution of population and building to neighborhoods was examined, and each neighborhood was evaluated separately. The usable area per capita in emergency assembly points was determined as 1.5 m² and calculated.

There are emergency assembly points in 16 neighborhoods in Erzincan city center. In the adequacy analysis of available emergency assembly points conducted on a neighborhood basis, the assembly points ratio of 14 neighborhoods has been evaluated to be sufficient for the current population. However, in the remaining 2 neighborhoods, the assembly points are insufficient according to the established standards. Additionally, there are no assembly points in 53 neighborhoods.

As a result of the studies conducted in the neighborhoods affiliated with city centre of Erzincan province, a total of 67 new emergency assembly points have been proposed

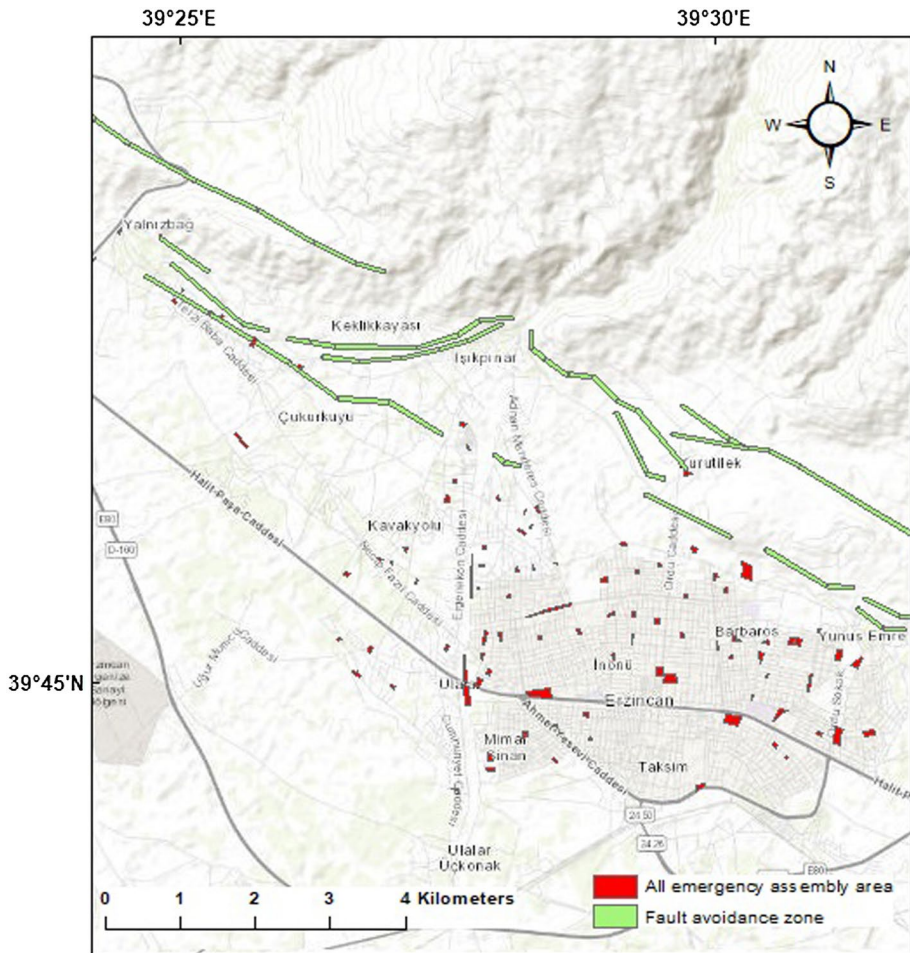


Fig. 4 Size of assembly points (m^2), and neighborhoods with and without emergency assembly points

within 26 neighborhoods. Thus, there are emergency assembly points in a total of 42 neighborhoods. In the neighborhood-scale adequacy analysis of the proposed emergency assembly points, it has been determined that the assembly points ratio of 26 neighborhoods is sufficient for the current population (1.5 m^2 per person). With the recent additions, there are still no emergency assembly points in 31 neighborhoods. Among these neighborhoods, 23 are distant from the city center, have a large agricultural land area, and mostly consist of single-storey detached houses or two-storey houses with gardens. Additionally, the remaining neighborhoods of Bayrak, Sancak, and Şehit Cengiz Topel, which are also distant from the city center, have a significant agricultural land area, and predominantly consist of single-storey detached houses, located around the airport, thus no emergency assembly point proposals could have been made. The neighborhoods of Hocabey, Taksim, and Kızılay, which also lack emergency assembly points, are located in the city center. However, as most of these neighborhoods are undergoing urban renewal processes, the construction process is still ongoing, hence no emergency assembly point proposals could have

been made. Moreover, the neighborhoods of Yenidoğan and Işıkpınar, which do not have emergency assembly points and are close to the city center, also could not have emergency assembly points proposals due to their predominantly consisting of agricultural areas and generally single-family homes with gardens.

It is evident that available neighborhood boundaries will not be binding for earthquake victims in the event of a possible earthquake. Therefore, the best alternative to neighborhood-scale analysis is an analysis based on the service area of assembly points. For the analysis, service areas (250 m and 500 m) were created by taking the emergency assembly points as the center (Figs. 5 and 6). Afterwards, it was determined how much of the building stock within the neighborhood boundaries is within the service area (Appendix Table 3).

The numbers (f) of neighborhoods where buildings fall within the 250 m and 500 m service area of available and proposed emergency assembly points, as shown in Table 1, were created using Table 3. Upon examination of Table 1, it is observed that for available

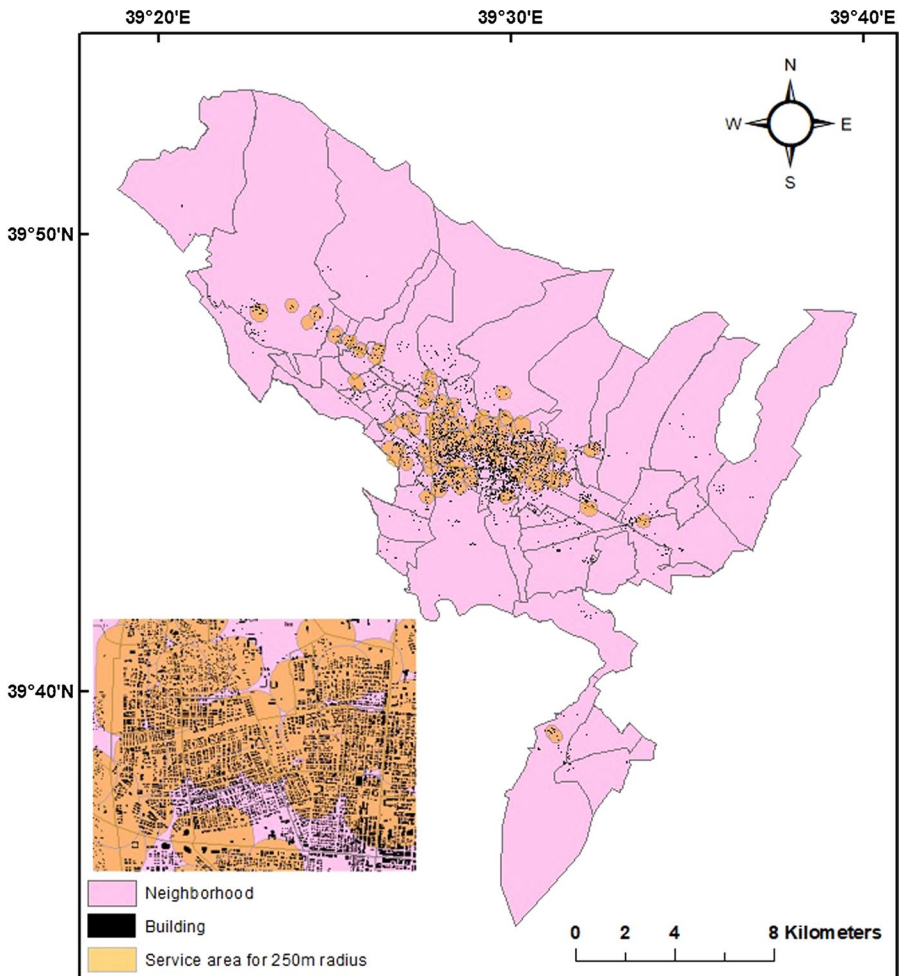


Fig. 5 Capacity analysis for 250 m service area

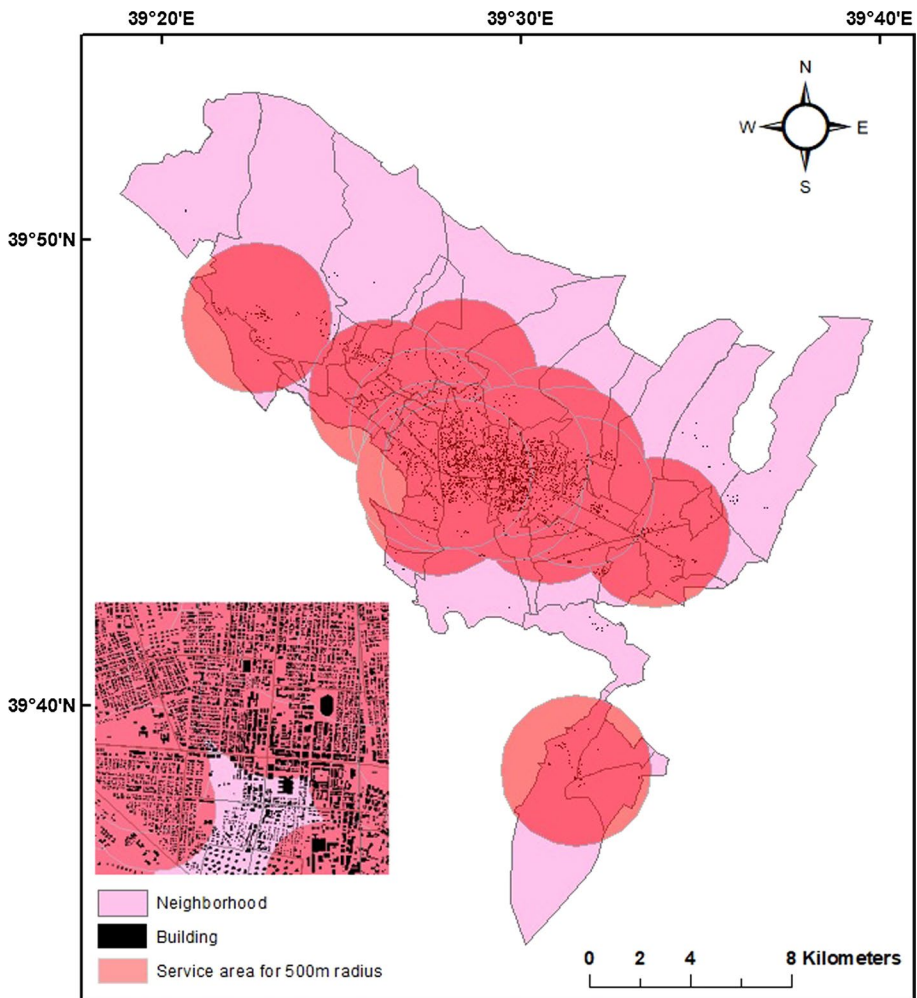


Fig. 6 Capacity analysis for 500 m service area

assembly points, 0–24% of buildings in 57 neighborhoods, 25–49% of buildings in 7 neighborhoods, 50–74%, of buildings in 2 neighborhoods, and 75–100% of buildings in 7 neighborhoods remained within the 250 m service area. For proposed assembly points, 0–24% of buildings in 32 neighborhoods, 25–49% of buildings in 12 neighborhoods, 50–74%, of buildings in 13 neighborhoods, and 75–100% of buildings in 16 neighborhoods fell within the 250 m service area. According to the 500 m service area, it was observed that available assembly points covered 0–24% of buildings in 47 neighborhoods, 25–49% of buildings in 6 neighborhoods, 50–74% of buildings in 3 neighborhoods, and 75–100% of buildings in 17 neighborhoods. For proposed assembly points, 0–24% of buildings in 22 neighborhoods, 25–49% of buildings in 5 neighborhoods, 50–74% of buildings in 6 neighborhoods, and 75–100% of buildings in 40 neighborhoods remained within the 500 m service area.

As observed, especially the neighborhoods close to the city center and with large populations are largely within the service area of the emergency assembly points according to

the conducted study. The neighborhoods outside the service area are generally located far from the city center or have a large agricultural area, characterized by predominantly single-story detached houses with gardens.

In addition, the adequacy of infrastructure in emergency assembly points was also examined (Appendix Table 2). As seen in Table 2, out of the 38 emergency assembly points identified by AFAD, 34 have electricity and water infrastructure, while 4 do not. Only 9 of these points have toilets. In the scope of the study, all 67 proposed emergency assembly points have electricity and water infrastructure, with 16 of them also having toilets. Despite the majority of parks and green areas throughout the city having electricity and water infrastructure, many of them lack toilets.

4.5 Fault avoidance distance analysis

The area affected by the surface deformation zone caused by active faults, which constitute the seismic source of earthquakes, is considered unsuitable for settlement, and construction is not allowed in these areas (Yıldız, 2023). In order to reduce the margin of error in identifying and mapping faults and to mitigate the impact of the expected surface faulting hazard on engineering structures (such as roads, bridges, viaducts, intersections, tunnels, etc.) by providing a safe distance, an avoidance zone is created on both sides of the surface faulting hazard zone (Nurlu 2017).

The Active Fault Map of Türkiye was published by the General Directorate of Mineral Research and Exploration (MTA) in 2012 at a scale of 1/250,000. In these maps, the existing faults in the Erzincan city are classified as Earthquake Surface Rupture (active faults causing surface faulting between 1900 and the present day) and Holocene Fault (fault causing surface faulting during the Holocene period). The city of Erzincan is located in the Erzincan NJ 37-3 quadrangle on the respective active fault maps (MTA 2012). The faults located in the city of Erzincan are classified as normal faults in the Active Faults Map of Türkiye prepared by MTA. There is no standard regarding the required avoidance distance for emergency assembly points. However, in studies conducted by Nurlu (2017) and Gürboğa et al. (2016), an avoidance distance of 55 m was considered for normal faults. In this study, the fault avoidance zone was also analysed based on a distance of 55 m.

The 38 available emergency assembly points designated as open and green spaces by AFAD do not have a direct relationship with fault lines. These points are outside the fault avoidance distance. Among the 67 proposed emergency assembly points designated as open and green spaces, six are located close to fault avoidance zones. One reason for selecting these locations is the absence of any assembly points in these neighborhoods previously and the lack of alternative spaces nearby. Additionally, the surroundings of these designated points are mostly open, with around houses generally being single or two-story structures, often newly built. Therefore, in the event of an earthquake caused by fault lines, rather than having no assembly points in these locations, the decision was made to at least identify alternative assembly points (Fig. 7).

5 Conclusion

This study evaluates the suitability and adequacy of emergency assembly points in the central district of Erzincan province, located in a high-risk geography due to its seismicity on the North Anatolian Fault. Geographic Information Systems were utilized for the

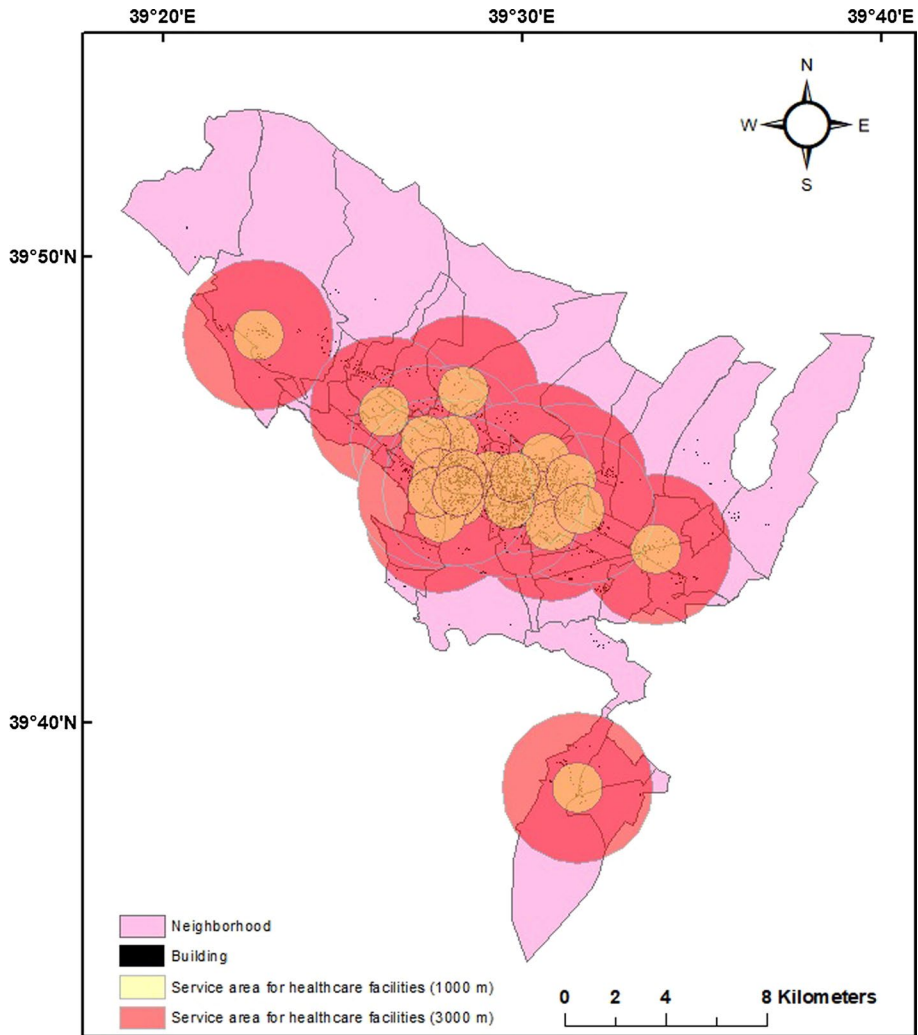


Fig. 7 Relationship between fault avoidance zone and emergency assembly points

assessment. The QGIS software, a multi-platform-supported, free, and open-source GIS application, was used for GIS analysis and mapping.

A total of 38 emergency assembly points have been identified for the central district of Erzincan province by AFAD. The majority of these points consist of municipal park areas. Analysis and assessment have revealed that these assembly points are not homogeneously distributed throughout the city and are insufficient. To minimize the problem, 67 new emergency assembly points have been proposed in the city center, increasing the number of neighborhoods with emergency assembly points to 42. As a result, the area of emergency assembly points, which was 258,703 m², has increased to approximately 54 hectares (535,446 m²). With proposed emergency points, it has been observed that the number of neighborhoods within the 250 m and 500 m service areas has also increased as 43.75% for 250 m and 42.5% for 500 m in the 75–100% range.

Additionally, the assessment has shown that as one moves away from the city center, the population decreases, agricultural areas within neighborhood boundaries are abundant, and houses are mostly single-story with gardens, making it challenging to determine emergency assembly points for these areas. Ongoing urban renewal projects in some neighborhoods near the city center where emergency assembly points have not been identified have further complicated the process of determining these points. The completion of urban renewal in densely populated neighborhoods near the city center without emergency assembly points will facilitate the identification of these points. When the accessibility of available and proposed emergency assembly points is analysed, it is concluded that there will be no accessibility issues due to wide urban roads and the absence of tall buildings that could pose a risk of closure in the event of an earthquake. Moreover, the proximity of available and proposed emergency assembly points to healthcare facilities has been analysed, revealing that most of these points are located within the designated service area.

The proximity analysis of emergency assembly points to fault avoidance zones revealed that upon evaluating all available and proposed points, only a small fraction of the proposed emergency assembly points are close to these zones. These points were selected out of necessity due to the absence of alternative points in the neighborhoods where they are located. The fact that the surroundings of these designated points are open suggests that potential adverse effects may be somewhat reduced.

As a result of the assessment of the adequacy of the infrastructure of emergency assembly points, it was determined that the number of toilets was insufficient. This deficiency could lead to hygiene problems in the event of a future earthquake and may also cause the emergence of epidemic diseases after a certain period. Therefore, toilets should be urgently installed in these points owned by local governments. As a result of assessment in the field have shown that there are not problems with access for disabled individuals to emergency assembly points. However, it has been observed that many emergency assembly points either lack warning signs and markers or have insufficient and poorly maintained ones.

Literature research has revealed the absence of legislation containing criteria for the identification of emergency assembly points throughout the country. The majority of Türkiye's population resides in the first-degree earthquake zone. Therefore, it is imperative to promptly establish and enforce legislation that includes criteria for determining emergency assembly points. Adhering to the necessary standards and criteria is essential to minimize the effects of disasters and ensure sustainability in disaster management. As long as these practices are supervised, it will be possible to minimize the effects of disasters on disaster victims.

Appendix

See Tables 2 and 3.

Table 2 Attributes of Available and proposed emergency assembly points

No	District	Population	ID	Assemble area				Capacity for available (m2)	Capacity with proposed (m2)	*Capacity adequacy	Type of Land	Usage Type	Infrastructure	
				Available (A), Proposed (P)	Latitude (dd°-mm'-ss.s'')	Longitude (dd°-mm'-ss.s'')	Area (m2)	Minimum Capacity (m2)					*Electric	*Water
1	Akşemsetin	2376	AK1	A	39-45-10.00	39-30-24.27	7534	3564	12,472	+	Green Space	Park	+	-
			AK2	A	39-44-58.65	39-30-51.19	4938				Green Space	Park	+	-
			AK3	P	39-45-01.60	39-30-27.55	1517				Green Space	Park	+	-
2	Aktoprak	582	AKT	P	39-43-40.33	39-33-40.15	2376	873	0	-	Green Space	Park	+	+
			AL1	P	39-30-04.40	39-31-03.33	1932	660	0	-	Green Space	Park	+	-
3	Alsancak	440	AL2	P	39-38-58.26	39-31-09.44	1104				Green Space	Park	+	-
			AR1	A	39-45-43.48	39-28-56.54	5687	8510	13,781	+	Green Space	Park	-	-
4	Arslanlı	5673	AR2	A	39-45-28.52	39-29-00.55	4294				Green Space	Park	+	-
			AR3	A	39-45-28.65	39-29-12.90	2240				Green Space	Park	+	-
			AR4	A	39-45-17.83	39-29-12.20	1560				Green Space	Park	+	-
											Green Space	Park	+	-

Table 2 (continued)

No	District	Population	ID	Assemble area			Type of Land				Usage Type	Infrastructure			
				Available (A), Proposed (P)	Latitude (dd° -mm' -ss.s'')	Longitude (dd° -mm' -ss.s'')	Area (m2)	Minimum Capacity (m2)	Capacity available (m2)	*Capacity adequacy with proposed (m2)		*Capacity adequacy	*Electric	*Water	
5	Atatürk	4603	AT1	A	39-45-00.75	39-29-33.56	19,081	6905	19,081	+	19,990	+	+	-	+
			AT2	P	39-44-52.63	39-30-18.84	909						+	+	-
6	Azizbaba	469	AZ	P	39-44-13.28	39-27-32.99	2572	704	0	-	2572	+	+	+	-
7	Bahçelievler	3924	BAH	P	39-44-54.65	39-28-20.63	29,676	5886	0	-	29,676	+	+	+	+
8	Barbaros	2165	BAR1	P	39-45-09.77	39-30-07.48	1702	3248	0	-	6432	+	+	+	-
			BAR2	P	39-45-17.56	39-30-10.14	4730						School Ground	+	+
9	Başbağlar	2467	BA1	A	39-45-44.89	39-29-58.77	3675	3701	6589	+	32,316	+	+	-	-
			BA2	A	39-45-38.88	39-30-04.61	2914						Green Space	+	-
			BA3	P	39-45-46.81	39-30-16.45	25,727						Green Space	+	+
10	Bulutlu	1565	BU1	P	39-47-16.07	39-26-07.09	3401	2348	0	-	4126	+	+	+	-
			BU2	P	39-47-27.58	39-26-12.20	725						Green Space	+	+

Table 2 (continued)

No	District	Population	ID	Assemble area			Area (m ²)	Longitude (dd° mm' - ss.')	Minimum Capacity (m ²)	Capacity for available (m ²)	*Capacity adequacy with proposed (m ²)	Type of Land	Usage Type	Infrastructure	
				Available (A), Proposed (P)	Latitude (dd° mm' - ss.')	Longitude (dd° mm' - ss.')								*Electric	*Water
11	Cumhuriyet	7431	CU1	A	39-45-36.15	39-29-42.09	1694		11,147	1694	12,238	Green Space	Park	+	-
			CU2	P	39-45-56.45	39-29-46.89	6124					Green Space	Park	+	-
			CU3	P	39-45-19.44	39-29-40.19	2842					Green Space	Park	+	-
			CU4	P	39-45-14.87	39-29-59.63	1578					Green Space	Park	+	-
12	Çukurkuyu	404	CUK	P	39-46-45.02	39-25-33.21	7180		606	0	7180	Green Space	Park	+	+
13	Demetevler	897	DE	P	39-45-06.94	39-31-18.33	7619		1346	0	7619	Green Space	Park	+	+
14	Demirkent	3638	DMR1	P	39-45-58.13	39-27-49.31	1910		5457	0	7589	Green Space	Park	+	-
			DMR2	P	39-46-04.59	39-28-10.41	2499					Green Space	Park	+	-
			DMR3	P	39-46-13.06	39-28-12.41	946					Green Space	Park	+	-
			DMR4	P	39-46-19.01	39-27-57.36	2234					Green Space	Park	+	+

Table 2 (continued)

No	District	Population	ID	Assemble area			Type of Land				Usage Type	Infrastructure						
				Available (A), Proposed (P)	Latitude (dd° -mm' -ss.s'')	Longitude (dd° -mm' -ss.s'')	Area (m2)	Minimum Capacity (m2)	Capacity available (m2)	*Capacity adequacy posed (m2)		*Capacity adequacy posed (m2)	*Electric	*Water	*WC			
15	Ergenekon	7692	ER1	A	39-45-10.22	39-27-49.51	4455	11,538	25,275	+	25,275	+	Green Space	Park	+	-	-	
			ER2	A	39-45-10.88	39-27-47.62	2909							Green Space	Park	+	-	+
			ER3	A	39-45-03.74	39-27-51.48	5109							Green Space	Park	+	-	-
			ER4	A	39-44-59.19	39-27-45.80	7965							Green Space	Park	+	-	-
			ER5	A	39-45-19.05	39-27-58.27	4837							Green Space	Park	+	-	-
16	Esentepe	348	ES	P	39-47-38.04	39-25-23.20	1788	522	0	-	1788	+	Green Space	Park	+	+	-	
17	Fatih	3781	FA1	A	39-44-45.36	39-30-34.42	10,247	5672	13,960	+	13,960	+	Green Space	Park	+	-	-	
			FA2	A	39-44-36.52	39-30-56.34	3713							Green Space	Park	+	-	-
18	Gülabbey	1383	GU	A	39-44-13.70	39-29-48.84	6968	2075	6968	+	6968	+	Green Space	Park	+	-	-	

Table 2 (continued)

No	District	Population	ID	Assemble area			Type of Land				Usage Type	Infrastructure						
				Available (A), Purposed (P)	Latitude (dd° -mm' -ss.s'')	Longitude (dd° -mm' -ss.s'')	Area (m2)	Minimum Capacity (m2)	Capacity available (m2)	*Capacity adequacy		*Capacity with purposed (m2)	*Electric	*Water	*WC			
19	Gölcük	1313	GO1	P	39-45-04.76	39-27-37.99	12,889	1970	0	-	18,977	+	+	+	-			
			GO2	P	39-45-14.63	39-27-28.18	2737						+	+	+	-		
			GO3	P	39-45-46.47	39-26-32.29	3351							+	+	+	-	
20	Hamidiye	3386	HA1	P	39-45-57.28	39-27-05.37	2860	5079	0	-	7312	+	+	+	+	-		
			HA2	P	39-45-43.01	39-27-11.41	1816							+	+	+	-	
			HA3	P	39-45-51.53	39-26-57.39	932							+	+	+	+	-
			HA4	P	39-45-52.95	39-26-50.88	1704							+	+	+	+	-
21	Halitpaşa	3214	HAL1	P	39-44-40.61	39-28-29.14	1395	4821	0	-	6356	+	+	+	+	+	-	
			HAL2	P	39-44-34.67	39-28-48.11	1470							+	+	+	+	-
			HAL3	P	39-44-45.34	39-28-45.42	3491							+	+	+	+	+

Table 2 (continued)

No	District	Population	ID	Assemble area			Area (m ²)	Minimum Capacity (m ²)	Capacity for available (m ²)	*Capacity adequacy with proposed (m ²)	*Capacity adequacy	Type of Land	Usage Type	Infrastructure	
				Available (A), Proposed (P)	Latitude (dd° -mm' -ss.s'')	Longitude (dd° -mm' -ss.s'')								*Electric	*Water
22	İnönü	5965	IN1	A	39-45-10.48	39-29-01.33	2538	8948	12,402	+	12,402	+	Green Space	+	-
			IN2	A	39-45-03.67	39-29-27.28	9864						Green Space	+	-
23	İzzetpaşa	2625	IZ1	A	39-44-31.53	39-30-31.64	3138	3938	3138	-	17,968	+	Open Space	-	-
			IZ2	P	39-43-57.50	39-32-07.60	13,838						Green Space	+	+
			IZ3	P	39-44-26.57	39-30-38.09	992						Green Space	+	-
24	Karaağaç	421	KA	A	39-44-42.54	39-30-07.91	26,178	632	26,178	+	26,178	+	Open Space	+	+
25	Kavaklıolu	2294	KAV1	P	39-46-26.35	39-27-33.10	1845	3441	0	-	7019	+	Green Space	+	-
			KAV2	P	39-46-50.82	39-27-37.40	3490						Green Space	+	-
			KAV3	P	39-46-40.74	39-27-40.88	1684						Green Space	+	-

Table 2 (continued)

No	District	Population	ID	Assemble area				Type of Land				Usage Type			Infrastructure	
				Available (A), Purposed (P)	Latitude (dd°-mm'-ss.s'')	Longitude (dd°-mm'-ss.s'')	Area (m2)	Minimum Capacity (m2)	Capacity for available (m2)	*Capacity adequacy (m2)	*Capacity adequacy with proposed (m2)	*Capacity adequacy	Usage Type	*Electric	*Water	*WC
26	Kazım Karabekir	3143	KAZ1	P	39-45-49.76	39-29-27.93	1486	4715	0	-	6369	+	Green Space	+	+	-
			KAZ2	P	39-45-58.98	39-29-07.63	2262						Green Space	+	+	-
			KAZ3	P	39-45-47.21	39-29-14.91	2621						Open Space	+	+	+
27	Kurutilek	432	KU	P	39-46-29.39	39-29-43.23	4749	648	0	-	4749	+	Green Space	+	+	-
			ME1	A	39-44-35.17	39-31-07.11	22,183	5303	31,154	+	31,154	+	Green Space	+	-	+
29	Menderes	3449	ME2	A	39-44-36.59	39-31-24.66	8971						Open Space	-	-	-
			MEN1	P	39-45-50.67	39-28-29.71	1075	5174	0	-	5536	+	Green Space	+	+	-
			MEN2	P	39-45-49.00	39-28-16.83	627						Green Space	+	+	+
			MEN3	P	39-45-48.33	39-28-07.65	1108						Green Space	+	+	-
			MEN4	P	39-46-14.41	39-28-19.42	1528						Open Space	+	+	-
28	Mengüceli	3535	MEN5	P	39-46-06.77	39-28-15.55	1198						Green Space	+	+	-

Table 2 (continued)

No	District	Population	ID	Assemble area			Type of Land				Usage Type	Infrastructure	
				Available (A), Proposed (P)	Latitude (dd° -mm'-ss.ss'')	Longitude (dd° -mm'-ss.ss'')	Area (m2)	Minimum Capacity (m2)	Capacity available (m2)	*Capacity adequacy with proposed (m2)		*Capacity adequacy	*Electric
30	Mimar Sinan	10,960	MI1	A	39-44-27.24	39-27-51.89	5331	16,440	18,129	+	Green Space	-	-
			MI2	A	39-44-21.67	39-27-52.31	3048				Green Space	+	-
			MI3	A	39-44-37.31	39-28-11.30	5218				Green Space	+	-
			MI4	A	39-44-35.93	39-28-11.30	2817				Green Space	+	-
			MI5	A	39-44-25.59	39-28-28.10	1715				Green Space	+	-
31	Munzur	3527	MU1	P	39-45-15.64	39-32-16.46	2639	5291	0	-	Green Space	+	-
			MU2	P	39-45-13.38	39-32-10.64	4085				Green Space	+	-
32	Mustafa Kemal Paşa	598	MUS	P	39-44-53.96	39-27-39.27	19,230	897	0	-	Green Space	+	-
33	Osmangazi	443	OS1	P	39-47-49.36	39-25-00.92	547	665	0	-	Green Space	+	-
			OS2	P	39-47-44.84	39-24-56.42	1656				Green Space	+	-

Table 2 (continued)

No	District	Population	ID	Assemble area			Area (m2)	Longitude (dd°-mm'-ss.s'')	Minimum Capacity (m2)	Capacity for availability (m2)	*Capacity adequacy with proposed (m2)	*Capacity adequacy	Type of Land	Usage Type	Infrastructure		
				Available (A), Proposed (P)	Latitude (dd° -mm' -ss.s'')	Latitude (dd°-mm' -ss.s'')									*Elec- tric	*Water	
34	Osmanlı	5111	OSM1	P	39-45-40.32	39-27-46.06	958		7667	0	-	11,897	+	Green Space	Park	+	+
			OSM2	P	39-45-49.83	39-27-47.70	1378							Green Space	Park	+	+
			OSM3	P	39-45-36.65	39-28-03.09	726							Green Space	Park	+	+
			OSM4	P	39-45-44.42	39-27-42.11	8835							Green Space	Park	+	+
35	Özgürlük	736	OZ	P	39-44-57.49	39-26-57.89	1715		1104	0	-	1715	+	Green Space	Park	+	+
36	Paşa	553	PA	P	39-46-18.76	39-27-28.76	4061		830	0	-	4061	+	Green Space	Park	+	+
37	Şehit Sertdar Yurtbaşı	473	SE1	P	39-47-27.80	39-25-41.22	2856		710	0	-	6172	+	Green Space	Park	+	+
			SE2	P	39-47-25.71	39-25-39.84	3316							Green Space	Park	+	+

Table 2 (continued)

No	District	Population	ID	Assemble area			Type of Land				Usage Type	Infrastructure				
				Available (A), Proposed (P)	Latitude (dd° -mm' -ss.s'')	Longitude (dd° -mm' -ss.s'')	Area (m2)	Minimum Capacity (m2)	Capacity available (m2)	*Capacity adequacy with proposed (m2)		*Capacity adequacy	*Electric	*Water *WC		
38	Ulular	2092	UL1	P	39-45-18.49	39-26-27.97	1476	3138	0	-	9326	+	+	+	-	
			UL2	P	39-45-14.14	39-26-45.24	3177					Open Space	+	+	+	+
			UL3	P	39-45-03.56	39-26-37.65	4673					Open Space	+	+	+	+
39	Yalınzbağ	2687	YAL1	P	39-48-03.10	39-24-11.41	1669	4031	0	-	37.694	+	+	+	-	
			YAL2	P	39-48-25.15	39-23-44.19	1018					Green Space	+	+	+	-
			YAL3	P	39-48-16.29	39-24-26.50	716					Green Space	+	+	+	-
			YAL4	P	39-48-14.63	39-24-25.65	862					Green Space	+	+	+	-
			YAL5	P	39-48-15.96	39-22-48.80	33,429					Green Space	+	+	+	+
40	Yavuz Selim	8267	YA1	A	39-45-31.10	39-28-27.33	19,748	12,401	25,603	+	25.603	+	+	+	+	
			YA2	A	39-45-18.85	39-28-20.25	1986					Green Space	+	+	+	-
			YA3	A	39-45-21.22	39-28-41.90	3869					Green Space	+	+	+	-

Table 2 (continued)

No	District	Popu- lation	ID	Assemble area			Type of Land					Usage Type	Infrastructure			
				Avail- able (A), Pur- posed (P)	Lati- tude (dd° -mm'- ss.s'')	Longi- tude (dd°-mm'- ss.s'')	Area (m2)	Mini- mum Capac- ity (m2)	Capac- ity for avail- able (m2)	*Capac- ity ade- quacy with pur- posed (m2)	*Capac- ity ade- quacy		*Elec- tric	*Water *WC		
41	Yenimahalle	2807	YE	A	39-45- 25.64	39-29- 25.76	6131	4211	6131	+	6131	+	Green Space	+	+	+
42	Yunus Emre	6194	YU1	A	39-45- 16.53	39-30- 27.41	3620	9291	31,630	+	31,630	+	Green Space	+	+	-
			YU2	A	39-45- 16.82	39-30- 41.67	7438						Open Space	+	+	+
			YU3	A	39-45- 16.15	39-30- 44.65	7442						Green Space	+	+	+
			YU4	A	39-45- 20.92	39-30- 56.43	2073						Green Space	+	+	-
			YU5	A	39-45- 10.50	39-31- 07.87	11,057						Open Space	+	+	-

* Available(+), Not Available(-)

Table 3 Service areas of emergency assembly points in neighborhoods for 250 m and 500 m

No	District	Population	Available			Available and proposed					
			Number of building in service area		Buildings in service area (%)		Number of building in service area		Buildings in service area (%)		
			Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)	Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)	
1	AKŞEMSETTİN	2376	457	363	457	79	100	440	457	96	100
2	AKTOPRAK	582	221	0	0	0	0	82	171	37	77
3	AKYAZI	1021	322	0	0	0	0	56	158	17	49
4	ALSANCAK	440	389	0	0	0	0	217	294	56	76
5	ARSLANLI	5673	393	386	393	98	100	391	393	99	100
6	ATATÜRK	4603	792	318	772	40	97	461	792	58	100
7	AZİZ BABA	469	268	0	63	0	24	101	151	38	56
8	BAHÇELİEVLER	3924	477	22	338	5	71	171	477	36	100
9	BARBAROS	2165	427	160	407	37	95	424	427	99	100
#	BARIŞ	842	280	0	0	0	0	0	0	0	0
#	BAŞBAĞLAR	2467	237	87	214	37	90	135	234	57	99
#	BAŞPINAR	355	150	0	0	0	0	0	0	0	0
#	BAYRAK	488	230	0	0	0	0	0	0	0	0
#	BOZYAZI	282	117	0	0	0	0	11	80	9	68
#	BUĞDAYLI	159	113	0	0	0	0	0	18	0	16
#	BULUTLU	1565	456	0	0	0	0	299	397	66	87
#	BÜYÜKÇAKIRMAN	282	110	0	0	0	0	0	0	0	0
#	CEMAL GÜRSEL	238	95	0	0	0	0	0	0	0	0
#	CUMHURİYET	7431	940	348	784	37	83	826	940	88	100
#	ÇARŞI	2761	179	8	62	4	35	8	62	4	35

Table 3 (continued)

No	District	Population	Number of building	Available		Available and proposed					
				Number of building in service area		Buildings in service area (%)		Number of building in service area		Buildings in service area (%)	
				Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)	Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)
#	ÇUKURKUYU	404	204	0	0	0	0	53	101	26	50
#	DAVARLI	72	70	0	0	0	0	0	0	0	0
#	DEMETEVLER	897	243	22	222	9	91	145	243	60	100
#	DEMİRKENT	3638	457	0	0	0	0	398	457	87	100
#	DEREYURT	162	124	0	0	0	0	0	0	0	0
#	ERGENEKON	7692	492	426	492	87	100	456	492	93	100
#	ERSEVENLER	956	275	0	0	0	0	0	0	0	0
#	ERTUĞRUL GAZİ	134	81	0	0	0	0	0	0	0	0
#	ESENTEPE	348	126	0	0	0	0	103	126	82	100
#	FATİH	3781	515	482	515	94	100	502	515	97	100
#	GAZİ	630	342	3	73	1	21	39	208	11	61
#	GÖLCÜK	1313	384	1	72	0	19	210	372	55	97
#	GÜLABİBEY	1383	533	154	404	29	76	154	404	29	76
#	GÜLLÜCE	367	157	0	0	0	0	0	0	0	0
#	HALİTPAŞA	3214	628	0	170	0	27	582	628	93	100
#	HAMİDİYE	3386	431	0	31	0	7	237	389	55	90
#	HANCI	300	115	0	0	0	0	0	36	0	31
#	HOCA AHMET YESEVİ	167	59	0	0	0	0	1	21	2	36
#	HOCABEY	1264	292	0	0	0	0	12	138	4	47
#	HÜREMPALANGASI	123	83	0	0	0	0	0	0	0	0

Table 3 (continued)

No	District	Population	Available		Available and proposed					
			Number of building in service area		Buildings in service area (%)		Number of building in service area		Buildings in service area (%)	
			Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)	Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)
#	IŞIKPINAR	567	0	0	0	0	4	37	1	8
#	İNÖNÜ	5965	634	1113	56	98	634	1130	56	99
#	İZZETPAŞA	2625	293	744	28	70	409	910	39	86
#	KARAĞAÇ	421	160	555	26	91	160	555	26	91
#	KAVAKYOLU	2294	0	0	0	0	167	220	65	86
#	KAZIM KARABEKİR	3143	66	383	15	90	368	427	86	100
#	KEKLİKKAYASI	546	0	0	0	0	2	81	1	24
#	KIZILAY	993	0	84	0	38	0	139	0	62
#	KURUTİLEK	432	0	0	0	0	109	202	41	77
#	MENDERES	3449	12	175	2	22	505	620	65	79
#	MENGÜCELİ	3535	175	290	20	33	242	742	28	86
#	MİMAR SİNAN	10,960	521	755	61	88	576	755	67	88
#	MUNZUR	3527	0	0	0	0	103	159	65	100
#	MUSTAFA KEMAL PAŞA	598	3	165	1	49	75	276	22	81
#	OSMAN GAZİ	443	0	0	0	0	129	195	66	99
#	OSMANLI	5111	24	184	6	49	376	377	100	100
#	ÖZGÜRLÜK	736	0	10	0	2	170	399	41	96
#	PAŞA	553	0	0	0	0	60	162	35	95
#	SANCAK	678	0	0	0	0	0	0	0	0

Table 3 (continued)

No	District	Population	Available		Available and proposed					
			Number of building in service area		Buildings in service area (%)		Number of building in service area		Buildings in service area (%)	
			Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)	Service radius (250 m)	Service radius (500 m)	Service area for 250 m (%)	Service area for 500 m (%)
#	SARIGÖL	599	0	0	0	0	0	18	0	6
#	SELÇUKLU	212	0	0	0	0	0	0	0	0
#	ŞEHİT CENGİZ TOPEL	1415	0	0	0	0	0	0	0	0
#	ŞEHİT SERHAT YURTBAŞI	473	0	0	0	0	53	54	98	100
#	ŞEHİTSERHAT	180	0	0	0	0	0	0	0	0
#	TAKSİM	1834	0	0	0	0	0	0	0	0
#	TERZİBABA	435	0	0	0	0	0	0	0	0
#	ULALAR	2092	0	0	0	0	225	290	78	100
#	ÜÇKONAK	296	0	0	0	0	0	0	0	0
#	YALNIZBAĞ	2687	0	0	0	0	159	337	35	74
#	YAVUZ SELİM	8267	586	642	91	100	597	642	93	100
#	YENİDOĞAN	611	25	91	17	61	25	131	17	88
#	YENİMAHALLE	2807	327	333	98	100	327	333	98	100
#	YUNUS EMRE	6194	377	409	91	99	377	409	91	99

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Declarations

Conflict of interest The authors have no conflicts of interest to declare.

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