What Our Cities Can Offer After Natural Disasters

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Abstract
The importance of open green spaces in cities is increasing every day. These areas are the air supply of cities and citizens and have an important place in the urban fabric due to the roles they assume after disasters. The earthquake studies in Turkey have accelerated after the Marmara earthquake in 1999 due to which 18373 people had lost their lives. After the earthquake, the importance of open green spaces that can be used for sheltering, housing and evacuation purposes has become clear and their deficiency has attracted attention. The study aims to reveal ana analyze the functions that will be assumed by open green spaces after an earthquake in the central district of Bingol, a city in the first-degree seismic zone in Turkey, the carrying capacity and locations of the green spaces and their adequacy using different analysis methods.

The study firstly examines the importance and adequacy of the open urban green spaces with respect to rapid urbanization-induced intense housing. In the second stage, we discussed the concept of earthquake and to what degree implications of a disaster are taken into consideration when planning green spaces in the urban fabric. Lastly, the central district of Bingol was selected as an exemplary case and the open green spaces that will be used after an earthquake were determined and their adequacy was analyzed.
Keywords: Earthquake, disaster management, post-disaster cities, adequacy of open green spaces, development plan

Introduction
Disasters are natural, technological and anthropogenic events that inflict financial and moral damages to people and manufactured artifacts and interrupt or halt daily life and human activities [1, 2, 3, 4, 5]. Many people had died or got injured or suffered severe losses after disasters. Earthquake is an unchanging reality for Turkey and has a distinct impact on the country [4, 6].

Due to 180 earthquakes that had happened in Turkey between 1900 and 2014, 96046 people had lost their lives and 77759 buildings were damaged or collapsed. Data reveals that earthquakes that cause death and damages happen frequently in Turkey [7].
Turkey has repeatedly suffered destructive earthquakes. Furthermore, Turkey is one of the countries that are more frequently inflicted by deadly earthquakes. Figure 1 shows the tectonic map of Turkey [8, 9].

Turkey is on the Alpine-Himalayan seismic belt, one of the most important seismic belts around the world. The Anatolian plate on which Turkey is situated is surrounded by the Eurasian plate to its north, by the African and Arabic plate to its south, by the East Anatolian block to its east and by the Aegean block to its west. Due to its tectonic location, majority of the Turkish soils are under the risk of earthquake. In Turkey, the number of active faults or fault-segments that can produce earthquakes of a magnitude of 5.5 or above is 485 [10]. Earthquakes in Turkey are shallow-focus earthquakes. Majority of the earthquakes occur intensively along the North Anatolian Fault (NAF), East Anatolian Fault (EAF), Northeast Anatolian Fault (NEAF) and West Anatolian Fault (WAF) due to the northern movements of the Arabic plate and African continent [8, 11, 12, 13].

The Bingol earthquake on 22 May1971 inflicted the greatest loss to Bingol and surrounding villages in East Anatolia and occurred at 18h 43' 58" according to the local time. The records of USCGS show that the instrumental epicenter of the earthquake was determined to be 38° 80 N-40° 50 E, its intensity was measured to be 6.0 Mb and 6.7 Ms and depth of focus was measured to be 3 km. Prior to the main shock, a medium-intensity earthquake had occurred and the main earthquake was followed by aftershocks for a month[14]. The seismic zone of Bingol is right on the south of an intersection of a second zone that is seismically active and stretches between the North Anatolia seismic belt and İskenderun Gulf-Batum (Caucasia) [15, 16]. According to the historical records, the earthquakes in the region were distributed in the Kiğı-Karlıova-Varto zone in the north and occasionally shifted to south and shook Bingol and its surroundings [14]. The seismic map of Bingol shows that there is about a 3-km distance between the active faults and city center.

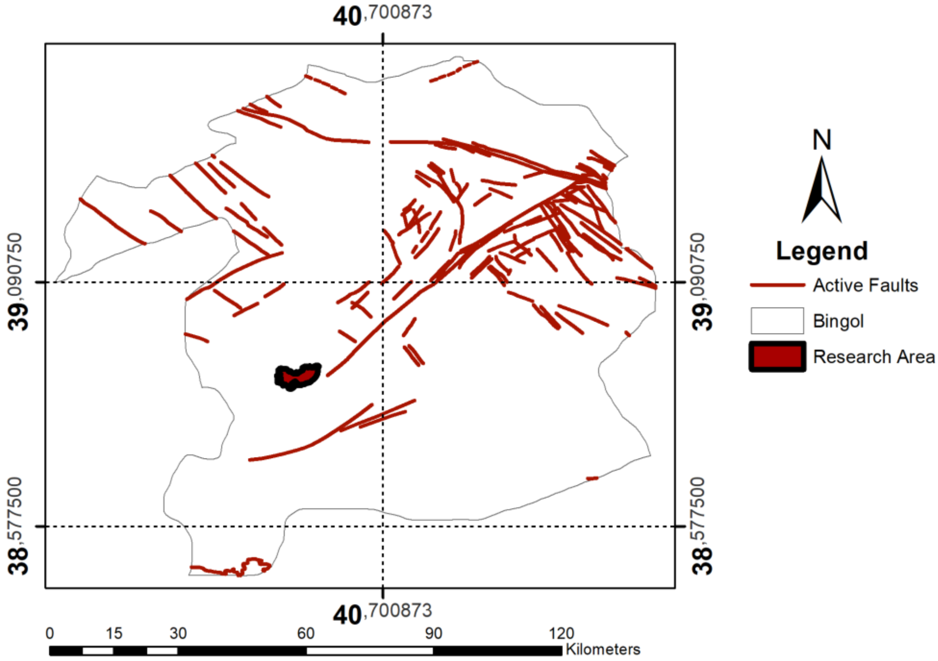

Figure 1. Seismic map of Bingol, Turkey [17].

A 4.7-magnitude earthquake occurred on 22 May 1971 in Bingol. Approximately 900 people had died, 700 people were injured and 5617 buildings were damaged during this earthquake [8, 18, 19]. Despite a 49-year gap between then and now, the quality of the weak buildings in Bingol is inexplicable.

Thirty-two years after that earthquake, an earthquake of a magnitude of 6.4 occurred on 1 May 2003 in Bingol and 694 people had died, 308 buildings collapsed and 5112 buildings were damaged. The most noteworthy side to this earthquake was that the most severely damaged buildings was school buildings. According to the Richter scale, 4 earthquakes occurred in Bingol with a magnitude greater than 5 comprising the earthquake in 1934 with a magnitude of 5.8, the earthquake in 1940 with a magnitude of 5.2, the earthquake in 1966 with a magnitude of 5.5 and the earthquake in 1968 with a magnitude of 5.1 [20]. After the 6.8-magnitude earthquake that occurred on 24.01.2020 in Elazığ, the EAF became active and Bingol should be alarmed of the possibility of an earthquake [21]. This study examines the adequacy of the assembly areas after a possible earthquake in Bingol, the access of buildings to the assembly areas and adequacy of the distribution of the green spaces in the city. The results showed that the green spaces that can be used as assembly areas after an earthquake were enough for the population of Bingol, but their locations were debatable. The necessary green space area to create a safe city during an earthquake was determined and included in the study.

2. Materials and Method

2.1. Study Area

The study area comprises the 2317.58-ha area covering İnönü, Kültür, İnalı, Yenişehir, Yeni, Yeşilyurt, Bahçeli Evler, Mirzan, Saray, Karşıyaka, Selahaddin-i Eyyübi, Şehit Mustafa Gündoğdu and Simani districts that are situated on the upper Fırat area of East Anatolia region in Turkey and within the borders of the central district of Bingol, accommodate 67.79% of the city and are included in the master development plan (Figure 1). For the ease of execution, the area was divided into three regions. The area comprising Saray, Karşıyaka, Selahaddin Eyyübi and Şehit Mustafa Gündoğdu districts was referred to as Zone 1, the area comprising İnönü, Kültür, İnalı, Yenişehir, Yeni Mahalle, Yeşilyurt, Bahçelievler and Mirzan districts was referred to as Zone 2, the area comprising Simani district was referred to as Zone 3. The city is neighbors with Muş to its east, Erzurum and Erzincan to its north, Tunceli and Elazığ to its west and Diyarbakır to its south. Bingol is situated between the 41º 20 and 39º - 56º east longitudes and 39º - 31 and 36º - 28º north latitudes. The location of Bingol is important in terms of highway transportation. The nationally and internationally important D300 highway passes through its city center.

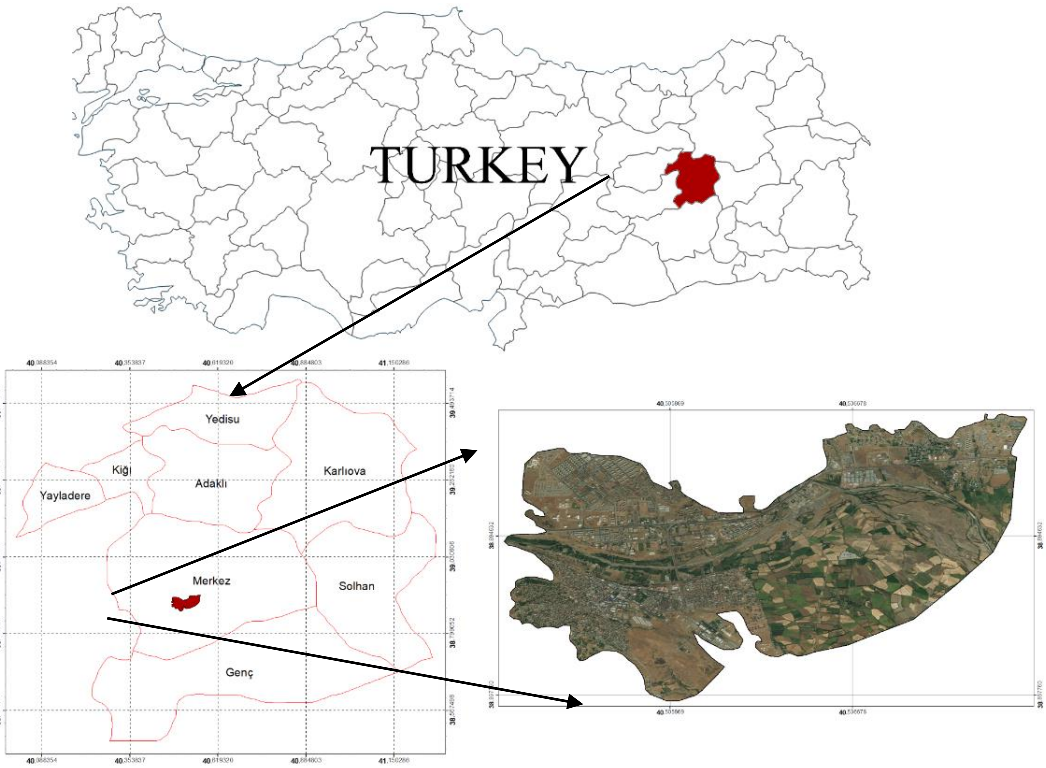

Figure 2. Study area.

2.2. Data Collection

In the first stage of the study, the SWOT (Strengths, Weaknesses, Opportunities and Threats) and TOWS (Threats, Opportunities, Weaknesses and Strengths) analyses were employed as planning and strategy tools. The SWOT analysis was carried out to determine the strengths, weaknesses, opportunities and threats to reveal the status and analyze internal and external factors emerging as a result of a possible earthquake that can affect the central district of Bingol. The TOWS analysis was carried out to evaluate the factors determined in the SWOT analysis and guide future strategies [22]. The study was carried out by a team of 41 experts and the results were scored on a scale from 0 to 4 ("0" low, "4" high). After consulting with the experts, the factors that scored 4 at a rate of more than 50% were included in the study. We also referred to the SWOT analysis performed by Vural et al. [22] for the urbanization of Bingol.

Then, the geographic information system (GIS) database was prepared based on the 1/1000 master development plan of the central district of Bingol. The master development plan was processed using the NetCAD GIS 8.0, ArcGIS Pro and AutoCAD Map programs and basic maps were created. Slope, hill groups, solar radiation index and hydrological maps were created using the digital elevation model (DEM) map developed using the elevations of the land.

3. Results and Discussion

3.1. Physical Structure of the Study Area

The slope map of the study area shows that 48.45 ha of the area (2,091%) has a slope of 0-2%; 1245,21 ha of the area (53,729%) has a slope of 2,1-6%; 177,75 ha of the area (7,669%) has a slope of 6,1-12%; 838,29 ha of the area (36,171%) has a slope of 12,1-20%; 7,81 ha of the area (0,337%) has a slope of 20,1-30%; 0,07 ha of the area (0,003%) has a slope of 30+ (Figure 2).

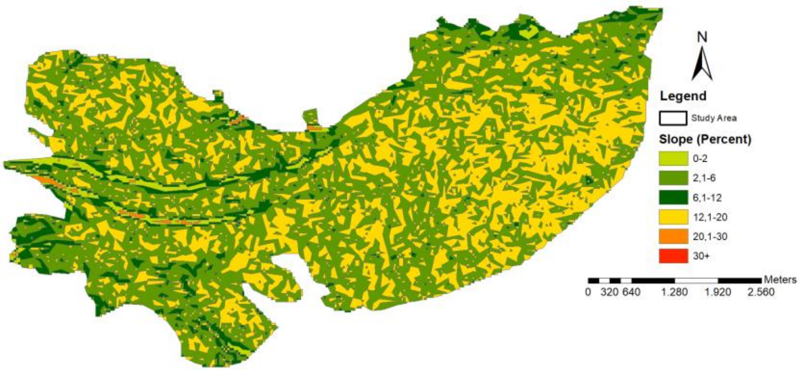

Figure 4. Slope map of the study area.

The altitude of the study area ranges from 1017 m to 1249 m. The hill groups map of the area revealed that 678,76 ha of the area (29,287%) was in the 1017 m-1050 m group; 678,96 ha of the area (29,296%) was in the 1050 m-1100 m group; 633,95 ha of the area (27,354%) was in the 1100 m-1150 m group; 305,56 ha of the area (13,184%) was in the 1150 m-1200 m group; 20,36 ha of the area (0,878%) was in the 1200 m-1249 m group (Figure 3).

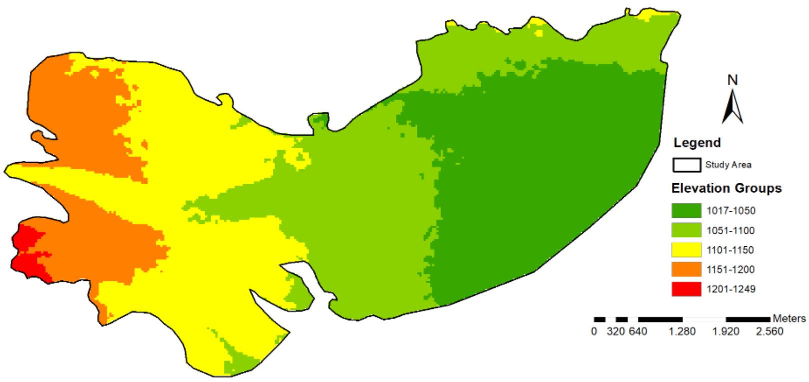

Figure 5. Hill groups map of the study area.

3.2. Zoning Status

The main aim of the study involves determining the facilities the city can offer after an earthquake, their open locations, accessibility and capacities. The capacity of the assembly areas and population they can serve for were determined by calculating the areas that will not be used by structural elements and so that an area of 1,5 m^2 is available per person using the formula: Ct=(Et-Eu)/1,5 (Ct: Capacity, Et: Total Area, Eu: Housing area) [23].

The total area of the open green spaces in Saray, Recep Tayyip Erdogan, Karsiyaka, Selahaddin-i Eyyubi and Sehit Mustafa Gundogdu districts that are referred to as Zone 1 in the study was 26,355 ha and their total carrying capacity was 175700 people. According to the data obtained from Bingol Municipality [24], Zone 1 had a population of 38998 people and, in theory, the green spaces in the zone were exceedingly sufficient for the residents in case of a disaster (Figure 4). Zone 1 had a total housing area of 152,473 ha and its housing/population index revealed that a housing area of 40 m^2 was available per person.

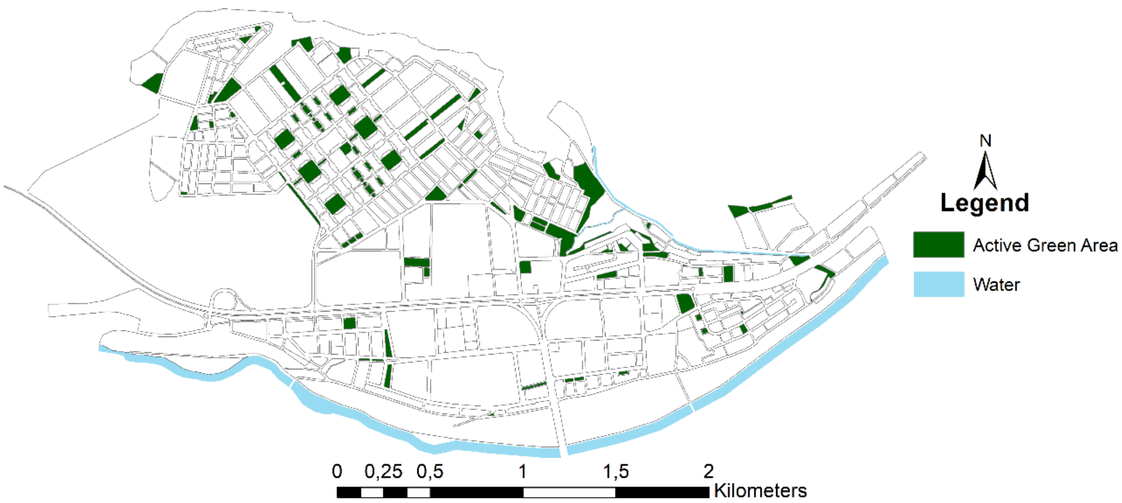

Figure 6. Green space distribution in Zone 1.

The total area of the open green spaces in Inonu, Kultur, Inali, Yenisehir, Yenimahalle, Yesilyurt, Bahcelievler and Mirzan districts that are referred to as Zone 2 in the study was 42,049 ha and their total carrying capacity was 280326 people. According to the data obtained from Bingol Municipality [24], Zone 2 had a population of 64232 people and, in theory, the green spaces in the zone were exceedingly sufficient for the residents in case of a disaster (Figure 5). Zone 2 had a total housing area of 42,049 ha and its housing area/population index revealed that a housing area of 41,6 m^2 was available per person.

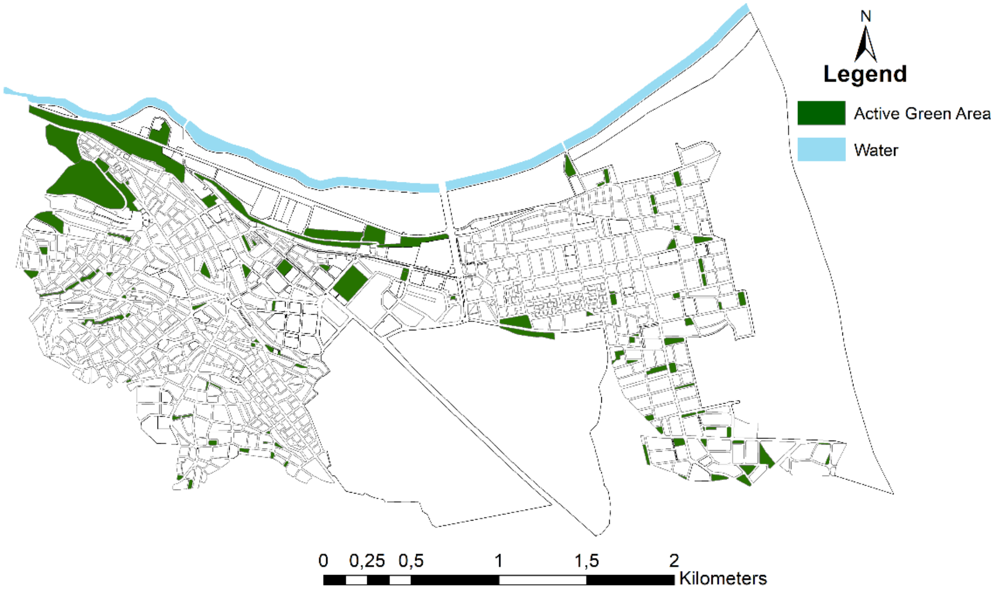

Figure 7. Green space distribution in Zone 2.

The total area of the active green spaces in Simani district that was referred to as Zone 3 in the study was 25,965 ha and their total carrying capacity was 173100 people. According to the data obtained from Bingol Municipality [24], Zone 3 had a population of 10603 people and, in theory, the green spaces in the zone were exceedingly sufficient for the residents in case of a disaster (Figure 6). Zone 3 had a total housing area of 160,149 ha and its housing area/population index revealed that a housing area of 166,6 m^2 was available per person.

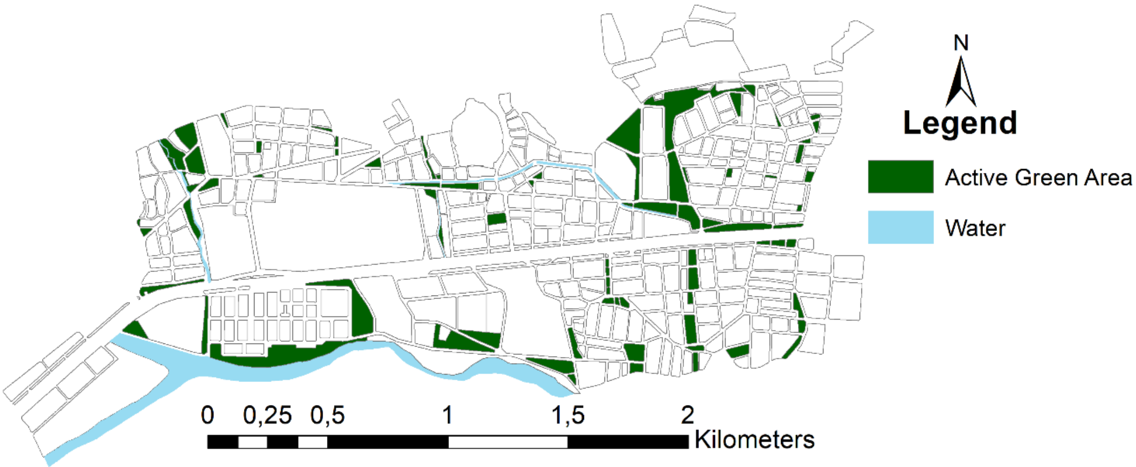

Figure 8. Green space distribution in Zone 3.

The examination of zones 1, 2 and 3 together revealed that their total population was 113833 people, total active green space was 94,369 ha and according to the formula "Ct=(Et-Eu)/1.5", the total carrying capacity of the green spaces was 629126 people. Figure 7 shows the current master development plan of the study area.

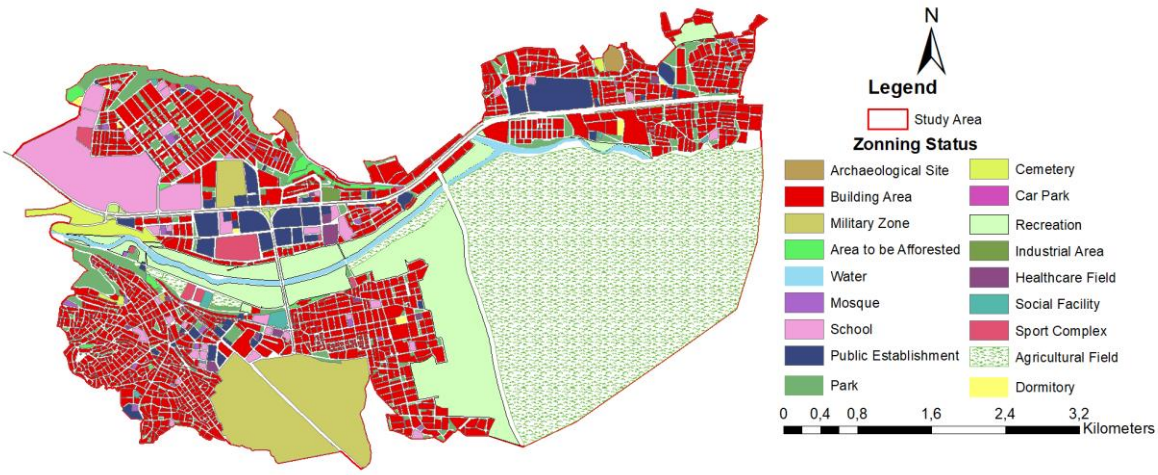

Figure 9. Master development plan of the study area.

3.3. Results of the TOWS and SWOT Analyses

As revealed by the master development plan, the size of the active green spaces was highly sufficient for the population currently living in the city. The TOWS and SWOT analyses revealed that (Table 1) although the green spaces were theoretically sufficient, they were lacking in functionality, accessibility, size and planning.

Table 1. The results of the SWOT analysis.

Strengths	• Presence of green spaces distributed across the city. • Existing buildings are not high-rise. • City center is already undergoing urban transformation.
Weaknesses	• Presence of dense housing and irregular urbanization • Housing strategies that ignore disaster scenarios • Not publicly announcing the action plans in the case of an earthquake • The lack of smart city applications
Threats	• City center is a first-degree seismic zone • Income pressure • Population of households
Opportunities	• A national agenda about earthquakes • Urban transformation legislation
Strategies	• Earthquake-oriented urban transformation strategies • Strategies involving the planning of green spaces as assembly areas

The issues voiced by the residents and the risk of earthquake in the city has directed and lighted the way of the study.

3.4. Location and Transportation Zones of the Green Spaces

In the first stage of the study, a maximum of 200 m traveling distance to the assembly areas was determined to evaluate the building blocks and population for which the assembly areas will serve. The 200m impact area of each assembly area and the building blocks in the impact area were determined [23] (Figure 8).

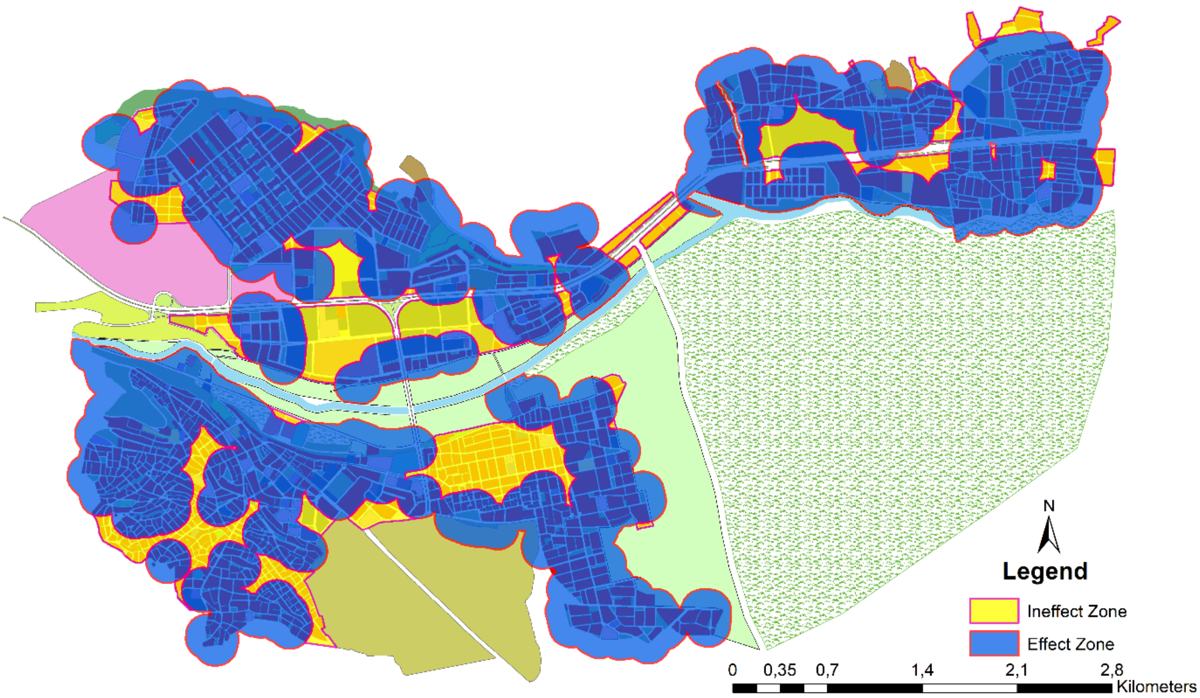

Figure 10. Impact areas of active green spaces.

The 200-m-long impact area of the active green spaces revealed that they were lacking in quantity and quality albeit their sufficiency in amount. According to the housing area/population index, after a possible disaster, 19017 people will not have access to an active green space in the 760,690m^2 housing area in Zone 122567 people will not have access to an active green space in the 942,560m^2 housing area in Zone 2 and 2971 people will not have access to an active green space in the 495100m^2 housing area in Zone 3.

Conclusion and Recommendations

Urban green spaces have numerous functions such as ecological, recreational, economic and social functions in an urban setting and serve as key elements that provide continuity of vital activities after an earthquake [23, 25]. This study aims to determine and guide the analysis of the assembly, shelter and evacuation areas for disaster management in Bingol, a first-degree seismic zone in Turkey.

The results revealed that issues had emerged in the shelter/assembly areas after the earthquakes that happened in the area, these areas were inadequate both in terms of location and quality especially in Bingol and there was a lack of planning prior to the earthquakes. However, the green spaces in the city are exceedingly sufficient in terms of carrying capacity.

Housing that is contrary to the zoning legislation and planning that contradict the rules and legislations are the main culprits of the losses due to the earthquakes in Turkey [26, 27]. Every area within the provincial borders is a first-degree seismic zone (Figure 9), which is a hypothesis supported by the earthquakes that already happened in Bingol.

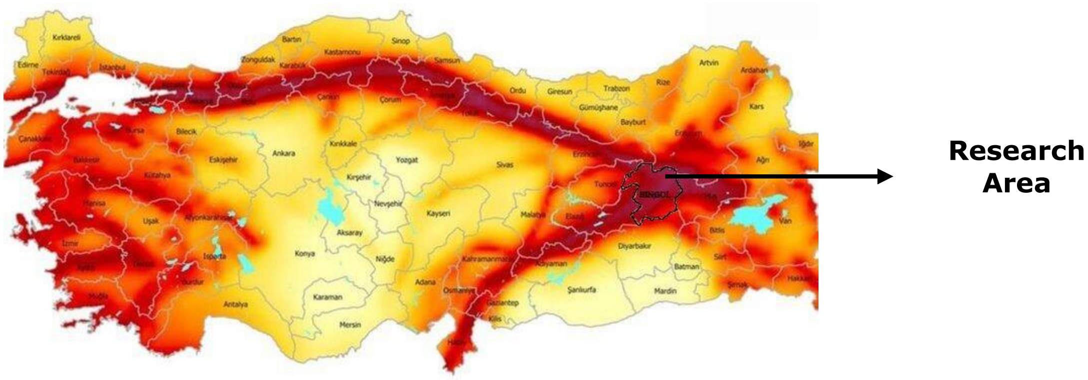

Figure 11. Seismic map of Turkey and Bingol [28].

The study discusses the quality, quantity and locations of the green spaces in the case of a potential earthquake and revealed that 39.14% (44555 people) of the population in the study area (113833 people) will not have access to the green spaces if an earthquake occurs. Moreover, the SWOT analyses revealed that the suitability of the available green area was debatable.

There were accessibility issues to the post-earthquake assembly areas in all three zones. The results revealed that for the access of the entire population to the assembly areas, planning of a total of 66832,5m^2 active green space comprising a 28525,5m^2 area for Zone 1, 33850,5m^2 area for Zone 2 and a 4456,5m^2 area for Zone 3 is needed. Moreover, the quality of the existing green spaces should be improved. The assembly areas should be revised to be convertible to areas for shelter tents and storage areas and infrastructure systems should be created to continue vital activities after an earthquake and meet food, water and shelter requirements. Further housing should not be allowed in the study area. Necessary research should be carried out and measures should be taken to add new green spaces. Moreover, evacuation corridors that are always open and will be used as life ways in the case of an earthquake should be arranged for the assembly areas.

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