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Scenario-Based Risk Assessment for Düzce Province

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Abstract

However, following the earthquake event of 12 November 1999, 80% of the built environment in the Düzce area had been destroyed and after the removal of the ruins, it was transformed into a huge open space. Subsequently, on 9 December 1999, Düzce was declared the provincial capital city, having 20 neighborhoods, 97 villages, and 7 districts under its administration. The main components featured in this study are 10 urban neighborhoods of Düzce that are all comprised of structural and natural environments located in the vicinity of the North Anatolian Fault Line. These areas are briefly defined and some benefits from their restructuring as viewed within this framework are presented. The most important result we obtained as a result of the earthquake scenario prepared for Düzce province; The fact that the ten neighborhoods we examined in the central district of Düzce are at a critical point on the fault line and Most of the buildings here were affected by the 17 August 1999 Izmit Gulf earthquake, If the buildings encounter a possible earthquake of this magnitude, it may be effective in the high number of dead and injured. Another important finding is; The main purpose of earthquake risk analyzes is to determine the number of tents that may be needed in advance and the area required for the tent. As a result; This study, which was carried out in the central district of Düzce province, will ensure that the necessary precautions are taken beforehand in case of a possible earthquake, and that the loss of life will be reduced to a minimum by acting more planned and faster at that time.

Keywords
Risk Analysis, Earthquake Scenario, Gulf of İzmit, Düzce

Düzce İli İçin Senaryo Bazlı Risk Değerlendirmesi

Özet

Düzce'de 12 Kasım 1999 depreminden sonra kentsel alandaki yapıların %80'i yıkılmış ve kalıntıların kaldırılmasından sonra büyük bir alanın etkilendiği görülmüştür. 9 Aralık 1999'da Düzce, idaresi altında 20 mahalle, 97 köy ve 7 ilçe bulunan il ilan edildi. Bu çalışmada öne çıkan ana bileşenler, Kuzey Anadolu Fay Hattı civarında yer alan, tümü yapısal ve doğal ortamlardan oluşan Düzce'nin 10 kentsel mahallesidir. Bu alanlar kısaca tanımlanmış ve risk değerlendirmelerine ait bulgular sunulmuştur. Düzce ili için hazırlanan deprem senaryosu sonucunda elde ettiğimiz en önemli sonuç; Düzce ili merkez ilçesinde incelediğimiz on mahallenin fay hattı üzerinde kritik bir noktada bulunması ve burada bulunan çoğu binanın 17 Ağustos 1999 İzmit Körfezi depreminden etkilenmiş olduğu, binaların yine bu şiddette olası bir depremle karşılaşması halinde ölü ve yaralı sayısının fazla olmasında etkili olabileceğidir. Başka önemli bulgu ise; deprem risk analizlerinin temel amacı olan önceden ihtiyaç duyulabilecek çadır sayısı ve çadır için gerekli olan alanın tespitidir. Sonuç olarak; Düzce ili Merkez ilçesi özelinde yapılan bu çalışma il genelinde düşünülerek olası bir deprem ile karşı karşıya kalınması durumunda önceden gerekli tedbirlerin alınmış olmasını ve o anda daha planlı ve hızlı hareket edilerek can kaybını minimum seviyeye inmesini sağlamış olacaktır.

Anahtar Sözcükler
Risk Analizi, Deprem Senaryosu, İzmit Körfezi, Düzce

1. Introduction

According to the United Nations, a disaster is defined as "any natural, technological, or human induced event that causes physical, economic, or social loss for humans, affects communities by stopping or interrupting normal life, and cannot be coped with by local facilities" (UNDRR 2009). In this case, a residential area may not recover from this negative event without support from outside. As urbanization rates are increasing worldwide, Globally, 29% of the world's population in 1950, 37.2% in 1975, 50.5% in 2010, and 54% in 2014 lived in cities. 59% in 2030 and 68.7% in 2050 are expected to live in cities (UN 2014). The impact rates from disasters are also increasing. These rates are further increasing in the locations where the urbanization has been unplanned and uncontrolled. The urbanization rate in Turkey had reached 88% in 2018 (URL-1 2021). In contrast to 24% in 1927 (Yüceşahin vd. 2004).

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This indicates how rapidly the urbanization rate is increasing in Turkey. Turkey's population had reached 84 680 273 in 2021. According to a population projection scenario, the population is expected to be 107 100 904 by 2080 (URL-2 2021). Industrialization and the opportunities offered by city life are assumed to be among the most important reasons for this increase. As Turkey is a country with a rapid population growth and high rate of urbanization, carrying out necessary disaster preparedness activities is important.

In Turkey, 66% of the land is located in active fault regions and 71% of the population continues to live in these areas (JICA 2004). Turkey is located on three major fault lines: the North Anatolian fault (NAF) line, the Eastern Anatolian fault (EAF) line, and the Western Anatolian fault (WAF) line. Almost the entire territory of Turkey is located within a seismic zone, with 70% of the total population living in seismic zones I and II and comprising 84% of the population in the metropolitan cities (Birinci 2013). Earthquakes cause 65% of the natural disaster-caused deaths in Turkey. This fact is the most obvious indication of the impact of major earthquakes among the natural disasters in Turkey (Akdur 2000). When the economic effects of earthquakes in Turkey are investigated, results show that after an earthquake, about 2% of the national income is consumed on reconstruction and other post-earthquake expenses (Avdar 2017). The necessity of urban transformation in Turkey emerged in 1999 after the 17 August Marmara/Gulf of İzmit and 12 November Düzce Earthquakes. Rapid application of urban transformation can reduce structural vulnerability and reduce loss of life and economic loss. With Law No. 6306 on the Transformation of Areas under Disaster Risk, adopted in 2012, urban transformation was included within the scope of legislation (Uslu ve Uzun 2014; Fahjan vd. 2015). In order to ensure that urban transformation is correctly planned and carried out, it is important to identify risky/hazardious locations for transformation, i.e., to determine the regions that can be affected by an earthquake and to identify unsafe structures within these areas. Forms listing basic urban characteristics, a physical inventory, the socio-economic status, and type of management of a city can be used to evaluate and reduce urban risks (Dodmana vd. 2017).

In residential areas, earthquakes and other disasters affect the society and the physical inventory negatively. For example, even when an earthquake event lasts for only a short time, the effects on the structures and people continue for many years (Karimzadeh vd. 2014). Scenario-based methods are used to predict the effects of an earthquake and its possible consequences. Possible effects can be estimated by simulating an earthquake scenario based on an actual situation. In this way, emergency measures to be applied against earthquake effects can be evaluated (Zhang vd. 2018). At the same time, scenario-building methods are often used to manage the uncertainty of technological outcomes and to shape prospective policies (Banuls and Salmeron 2007). Earthquake scenarios can also be created by applying seismic values. In the estimation of damage and losses, parameters that are evaluated in a seismic risk analysis include earthquake magnitude, focal depth, and distance from the source (Pavel and Vacareanu 2016). Today, studies on earthquake prediction are developing rapidly. Although scientific studies have been conducted on earthquake events, the exact timing of the earthquake cannot be predicted. However, looking at the long-term data, it is seen that there is no significant change in the frequency of earthquakes. According to the graph of records from the 1900s to 2019 (Figure 1), an average of 16 major earthquakes are expected in any given year. Statistically, 15 of the 16 earthquakes expected to occur during the year are expected to be around 7 in magnitude, and 1 of them is expected to be around 8 or larger. In the last 40-50 years, this generalization has been exceeded only 10-12 times; In the remaining years, it was observed that earthquakes were always around the expected average (URL-4 2022).

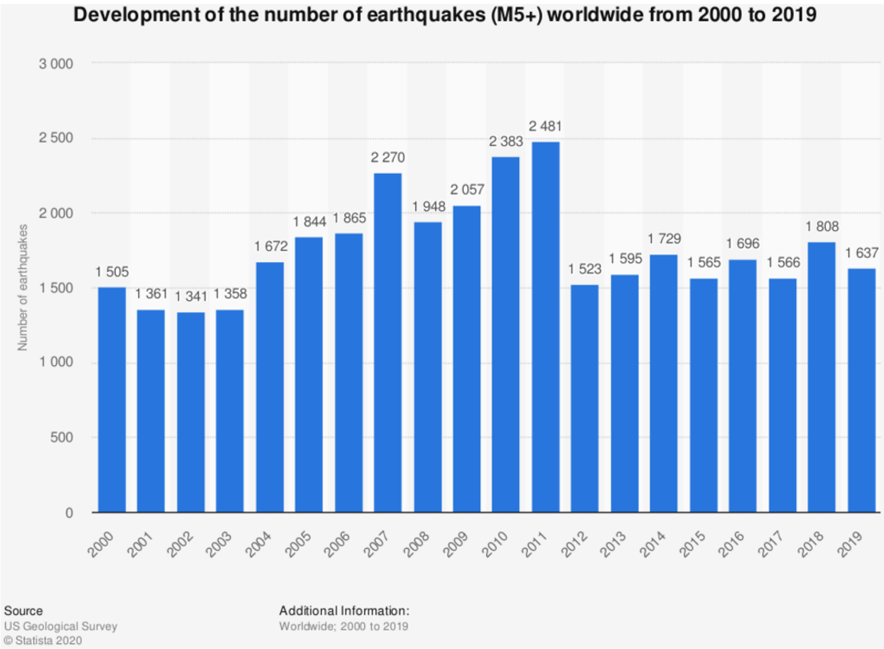


Figure 1: Development of the number of the earthquakes (M5+) worldwide from 2000 to 2019 (URL-4 2022)

According to Figure 1, 2010 was one of the years with the most earthquakes recorded until 2019. In 2010, 24 major earthquakes with a magnitude of 7 and above were experienced. In a significant part of the other years, the number of major earthquakes was less than 16. For example, there were only 6 major earthquakes in the world in 1989, and only 7 major earthquakes in 1988. As a result, there is no data showing that earthquakes increase or decrease significantly, and even in the event of a change in this direction, this trend cannot be seen as a predictable, predictable predictor of a large earthquake (URL-4 2022).

The inadequacy of interventions against accidents, fires, etc. That are common occurrences of daily life in cities can reveal similar deficiencies in the event of an earthquake and may serve as a reference for pre-earthquake preparations (Buldurur and Kurucu 2015).

Osuteye vd (2017) indicated that six sub-Saharan African cities had been increasingly affected by disasters and hazards on a daily basis. Some studies had been done on those living in sub-Saharan cities. In particular, the lack of keeping records in squatter settlements may have reduced the reliability of data at the national level. It was concluded that a regular registration system could be created on a national scale by providing data from accident records, police, fire, and hospital record data, and information from the mass media (Osuteye vd. 2017). It is important to plan the work to be done and the precautions to be taken before an earthquake occurs. In order for these planning studies to be carried out correctly, prospective scientific studies on the magnitude of a possible earthquake and how it will affect the population centers can help the authorities to determine the risks.

2. Aim and Scope

In the study, an earthquake scenario for the selected central neighborhoods was prepared by analyzing the history and risks of the area in terms of earthquakes. In light of the findings, after determining the number of structures and people to be affected and the designated tent city areas, the aim was to demonstrate the approach in terms of architectural and urban planning principles for the study area.

Within the scope of the study, by obtaining a structural inventory and recent earthquake information, an earthquake scenario was prepared for a total of ten neighborhoods located near the North Anatolian Fault Line, including those of Uzun Mustafa, Kültür, Şerefiye, Burhaniye, Nusrettin, Kiremitocağı, Camikebir, Cedidiye, Çay, and Azmimilli (Figure 2).

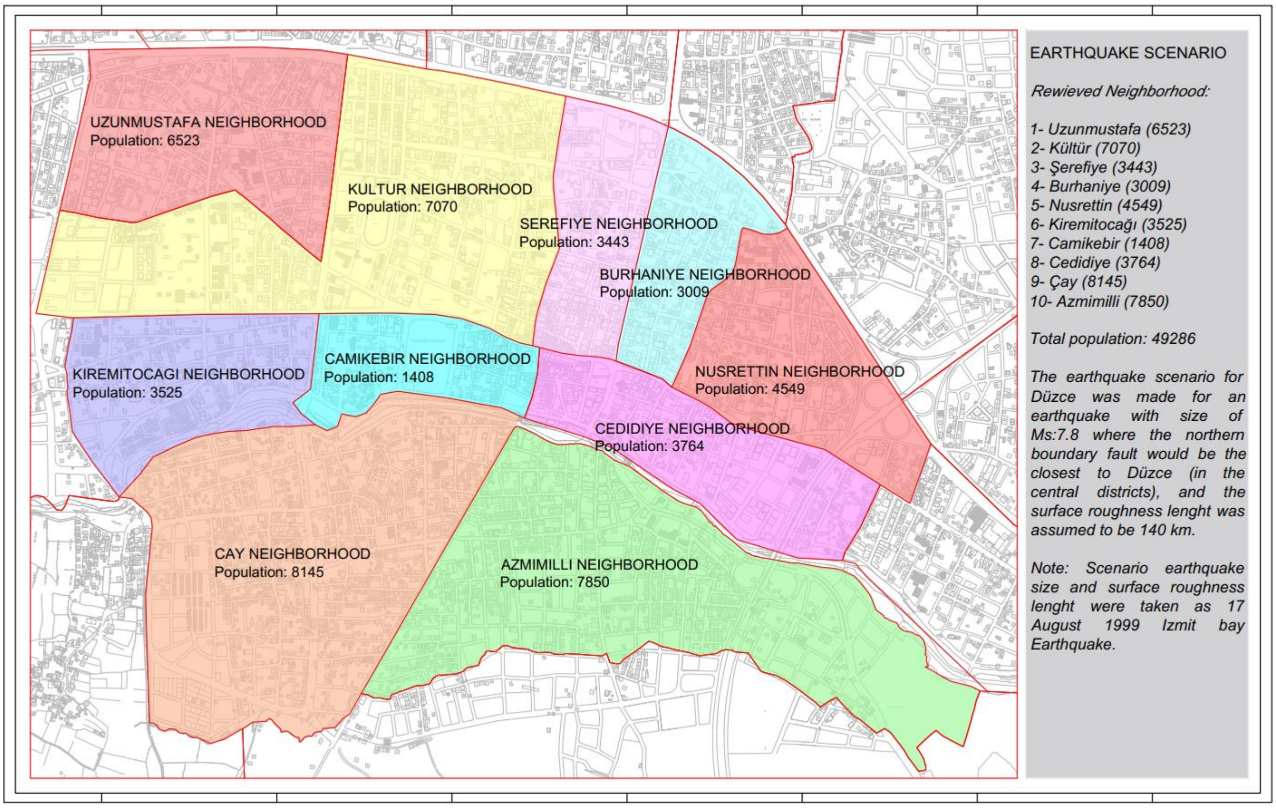


Figure 2: Düzce earthquake scenario study area

3. Material and Methods

3.1. Material

The main material of the study consists of information on the boundaries and structures of ten neighborhoods in Düzce that are located on a first-degree seismic zone, namely, the neighborhoods of Uzun Mustafa, Kültür, Şerefiye, Burhaniye, Nusrettin, Kiremitocağı, Camikebir, Cedidiye, Çay, and Azmimilli.

3.2. Methods

The first part is the introductory part. The earthquake, which is one of the natural disasters, and its impact areas are mentioned in general terms. The second part is the part where the purpose and scope are explained. What is aimed with the findings to be obtained in the study is explained. The third section is the material and method section. In the study, the criteria used by Özmen (2002) in the earthquake scenario study for Istanbul were used. It will be explained in more detail. In the fourth chapter, Düzce settlement, geological structure and seismicity, which consists of structural damage and existing land use after the Düzce earthquake, are explained. In the fifth chapter, Düzce earthquake scenario application was made. In the sixth section, the results section is given.

4. Settlement, Geological Structure, and Seismicity of Düzce

Düzce is a city located in the Western Black Sea Region of Turkey with a population of 387 844 From 1390 BC up to the present day it has been a settlement. It became an important center in the Roman and Byzantine periods and continued its status when it came under Ottoman rule in 1321. It has the advantage of being located between the two major cities of Istanbul and Ankara. However, after the earthquake of 12 November 1999 (hereafter referred to as the Düzce Earthquake), 80% of the structures of the settlement had been destroyed and the city lost its functionality (Erdoğan vd. 2004). With the decree of the Council of Ministers on 9/12/1999, Düzce was designated the provincial capital (central) city, which included 20 neighborhoods, 97 villages, and 7 districts.

Düzce is surrounded by the Black Sea in the north and by mountains in the east and south. The land is fertile and suitable for agriculture and animal husbandry, and the area continues to develop rapidly industrially. The population continues to increase, with an annual growth rate of about 1,5% in 2021 (URL-3 2022).

The settlement and its population are mainly concentrated in and around the city. In Figure 2, the position of Düzce Province and neighborhoods investigated in this study is.

The provincial center of Düzce is located on a fertile plain having a slope of approximately 3°, which is directed toward the southwest. The Asar and Melen Streams passing through the city center have contributed to the formation of its soil with a great extent of silt and clay. For this reason, the depth of the groundwater is 2.5–3.5 m below the surface, (Özaslan vd. 2001). As the level of underground water is close to the surface and the the soil is saturated, a possible increase in earthquake severity may arise. The people settled here live mostly in the plain area of Düzce. The vulnerability of structures and humans may be higher in the event of possible earthquakes because of the increased density of the ground.

All of Düzce Province remains under the influence of one of Turkey's most important tectonic structures, the 1200-km long strike-slip NAF system. The NAF line is divided into a separate segment as the Düzce fault. The Düzce fault line, located between the settlements of Akyazı and Kaynaşlı, is 70-km long in total, (Erdoğan vd. 2004). The Düzce Earthquake occurred on the Düzce fault and Düzce Province suffered heavy damage from this earthquake.

Active faults include the NAF line passing through the Düzce residential area in addition to the Hendek, Çilimli, and Yığılca faults present in the vicinity of Düzce. An earthquake along the NAF line can also cause large earthquakes by affecting the Düzce fault and its immediate vicinity. The fact that Düzce is located in a region among such intense seismic fault lines demonstrates the vital importance of pre-earthquake studies.

4.1. Structural Damage

Özmen (2002) indicated that the intensity of an earthquake is determined by its effects on structures, nature and people. This effect varies depending on the earthquake's magnitude, focal depth, distance, earthquake resistance of structures, local soil structure and geology. The greatest structural damage from the Düzce Earthquake occurred in the Düzce urban central district and in the Kaynaşlı district. Despite its position along the center of the surface rupture, not much structural damage occurred in the Dariyeri Hasanbey village in Kaynaşlı due to its low-rise (one- and two-storey) buildings and separate houses in garden layouts. This fact shows that the most important vulnerable parameters for Düzce and Kaynaşlı structures in particular are multi-storey and poor-quality buildings. The distribution of structural damage in Düzce and its vicinity as a result of the Düzce Earthquake is presented in Table 1.

Table 1: Post-Düzce Earthquake distribution of damaged houses and workplaces by provinces (Özaslan vd. 2001)

Province	Collapsed-Extensive Damage		Moderate Damage		Slight Damage	
	Residence	Workplace	Residence	Workplace	Residence	Workplace
Bolu	2532	218	5745	757	5736	828
Düzce	12513	2478	9065	2066	10222	1446
Eskişehir	10	2	71	10	84	10
İstanbul	0	0	2059	612	2855	700
Karabük	0	0	74	0	99	1
Kocaeli	2355	608	10260	1599	11055	1502
Sakarya	5675	1089	6270	1804	8576	1036
Yalova	3511	92	3969	99	1364	104
Zonguldak	108	6	312	3	953	8
Total	**26704**	**4493**	**37825**	**6950**	**40944**	**5635**

Table 1 shows the proportional distribution of the damage caused by the Düzce Earthquake to Düzce and nearby cities. In terms of collapsed or extensively damaged residences, Düzce Province suffered the most severe damage in residential areas (47%) compared to the collapsed or extensively damaged housing among the nearby cities. However, it also had the most (55%) collapsed or extensively damaged workplaces. The percentage distribution of those who died in the Düzce Earthquake was 6% in Bolu, 93% in Düzce, 0.4% in Sakarya, 0.1% in Kocaeli, and 0.1% in Yalova. The highest mortality rate was observed in the Düzce urban central district and the Kaynaşlı district (Özaslan vd. 2001).

4.2. Current Land Use of Düzce Province After the Earthquake

The 17 August 1999 Marmara/Gulf of İzmit and 12 November 1999 Düzce Earthquakes caused great damage to the city. After the earthquakes, the urban neighborhoods that had the most damage were evacuated and the inhabitants were settled in residential areas in nearby villages in one- and two-storey housing zones with garden layouts. To reduce the effects of the earthquakes, the former Ministry of Public Works and Settlement built 7,000 permanent residences in the mountainous area in the northeastern section of Düzce (Özmen 2000). According to Figure 3, the urban post-earthquake development between 2000 and 2010 was directed towards the geologically earthquake-resistant suburb areas and displayed a splash development.

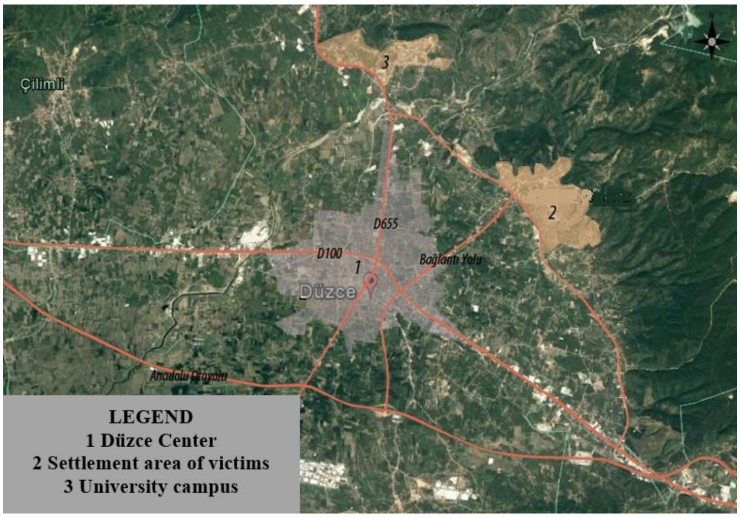


Figure 3: Post-Earthquake splash development of Düzce

5. Earthquake Scenario for Düzce Province

Earthquake scenarios can also benefit from previous earthquake information as a basis for damage reduction studies to estimate possible post-earthquake effects and capacity increases and to facilitate administrative decision-making. In this study, the calculation tables used in the earthquake scenario for the Düzce urban central district were derived from the study "Earthquake Scenario for Istanbul Province" (ATN İMAR 2013). The severity scales given in the table were determined according to the severity of previous earthquakes and the current restoration status of the neighborhoods. The earthquake scenario was prepared for ten neighborhoods located in the Düzce Municipality central district.

These included the neighborhoods of Uzun Mustafa, Kültür, Şerefiye, Burhaniye, Nusrettin, Kiremitocağı, Camikebir, Cedidiye, Çay, and Azmimilli. The earthquake scenario was designed for a Mw 7.8 magnitude earthquake which would follow the lines of the northern boundary faults nearest to the central Düzce neighborhoods, and the surface rupture length was assumed as 140 km. The magnitude and the surface rupture length of the scenario earthquake were taken as those of the earthquake of 17 August 1999 (hereafter referred to as the Gulf of İzmit Earthquake).

Table 2 shows the percentages of extensive, moderate, and slight damage of the affected houses in the Gulf of İzmit Earthquake. The ratios given in Table 3 were used in estimating the housing damage in the study. According to Table 3, for example, in an area affected by an earthquake with a magnitude of IX, 15.7% of the houses might be extensively damaged, 18% moderately damaged, and 23% slightly damaged (ATN İMAR 2013).

Table 2: Damage rates in the regions affected by the Gulf of İzmit Earthquake (Özmen 2002)

Intensity (MSK)[1]	Extensive Damage and Collapse (%)	Moderate Damage (%)	Slight Damage (%)
VI	0.04	0.22	0.24
VII	0.91	2.67	2.59
VIII	2.82	4.41	5.31
IX	15.70	18.16	22.75
X	33.06	15.29	19.14

The number of dead in the earthquake scenario was calculated using the 26% rate obtained by dividing the death toll in the Gulf of İzmit Earthquake by the number of the extensively damaged houses, whereas the number of injured was calculated by taking the number 2.515 into account (obtained from the ratio of injured over the death toll in the Gulf of İzmit Earthquake). Furthermore, the number of people left exposed was calculated according to the number household members (obtained by considering the extensively and moderately damaged housing). Generally it was accepted that 75% of the injured in an earthquake could be treated as out-patients, and 25% hospitalized (Özmen 2002). The number of residents in the district was found by dividing the number according to the population census into the household size determined by Turkish Statistical Institute (TurkStat) data.

The possible outcomes in the event of an earthquake of 7.8 magnitude according to population and household data are represented in Table 3. The table presents the magnitudes of an earthquake that could affect the neighborhood population and the housing damage status. The calculated housing data, death toll, number of injured and exposed, and the tent requirements are presented in the table.

Table 3: Damage status results in the Düzce central district neighborhoods based on the earthquake scenario

Name of Neighborhood	Magnitude	Population (2021)	Number of Households	Extensively Damaged Households	Moderately Damaged Households	Slightly Damaged Households	Number of deaths	Number of Injured	Number of Exposed	Tent requirements	Ambulatory Treatment	Hospital Treatment
Uzun Mustafa	VI	6523	2038	1	4	5	1	3	17	5	2	1
Kültür	VII	7070	2209	20	59	57	5	13	253	79	10	3
Şerefiye	VIII	3443	1076	30	47	57	8	20	249	78	15	5
Burhaniye	VIII	3009	940	27	41	50	7	17	218	68	13	4
Nusrettin	VIII	4549	1422	40	63	75	10	26	329	103	20	7
Kiremitocağı	VII	3525	1102	10	29	29	3	7	126	39	5	2
Camikebir	IX	1408	440	69	80	100	18	45	477	149	34	11
Cedidiye	IX	3764	1176	185	214	268	48	121	1274	398	91	30
Çay	IX	8145	2545	400	462	579	104	261	2758	862	196	65
Azmimilli	IX	7850	2453	385	445	558	100	252	2658	831	189	63
Total		**49286**	**15402**	**1166**	**1446**	**1778**	**304**	**765**	**8359**	**2612**	**574**	**191**

According to the results in Table 3, it is probable that there would be difficulties in reaching the neighborhoods in a possible earthquake. The evaluation concluded that the proposed death toll would be 304, and of a total of 765 injured, those given ambulatory care would be 574, and those hospitalized 191. There would be 8359 people left exposed, with 1166 buildings collapsed, 1446 moderately damaged, and 1778 slightly damaged. Rescue work would be difficult because the main or side streets in residential areas would be blocked due to the collapsed buildings. There would be power outages and the need for drinking water would arise as a result of the damage to the infrastructure. Hospitals might also suffer from damage.

In the earthquake scenario study conducted in Kırşehir, it was estimated that a total of 90,337 buildings would suffer between 2% and 5% heavy damage and very heavy damage, and 14% and 26% moderate and light damage. It is estimated that the population of Kırşehir province is 225,197 and there will be losses between 17 and 57 people. It was found that the number of injured in the hospital would vary between 42 and 138 people (Işık vd. 2019). In the earthquake scenario study conducted for the Zeytinburnu district of Istanbul, 43.78% of the 17,219 buildings were found to be slightly damaged, 35.60% moderately damaged, 16.40% heavily damaged, and 4.22% collapsed. In the study, comparative loss estimation data of different earthquake scenarios are given (Karaman ve Şahin 2009).

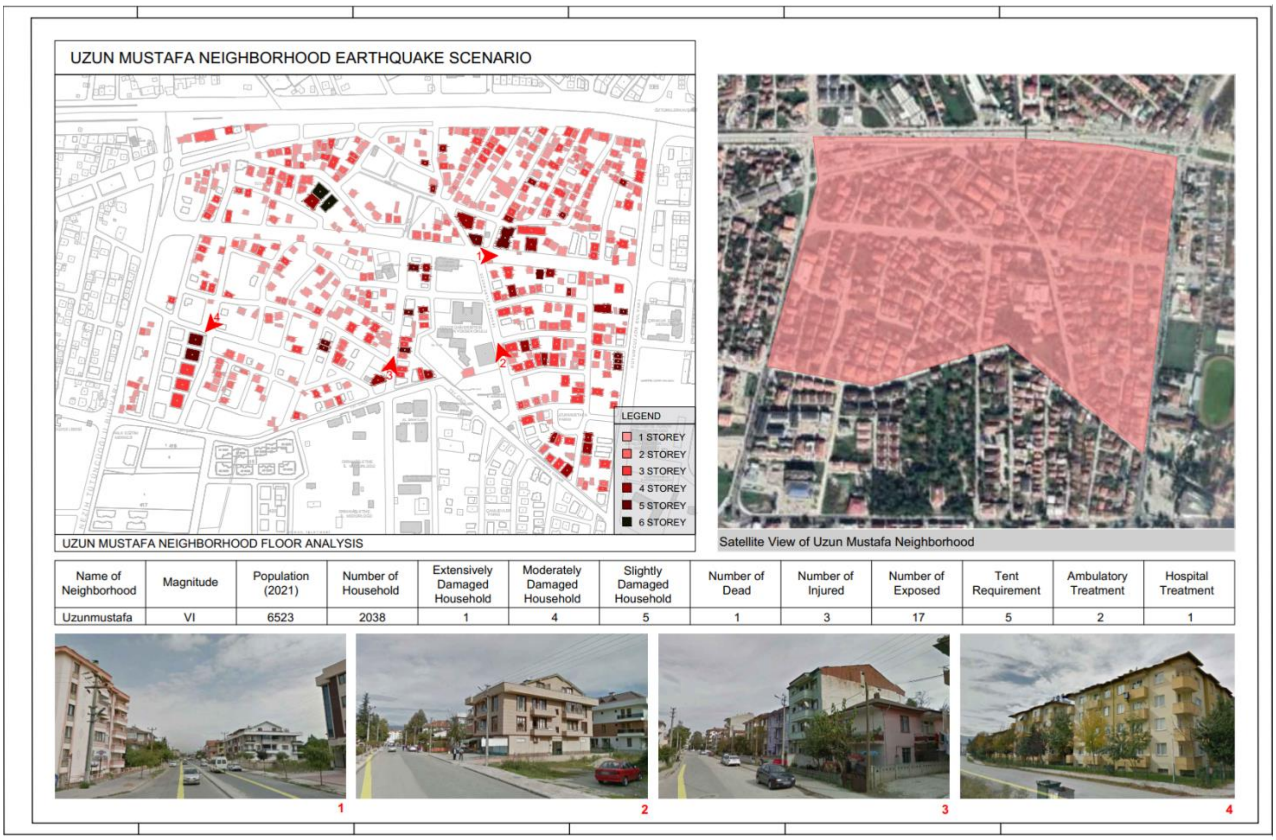
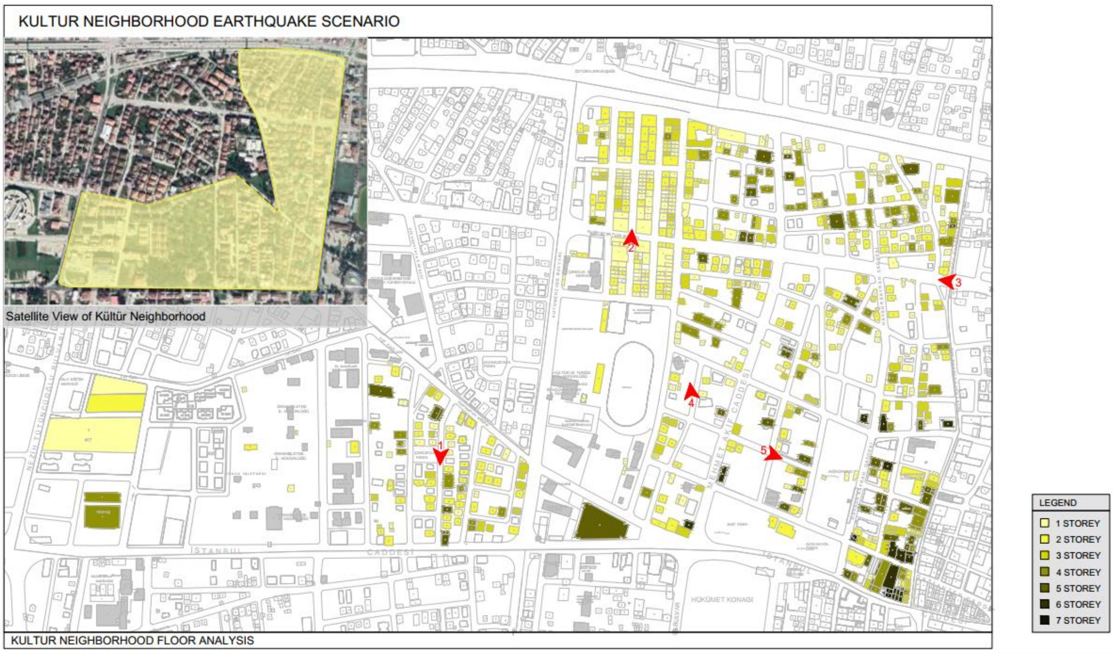


Figure 4: Uzun Mustafa Neighborhood earthquake scenario

Figure 4 gives a satellite image showing the borders of Uzun Mustafa neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. Most of the buildings in the neighborhood (75%) consist of one and two storeys. There are 539 buildings in the neighborhood, including 250 one-storey, 154 two-storey, 94 three-storey, 25 four-storey, 14 five-storey and 2 six-storey buildings. No building in the neighborhood consists of more than six storeys. According to the prepared earthquake scenario, one extensively damaged, four moderately damaged, and five slightly damaged residences would be found in the neighborhood. The number of dead was calculated as one, whereas the number of injured was three, and the number of exposed people was 17. The required number of tents was predicted to be five.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Kultur	VII	7070	2209	20	59	57	5	13	253	79	10	3

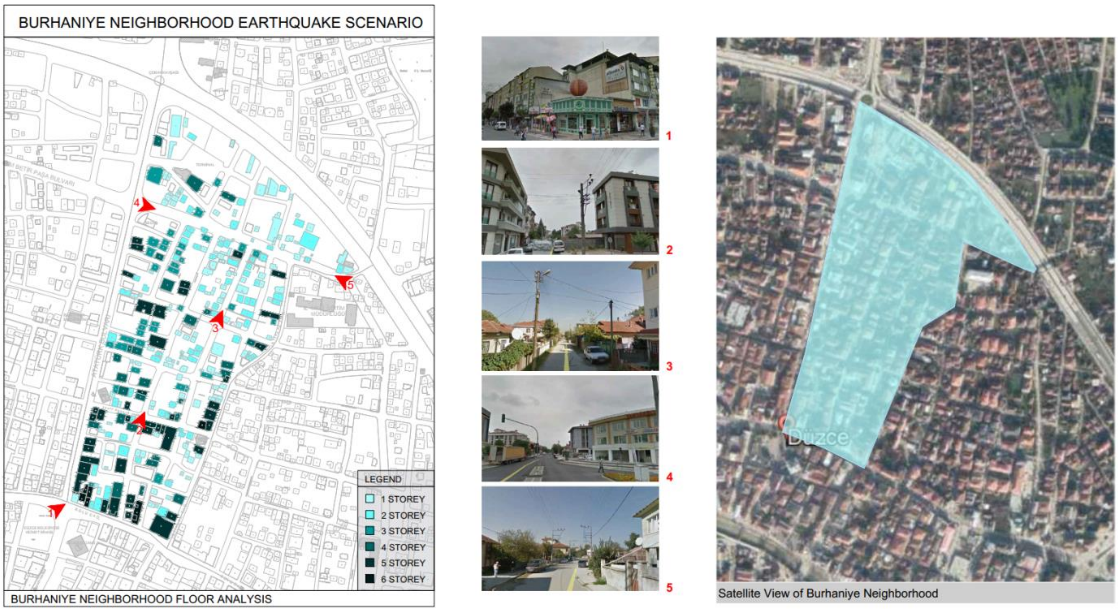
Figure 5: Kültür neighborhood earthquake scenario

There are a total of 663 buildings in Kültür Neighborhood. Among these, 223 are one-storey, 228 two-storey, 84 three-storey, 71 four-storey, 39 five-storey, 15 six-storey, and 3 seven-storey buildings. No buildings in the neighborhood are more than seven storeys. Most (68%) of the buildings have one or two storeys. A satellite image showing the borders of Kültür Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood are presented in Figure 5. According to the prepared earthquake scenario, 20 extensively damaged, 59 moderately damaged, and 57 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as five, whereas the number of injured was 13, and the number of exposed people 253. The required number of tents was predicted to be 79.

Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Serefiye	VIII	3443	1076	30	47	57	8	20	249	78	15	5

Figure 6: Şerefiye Neighborhood earthquake scenario

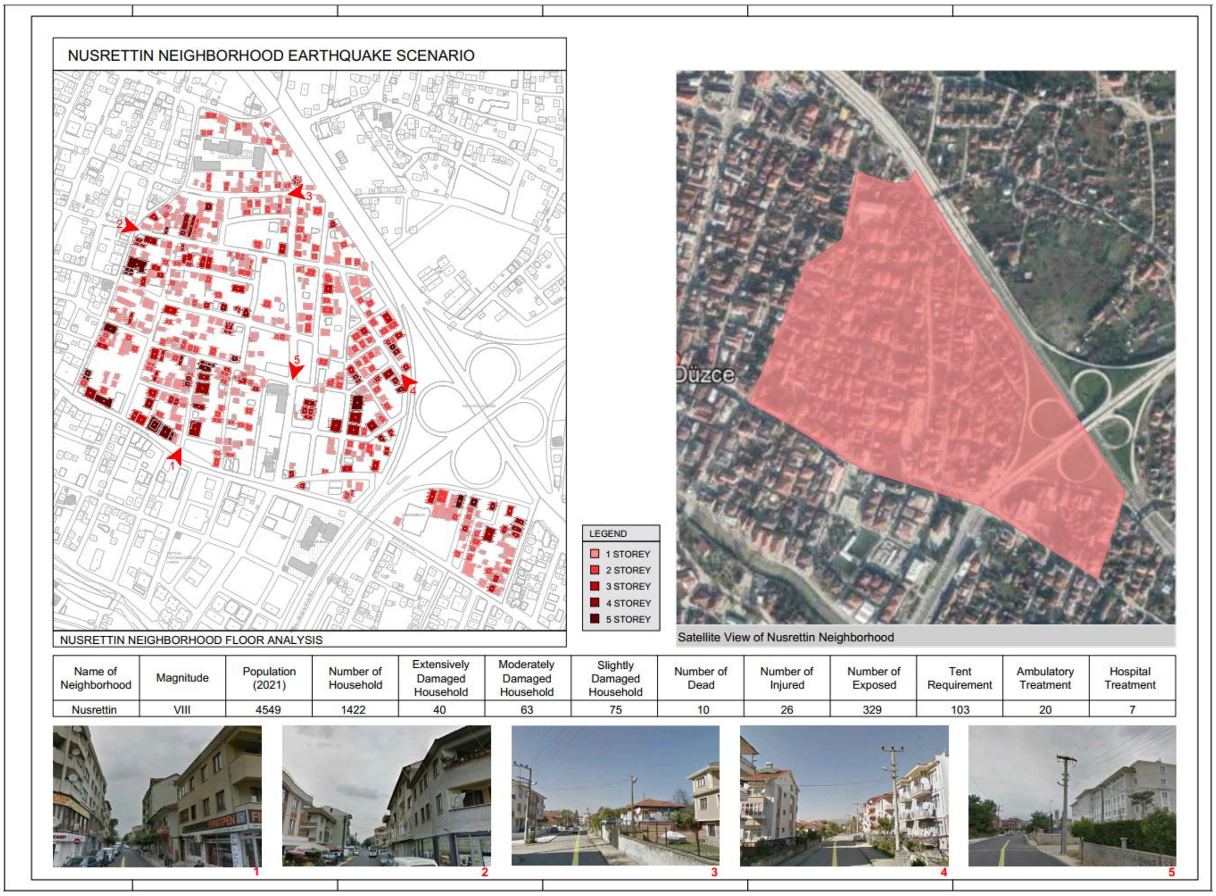
There are a total of 334 buildings in Şerefiye Neighborhood. Among these, 102 are one-storey, 81 two-storey, 68 three-storey, 41 four-storey, 29 five-storey, 10 six-storey, and 3 seven-storey buildings. No buildings in the neighborhood are more than seven storeys and 55% are one- and two-storey buildings. Figure 6 includes a satellite image showing the borders of Şerefiye Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. According to the prepared earthquake scenario, 30 extensively damaged, 47 moderately damaged, and 57 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as eight, the number of injured as 20, and the number of exposed people as 249. The number of tents required was predicted to be 78.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Burhaniye	VIII	3009	940	27	41	50	7	17	218	68	13	4

Figure 7: Burhaniye Neighborhood earthquake scenario

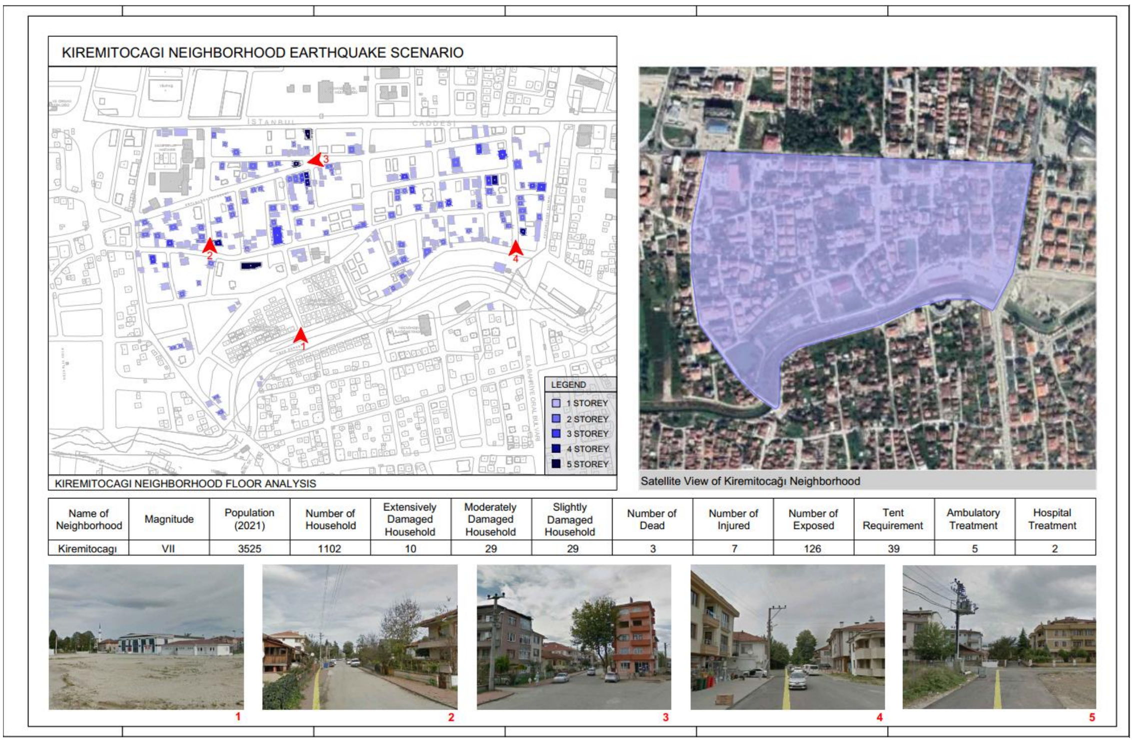
In Figure 7, a satellite image showing the borders of Burhaniye Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood are presented. There are a total of 310 buildings in the neighborhood. Among these 127 are one-storey, 70 two-storey, 36 three-storey, 27 four-storey, 42 five-storey, and 7 six-storey buildings. No buildings in the neighborhood are more than six storeys, and one- and two-storey buildings make up 64% of the buildings. According to the prepared earthquake scenario, 27 extensively damaged, 41 moderately damaged, and 50 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as seven, the number of injured as 17, and the number of exposed people as 218. The number of tents required was predicted to be 68.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Nusrettin	VIII	4549	1422	40	63	75	10	26	329	103	20	7

Figure 8: Nusrettin Neighborhood earthquake scenario

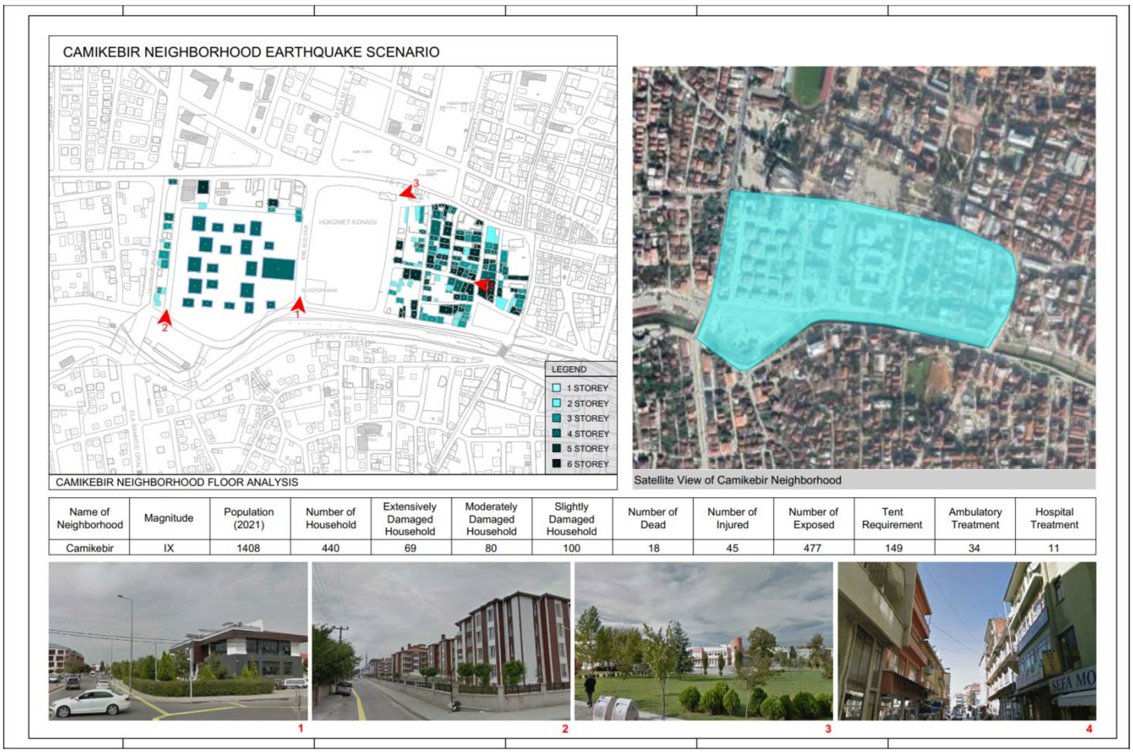
Figure 8 presents a satellite image showing the borders of Nusrettin Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. There are a total of 547 buildings in the neighborhood, including 280 one-storey, 152 two-storey, 60 three-storey, 37 four-storey, and 18 five-storey buildings. No buildings in the neighborhood are more than five storeys, with the majority (79%) consisting of one- and two-storey buildings. According to the prepared earthquake scenario, 40 extensively damaged, 63 moderately damaged, and 75 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 10, the number of injured as 26, and the number of people left exposed as 329. The required number of tents was predicted to be 103.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Kiremitocagı	VII	3525	1102	10	29	29	3	7	126	39	5	2

Figure 9: Kiremitocağı Neighborhood earthquake scenario

Figure 9 gives a satellite image showing the borders of Kiremitocağı Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. There are a total of 353 buildings in the neighborhood, including 258 one-storey, 75 two-storey, 12 three-storey, 5 four-storey, and 3 five-storey buildings. There are no buildings of more than five storeys in the neighborhood, with 94% comprised of one- and two-storey buildings. According to the prepared earthquake scenario, 10 extensively damaged, 29 moderately damaged, and 29 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 3, the number of injured as 7, and the number of people left exposed as 126. The required number of tents was predicted to be 39.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Camikebir	IX	1408	440	69	80	100	18	45	477	149	34	11

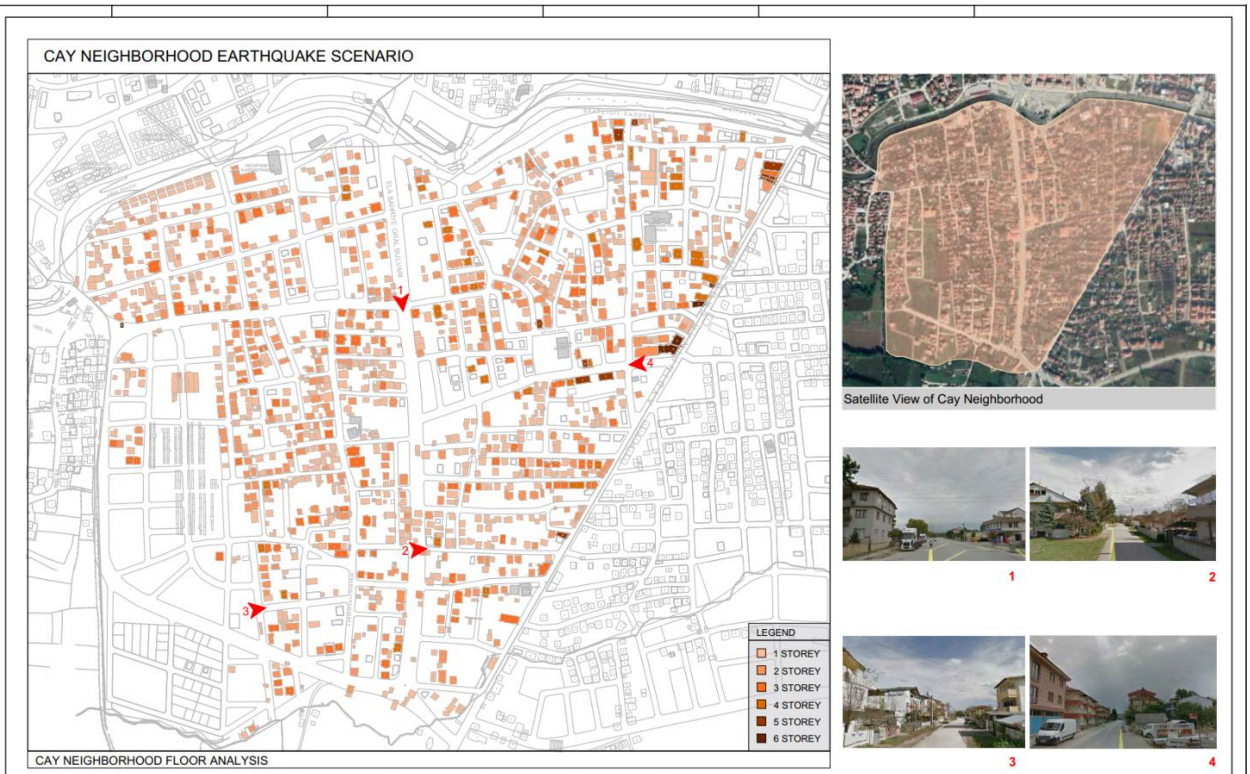
Figure 10: Camikebir Neighborhood earthquake scenario

Figure 10 presents a satellite image showing the borders of Camikebir Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. There are a total of 304 buildings in the neighborhood. Among these, 104 are one-storey, 96 two-storey, 41 three-storey, 37 four-storey, 21 five-storey, 4 six-storey, and 1 seven-storey. No buildings in the neighborhood are more than seven storeys, with 66% consisting of one- and two-storey buildings. According to the prepared earthquake scenario, 69 extensively damaged, 80 moderately damaged, and 100 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 18, the number of injured as 45, and the number of people left exposed as 477. The required number of tents was predicted to be 149.

Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Cedidiye	IX	3764	1176	185	214	268	48	121	1274	398	91	30

Figure 11: Cedidiye Neighborhood earthquake scenario

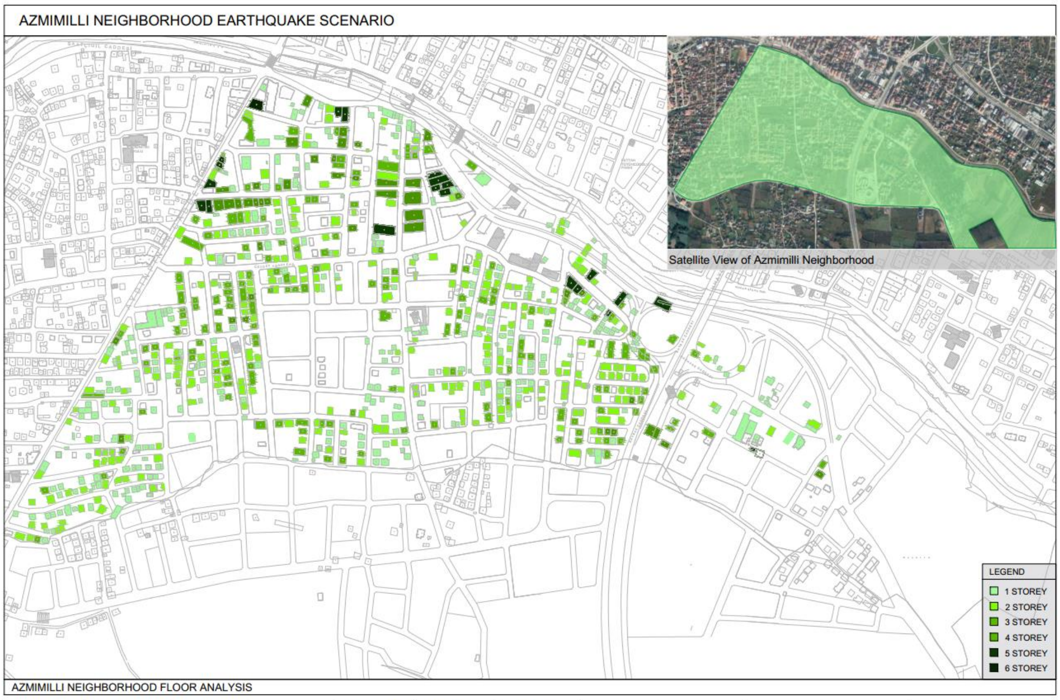
In Figure 11, a satellite image showing the borders of Cedidiye Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood are presented. There are a total of 393 buildings in the neighborhood, including 123 one-storey, 96 two-storey, 52 three-storey, 70 four-storey, 42 five-storey, 6 six-storey, 3 seven-storey, and 1 eight-storey. No buildings in the neighborhood are more than eight storeys, with 56% of the buildings made up of one- and two-storey buildings. According to the prepared earthquake scenario, 185 extensively damaged, 214 moderately damaged, and 268 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 48, the number of injured as 121, and the number of exposed people as 1274. The number of tents required was predicted to be 398.



Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Cay	IX	8145	2545	400	462	579	104	261	2758	862	196	65

Figure 12: Çay Neighborhood earthquake scenario

Figure 12 presents a satellite image showing the borders of Çay Neighborhood, a map section with a storey analysis, and some photographs of the neighborhood. There are a total of 1465 buildings in the neighborhood. Among these, 920 are one-storey, 352 two-storey, 143 three-storey, 35 four-storey, 10 five-storey, and 5 six-storey buildings. There are no buildings in the neighborhood with more than six storeys, and 87% are made up of one- and two-storey buildings. According to the prepared earthquake scenario, 400 extensively damaged, 462 moderately damaged, and 579 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 104, the number of injured as 261, and the number of exposed people as 2758. The number of tents required was predicted to be 862.



AZMIMILLI NEIGHBORHOOD FLOOR ANALYSIS

Name of Neighborhood	Magnitude	Population (2021)	Number of Household	Extensively Damaged Household	Moderately Damaged Household	Slightly Damaged Household	Number of Dead	Number of Injured	Number of Exposed	Tent Requirement	Ambulatory Treatment	Hospital Treatment
Azmimilli	IX	7850	2453	385	445	558	100	252	2658	831	189	63

Figure 13: Azmimilli Neighborhood earthquake scenario

In Figure 13, a satellite image of the borders of Azmimilli Neighborhood and a map section with a storey analysis are presented. There are a total of 813 buildings in the neighborhood, including 329 one-storey, 266 two-storey, 155 three-storey, 42 four-storey, 19 five-storey, and 2 six-storey buildings. No buildings in the neighborhood are more than six storeys, with most (73%) consisting of one- and two-storey buildings. According to the prepared earthquake scenario, 385 extensively damaged, 445 moderately damaged, and 558 slightly damaged residences would be found in the neighborhood. The number of dead was calculated as 100, the number of injured as 252, and the number of exposed people as 2658. The number of tents required was predicted to be 831.

6. Conclusion

In a predictive earthquake in Düzce, it was estimated that there would be 304 dead, and 765 injured individuals, and 1166 extensively damaged, 1446 moderately damaged, and 1778 slightly damaged residences. The people left exposed due to this damage would number 8359, and 2612 tents would be needed to accommodate them. If damage due to secondary disasters and damage to infrastructures were added to these numbers, the damage estimate would be even greater.

Damages to road, brıdge, port, drınkıng water and wastewater networks, electrıcıty network, sewage, natural gas that may occur as a result of the scenario earthquake could not be included in the scenario due to lack of data. In a big earthquake that may affect Düzce (Scenario earthquake), in addition to the jolts to be caused by strong ground movements, damages may also occur due to landscape, ground surfaces, lıquıdatıons, tsunamı, fıre, flood, dangerous materıals leaks. Before making disaster planning, it is necessary to estimate the damages that may occur in the above-mentioned issues as a result of the scenario earthquake and to prepare the plan accordingly. In order to make these predictions, detailed databases and long-term teamwork are needed.

Using earthquake scenarios to estimate the magnitude of the damage that might occur during an earthquake, the situation likely to be faced in the event of a possible disaster can be realized. These studies should not be considered as absolute scientific studies because naturally, many uncertainties and errors are involved. The aim of these studies is to help authorities take all the necessary technical, administrative, and legal precautions and to carry out more realistic planning to ensure that the community recovers with the least amount of damage and physical loss in the event of a possible disaster. Awareness of earthquakes as the most frequent type of natural disaster in Turkey must be emphasized. Moreover, within the context of ensuring coordination during a possible large earthquake, the data created in the light of planning studies in Düzce can perceptibly contribute to application areas in the future.

It has been stated that there are many factors affecting the earthquake phenomenon in the study adapted for Düzce, by taking this study as an example with the earthquake scenario study conducted for the province of Istanbul. However, in both studies, it is aimed to help the authorities take all the necessary technical, administrative and legal measures and make their planning more realistically in order for the society to survive a possible disaster with the least damage and physical loss. According to the Istanbul earthquake scenario with a total population of 10033478 in 2000, calculated on the basis of the intensity and numerical ratios of the 17 August 1999 Izmit Bay Earthquake, which is one of the major earthquakes, the number of dead will be 32536, the number of injured will be 81828, the number of heavily damaged houses will be 125137, the number of moderately damaged houses will be It is estimated that the number of houses with light damage will be 169473 and 206187 with light damage, and 1219685 people will be exposed due to these damages and 294610 tents will be needed (Özmen 2002). However, these data were calculated only for the provincial borders, as mentioned in the earthquake scenario of Düzce province. Better results can be obtained if the damages in the surrounding provinces on the same fault line are taken into account.

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