



Research Article

Turkey's disaster and emergency profile: Settlement information and analysis of earthquake parameters

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ABSTRACT

Thousands of people die and billions of dollars of financial loss occur every year in Turkey and the world due to natural disasters. Although many reports and regulations have been prepared to eliminate the negative situations caused by natural disasters, changing climate conditions, technological advances and social habits require these measures to be developed, renewed, and made sustainable over time. In this context, creating a data pool to prevent the loss of life and property caused by disasters and performing the necessary studies becomes even more important. In addition to disaster-related information, this data pool should include physical and geographic information such as the distances of people's communal living areas to the administrative centers, the population in these living areas, and transportation facilities. In this study, a disaster and emergency profile for Turkey has been tried to be presented. For this, the distances of all settlements to the districts and provincial centers they are connected to, the transportation times and speeds of these centers, the altitudes of the settlements, earthquake zone numbers, earthquake hazard map parameters, populations, and areas were compiled or calculated. The evaluation was made separately according to the districts and provinces, taking into account the determined limits. Based on the profile reached at the end of the study, suggestions were developed for planning and projects for disasters and emergencies.

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1. Introduction

Important legal regulations and very expensive measures have been implemented since the early 2000s to reduce the effects of disasters and emergencies in Turkey (Tüney 2015). However, the desired result has not been reached yet. Despite measures being taken in disasters originating from geological, climatic, biological, technological, and social reasons, negative consequences continue to be encountered (President's Annual Program 2020). For this reason, it is aimed to obtain data including the whole country that will contribute to achieving the intended results.

Turkey is located in a geography that is affected by some of the sources of disaster and emergencies around the world less, and also some of them more (AFAD 2014). By combining the definitions given by Şahin

(2013), Ergüney (2007), Özşahin (2013), Akıncı et al. (2010), Altun (2018), and Birinci and Yılmaz (2020), a comprehensive definition of disaster can be given as "Unavoidable, natural or human-induced, mass injury, and mass death, major loss of property or environmental damage". Disaster sources (and subgroup numbers) can be categorized into 4 main groups and 24 subgroups such as biological (4 subgroups including epidemic disease, insect invasion, animal invasion, and erosion), earthquake and water events (6 subgroups including earthquake, volcanic eruption, dry mass movement, crashes from space to earth, flood-flood and including wet mass movement), atmospheric and climatic events (7 subgroups including storm, rainfall, lightning strike, extreme cold, extreme heat, drought, and fire) and human-related incidents (7 subgroups including mining accidents, gun accidents, transportation accidents, fire,

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war, terror, and mass migration). For an incident to be considered a disaster”, there should consider some determining limit values such as at least 10 dead or 50 injured, become at least 100 people affected, effective in general life, historical value, and at least 20 hectares of burned area in case of a forest fire. No such preliminary assessment isn't made for an "emergency”.

7628 people died in natural disasters and 411 million people were affected by disasters only in 2016 (Gökçe et al. 2008; Ersoy et al. 2017). The five major disasters and deaths that caused the most casualties in 2017 were in South Asia (flood) 2700, Iran and Mexico (earthquake) 999, Sierra Leone (landslide) 500, and Colombia (flood + landslide) 329, with a total death toll of 4498. (Erhan et al. 2018).

Considering all disasters in Turkey, it is seen that natural disasters have a distinct impact. In approximately 100 years after the beginning of the 20th century, in natural disasters such as earthquakes, landslides, floods, rock falls, and avalanches, 87000 people died, 210000 people were injured and 650654 buildings were destroyed or severely damaged (Ergüney 2007), in approximately 10 years after 1990, 19964 people died, 55802 people were injured, 1078200 people were left homeless, 19494300 people were affected by disasters, and an economic loss of 17.46 billion US dollars (average 1.74 billion \$/year) are recorded (JICA 2004). On the other hand, Keleş (2002) gives the number of people who lost their lives as a result of natural disasters in Turkey between the years 1930-2020 as 100000 and the number of damaged houses as 600000. If the Elazığ-Malatya earthquake (6.8 magnitudes, 41 dead), İzmir-Samos earthquake (6.6 magnitudes, 117 dead), and Van-Bahçeşarayı avalanche fall (42 dead) are added to these, the importance that should be given to disasters and emergencies in Turkey emerges. In the avalanche incident in Van, 5 of the 7 first people who were under the avalanche died. In the comprehensive intervention to save the remaining 2 people, when there is an avalanche blasted again, 35 more people from the rescue team died. The absence of any means of communication at the scene increased the death toll.

Considering the case studies in the form of very short notes presented above in the world and Turkey, it is understood that more comprehensive studies and a data repository are needed to develop extensive planning and applicable projects for disasters and emergencies. Experience has shown that 75% of survivors survive when rescue and debris removal efforts are initiated 30 minutes after the disaster (Dedeoğlu 2017; Erkal and Değerliyurt 2013), 95% of the cases in the centers in the first 10 minutes, 97% of the rural cases are reached within 30 minutes. Although the 20-30 minutes access time is considered reasonable for disasters, it should be taken into account that this time is too long in emergencies. Today there are many polymer-based materials in workplaces and vehicle manufacturing. In environments with polymer-based materials, the spread of the fire to the whole environment takes place in the order of 2-3 minutes. Therefore, it should be aimed to reduce the response time to emergencies due to burning in workplaces and vehicles to much less than 10 minutes.

For this purpose, in this study, a disaster and emergency profile have been tried to be created from the data prepared by taking the current situation in Turkey into consideration to be used in disaster and emergency preparation studies. It has been tried to determine how it will be possible to respond quickly in disaster and emergency situations with sufficient trained and equipped core teams. It has developed suggestions about efforts to obtain results that would minimize access time.

2. Methodology

Turkey is between 26-45 East and 36-42 North latitudes. In Turkey, there are 81 provinces (30 metropolitan cities, 51 cities), 828.88 districts belonging to these cities, metropolitan cities, and 50305 neighborhoods or villages belonging to these metropolitan cities, cities, and districts. At the beginning of 2021 (31 December 2020-01 January 2021), its population is 83614362 (TÜİK 2021) and its acreage is 780040 km². All compiled or calculated data were collected in 43 columns and 50305 rows. The transportation speed values of the settlements to the districts and provincial centers to which they are connected were calculated simply from the distance and time information (speed = road/time). Approximate area values of the neighborhoods and villages were calculated by dividing the district area by the number of settlements and assuming equal (this data is not available collectively in any institution). Population density is approximately calculated from population and area information (density = population/area). Area values of districts and provinces were taken directly (HGM 2021), and population densities were calculated.

The earthquake hazard map parameters are approximately determined by using fuzzy logic according to the latitudes and longitudes of the settlements from the published parameters (AFAD 2018), which are not related to residential areas, calculated with equal spacing and equal increment. Parameters in the project design are determined according to the coordinates of the land where the building will be built. Published or calculated values are not available as project data. The approximate values calculated here belong to a coordinate belonging to the center of the settlements and were determined only for evaluation in the analysis of the data. Very few were calculated as $R > 0.85$, and most were calculated as close to $R > 0.95$ and were used. Considering the geographical features, meteorological characteristics, altitudes, and earthquake risks of the settlements, "similar regions" were determined (this is zoning specific to the study). Similar regions were specially designed for this study according to the color intensity from the earthquake hazard map, with latitude and longitude being integers. Similar regions are given in Fig. 1(a) and "geographical regions" are given in Fig. 1(b).

Since the "Earthquake Hazard Map" used in Turkey before 2018 is in many publications and official documents, Fig. 2(a) shows the "Earthquake Hazard Map (Parameters)", then it was developed using more advanced methods after 2018 and started to be used since 2020 shown in Fig. 2(b). Selected settlements (province, dis-

trict, town, neighborhood, and village) in the same geography are shown in Fig. 2(c) to make a comparison for the parameters to be used in the design phase with both

maps. The locations, earthquake zone numbers, and earthquake hazard map parameters of the settlements selected for comparison are given in Table 1.

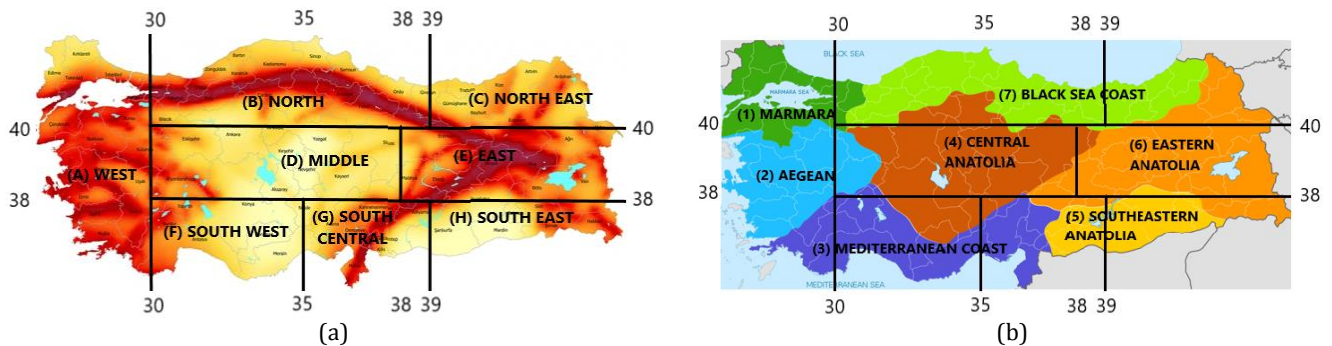


Fig. 1. Similar and geographical regions: a) Similar regions (8 pieces); b) Geographical regions (7 pieces).

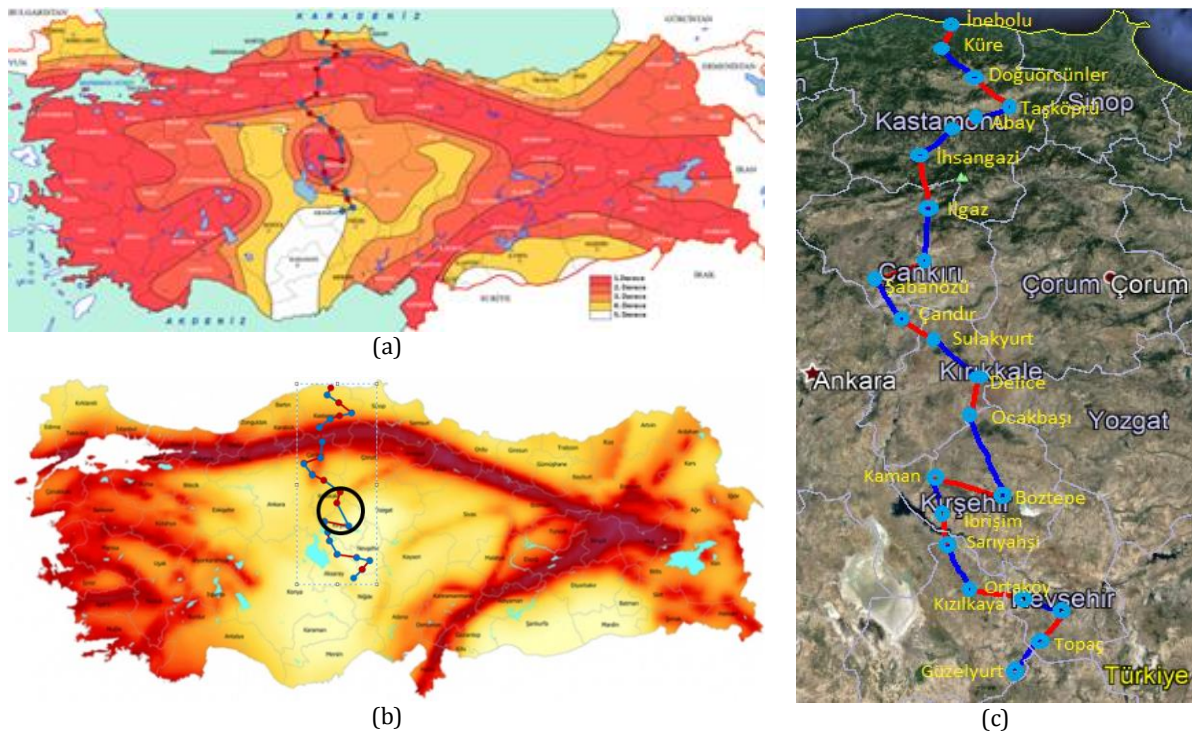


Fig. 2. Earthquake map before and after 2018 in Turkey: a) Turkey earthquake zones map (Özmen, 2012); b) Turkey earthquake hazard map (AFAD, 2018); c) Compared geography.

Spectral acceleration $S_s - 475$ was chosen since the design is thought to be based on a design spectrum, 10% probability of being exceeded in 50 years. ZC was chosen as an average soil class from the old earthquake code to include soil properties. In the new earthquake regulation, $S_{Ds} = S_s * F_s = S_s * 1.3$ was used, taking into account the 30% magnification factor in which S_{Ds} and F_s refer to the spectral acceleration coefficient and soil effect coefficient, respectively. In order to be able to make a comparison along the entire line (Fig. 2(c)), by considering $I=1$ for the formula $A(T) = A_0 * I * S(T)$ in DBYBHY (2007), $S(T)=2.5$ is taken from the acceleration spectrum curve for the earthquake with 10% probability of being exceeded in 50 years and acceleration spectrum coefficients were determined as $A_0 * 2.5$ (Table 1). The comparison of the obtained design earthquake parameters is given in Fig. 3, the longitudinal section of the line with

the compared settlements, and the map views corresponding to this longitudinal section in both old (before 2018) and new (after 2018) earthquake hazard maps are given in Fig. 4. While the earthquake zones between Delice and Ortaköy (the area in the east and north-east of Salina) on the line examined change as 2, 1, 3 in the old earthquake zones map, they are seen as low, medium, and low risk in the new earthquake hazard map (Fig. 2(a-b)).

3. Application and Results

After the compiled or calculated values of each settlement are placed in the table, they are determined separately according to the districts and provinces, according to each option of distance, transportation time, and

transportation speed, according to the number of earthquake zones (EQ+) and without taking into account earthquake zones (EQ-), the number of settlements in Turkey in general, similar regions and geographical regions corresponding to the limit values, living population, and settlement areas are calculated on the tables. Calculation steps and distance, time, speed, altitude, and earthquake zone range values are shown in Fig. 5, and the interval values determined for the earthquake hazard map parameters are given in Table 2.

The number of settlements, areas, and populations of similar regions, geographical regions, and settlements,

which are calculated for Turkey in general, are given in Tables 3 and 4.

Turkey's average values of all data; according to the district center; distance: 17.79 km, transportation time: 23.94 minutes, transportation speed: 42.04 km/h, depending on the city center; distance: 64.15 km, travel time: 62.85 minutes, travel speed: 57.78 km/h are found. The average altitude of settlements is 828.88 m. In practice, it is thought that it would be more appropriate to use distances as planning data rather than transportation speed and times to city and district centers because the actual values differ.

Table 1. Comparison of old and new earthquake data.

Settlement unit (city, district, neighborhood/village)	Intermediate distance (km)	Distance to start (km)	Earthquake zone number	Old regulation, $A_0 * S(T) = A_0 * 2.5$	New regulation, $S_S - 475 * 1.3$	Latitude	Longitude
İNEBOLU/KASTAMONU	0	0	4	0.25	0.507	41.978799	33.759147
KÜRE/KASTAMONU	23	23	3	0.50	0.562	41.804781	33.712784
DOĞUÖRCÜNLER/DEVREKANİ/KASTAMONU	28	51	3	0.50	0.607	41.673763	33.943993
TAŞKÖPRÜ/KASTAMONU	28	79	2	0.75	0.562	41.804781	33.712784
ABAY/TAŞKÖPRÜ/KASTAMONU	23	102	2	0.75	0.809	41.438261	33.987094
KASTAMONU	24	126	1	1.00	0.904	41.367804	33.769450
İHSANGAZI/KASTAMONU	30	156	1	1.00	1.278	41.203793	33.554760
ILGAZ/ÇANKIRI	32	188	1	1.00	1.936	40.925326	33.627021
ÇANKIRI	38	226	1	1.00	0.907	40.595661	33.613251
ŞABANÖZÜ/ÇANKIRI	33	259	2	0.75	0.879	40.473757	33.278431
ÇANDIR/KALECİK/ANKARA	32	291	3	0.50	0.796	40.257377	33.467243
SULAKYURT/KIRIKKALE	28	319	3	0.50	0.581	40.157698	33.717195
DELİCE/KIRIKKALE	38	357	2	0.75	0.623	39.943350	34.032498
OCAKBAŞI/DELİCE/KIRIKKALE	23	380	2	0.75	0.572	39.750543	33.995350
BOZTEPE/KIRŞEHİR	24	404	1	1.00	0.268	39.270311	34.265943
KAMAN/KIRŞEHİR	32	436	1	1.00	0.511	39.358468	33.723322
İBRİŞİM/KAMAN/KIRŞEHİR	23	459	1	1.00	0.350	39.175461	33.820492
SARIYAŞI/AKSARAY	30	489	2	0.75	0.317	38.979569	33.836312
ORTAKÖY/AKSARAY	32	521	3	0.50	0.285	38.736610	34.039259
KIZILKAYA/GÜLŞEHİR/ NEVŞEHİR	38	559	3	0.50	0.242	38.698141	34.420738
NEVŞEHİR	28	587	4	0.25	0.270	38.625088	34.719940
TOPAÇ/ACIGÖL/NEVŞEHİR	23	610	4	0.25	0.273	38.473841	34.558962
GÜZELYURT/AKSARAY	35	645	5	0.00	0.354	38.276798	34.369992
TOTAL	645						

Note: The values A_0 are corresponding to the DBYBHY, Table 2.4 (2007)

Table 2. Specified ranges for earthquake hazard map parameters (TBDY 2018).

*	PGA 2475	PGA 475	PGA 72	PGA 43	$S_S - 2475$	$S_S - 475$	$S_S - 72$	$S_S - 43$
1	PGA>1	PGA>0.75	PGA>0.3	PGA>1	$S_S > 3$	$S_S > 1.8$	$S_S > 0.75$	$S_S > 0.4$
2	$0.75 < PGA \leq 1$	$0.5 < PGA \leq 0.75$	$0.225 < PGA \leq 0.3$	$0.75 < PGA \leq 1$	$2.25 < S_S \leq 3$	$1.35 < S_S \leq 1.8$	$0.5 < S_S \leq 0.75$	$0.3 < S_S \leq 0.4$
3	$0.5 < PGA \leq 0.75$	$0.25 < PGA \leq 0.5$	$0.15 < PGA \leq 0.225$	$0.5 < PGA \leq 0.75$	$1.5 < S_S \leq 2.25$	$0.9 < S_S \leq 1.35$	$0.25 < S_S \leq 0.5$	$0.2 < S_S \leq 0.3$
4	$0.25 < PGA \leq 0.50$	$0.125 < PGA \leq 0.25$	$0.075 < PGA \leq 0.150$	$0.25 < PGA \leq 0.50$	$0.75 < S_S \leq 1.50$	$0.45 < S_S \leq 0.9$	$0.125 < S_S \leq 0.25$	$0.1 < S_S \leq 0.2$
5	PGA≤0.25	PGA≤0.125	PGA≤0.075	PGA≤0.25	$S_S \leq 0.75$	$S_S \leq 0.45$	$S_S \leq 0.125$	$S_S \leq 0.1$
*	$S_1 - 2475$	$S_1 - 475$	$S_1 - 72$	$S_1 - 43$	PGV 43	PGV 72	PGV 475	PGV 2475
1	$S_1 > 0.8$	$S_1 > 0.4$	$S_1 > 0.19$	$S_1 > 0.1$	PGV>10	PGV>18	PGV>60	PGV>100
2	$0.6 < S_1 \leq 0.8$	$0.3 < S_1 \leq 0.4$	$0.135 < S_1 \leq 0.18$	$0.075 < S_1 \leq 0.1$	$7.5 < PGV \leq 10$	$13.5 < PGV \leq 18$	$45 < PGV \leq 60$	$75 < PGV \leq 100$
3	$0.4 < S_1 \leq 0.6$	$0.2 < S_1 \leq 0.3$	$0.09 < S_1 \leq 0.135$	$0.05 < S_1 \leq 0.075$	$5 < PGV \leq 7.5$	$9 < PGV \leq 13.5$	$30 < PGV \leq 45$	$50 < PGV \leq 75$
4	$0.2 < S_1 \leq 0.4$	$0.1 < S_1 \leq 0.2$	$0.045 < S_1 \leq 0.09$	$0.025 < S_1 \leq 0.05$	$2.5 < PGV \leq 5$	$4.5 < PGV \leq 9$	$15 < PGV \leq 30$	$25 < PGV \leq 50$
5	$S_1 \leq 0.2$	$S_1 \leq 0.1$	$S_1 \leq 0.045$	$S_1 \leq 0.025$	PGV≤2.5	PGV≤4.5	PGV15	PGV≤25

*Sequence, earthquake zone number

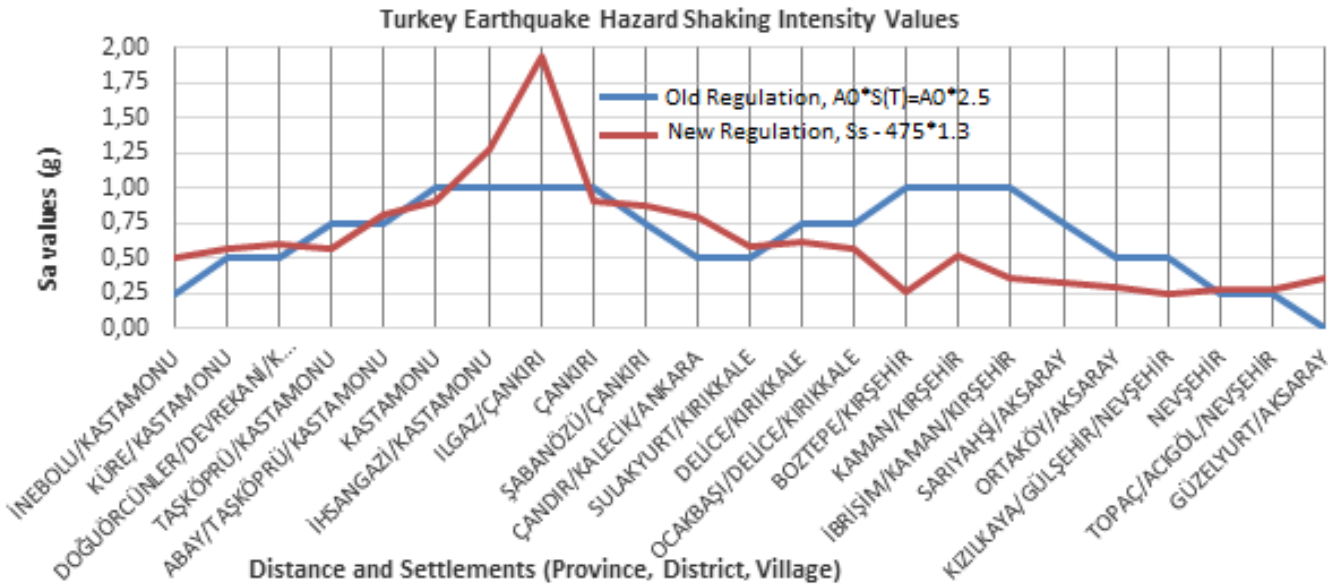


Fig. 3. Comparison of earthquake data before and after 2018 in Turkey.

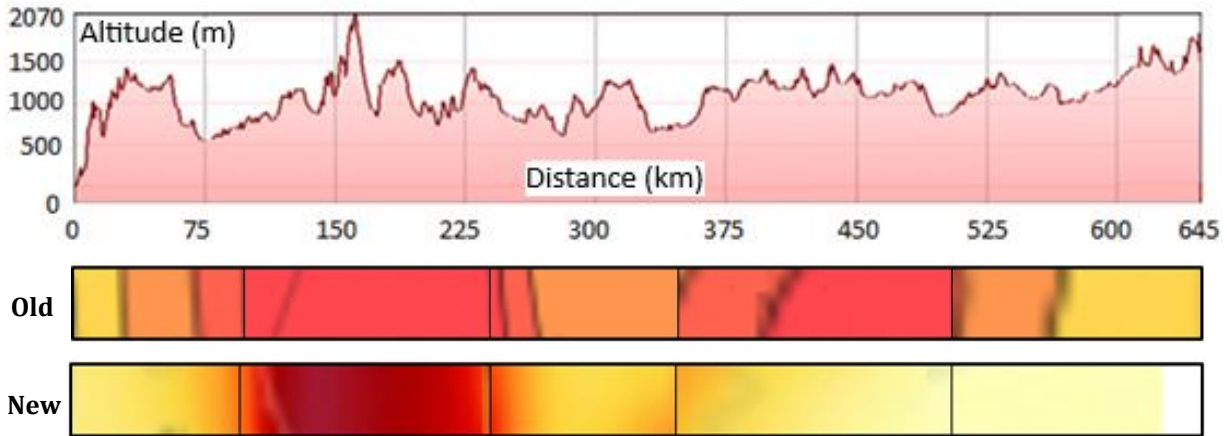


Fig. 4. Settlements longitudinal section and their situations in the old and new earthquake map.

Table 2. Specified ranges for earthquake hazard map parameters (TBDY 2018).

*	PGA 2475	PGA 475	PGA 72	PGA 43	S _s - 2475	S _s - 475	S _s - 72	S _s - 43
1	PGA>1	PGA>0.75	PGA>0.3	PGA>1	S _s >3	S _s >1.8	S _s >0.75	S _s >0.4
2	0.75<PGA≤1	0.5<PGA≤0.75	0.225<PGA≤0.3	0.75<PGA≤1	2.25<S _s ≤3	1.35<S _s ≤1.8	0.5<S _s ≤0.75	0.3<S _s ≤0.4
3	0.5<PGA≤0.75	0.25<PGA≤0.5	0.15<PGA≤0.225	0.5<PGA≤0.75	1.5<S _s ≤2.25	0.9<S _s ≤1.35	0.25<S _s ≤0.5	0.2<S _s ≤0.3
4	0.25<PGA≤0.50	0.125<PGA≤0.25	0.075<PGA≤0.150	0.25<PGA≤0.50	0.75<S _s ≤1.50	0.45<S _s ≤0.9	0.125<S _s ≤0.25	0.1<S _s ≤0.2
5	PGA≤0.25	PGA≤0.125	PGA≤0.075	PGA≤0.25	S _s ≤0.75	S _s ≤0.45	S _s ≤0.125	S _s ≤0.1
*	S _i - 2475	S _i - 475	S _i - 72	S _i - 43	PGV 43	PGV 72	PGV 475	PGV 2475
1	S _i >0.8	S _i >0.4	S _i >0.19	S _i >0.1	PGV>10	PGV>18	PGV>60	PGV>100
2	0.6<S _i ≤0.8	0.3<S _i ≤0.4	0.135<S _i ≤0.18	0.075<S _i ≤0.1	7.5<PGV≤10	13.5<PGV≤18	45<PGV≤60	75<PGV≤100
3	0.4<S _i ≤0.6	0.2<S _i ≤0.3	0.09<S _i ≤0.135	0.05<S _i ≤0.075	5<PGV≤7.5	9<PGV≤13.5	30<PGV≤45	50<PGV≤75
4	0.2<S _i ≤0.4	0.1<S _i ≤0.2	0.045<S _i ≤0.09	0.025<S _i ≤0.05	2.5<PGV≤5	4.5<PGV≤9	15<PGV≤30	25<PGV≤50
5	S _i ≤0.2	S _i ≤0.1	S _i ≤0.045	S _i ≤0.025	PGV≤2.5	PGV≤4.5	PGV15	PGV≤25

*Sequence, earthquake zone number

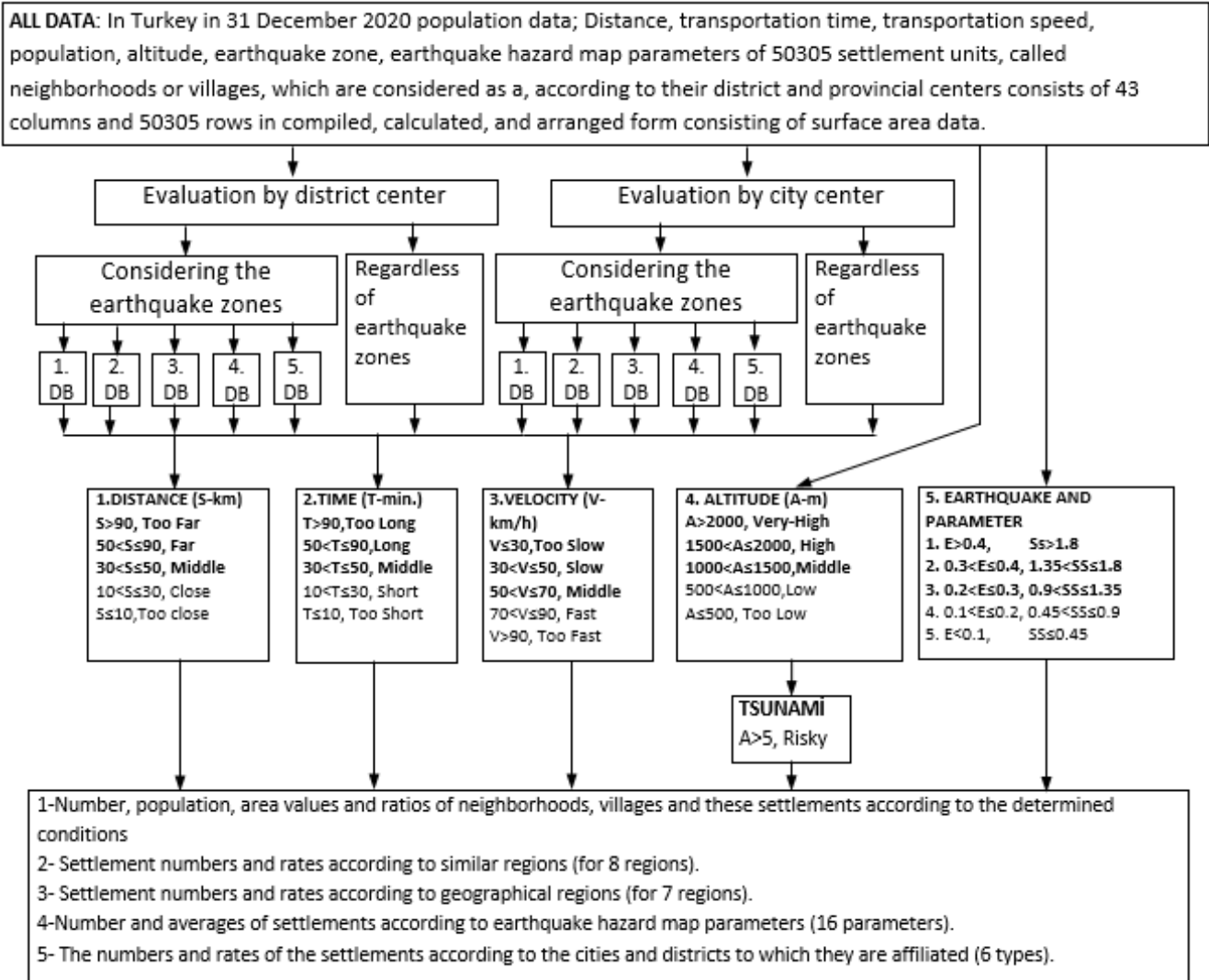


Fig. 5. Data and spreadsheet formatting.

According to similar regions in Tables 3 and 4, the number of settlements is highest in the North (11585 people), the largest area (157292.93 km², in the Middle), and the highest population in the West (34097535 people) takes place. According to geographical regions, the number of settlements takes place the highest in the Black Sea (11221), the largest area in Central Anatolia

(192328.10 km²), and the highest population in Marmara (25377324 people). According to the state of the district to which the settlements are connected, the highest number of settlements (20392), the largest area (343879.00 km²), and the highest population (37214062 people) is found in the settlements defined as “MD: Metropolitan District”.

Table 3. Number, area, and population of settlements in similar regions and geographical regions.

Similar regions					Geographical regions				
Code	Nomenclature	Number	Area*	Populations	Code	Nomenclature	Number	Area	Populations
(A)	West	10652	140353.87	34097535	(1)	Marmara	6074	66746.42	25377324
(B)	North	11585	126147.41	8950081	(2)	Aegean	6189	89478.70	10689115
(C)	North East	3624	54365.13	2154723	(3)	Mediterranean	4885	89671.16	10759218
(D)	Middle	7197	157292.93	11449973	(4)	Central Anatolia	8604	192328.10	13691779
(E)	East	6882	122769.21	5926494	(5)	Southeastern Anatolia	5862	76151.20	9118921
(F)	South West	3152	77251.04	7095001	(6)	Eastern Anatolia	7470	149157.80	6061837
(G)	South Central	4486	53657.05	9518321	(7)	Black Sea	11221	116506.60	7916168
(H)	South East	2727	48203.36	4422234					
Top three totals		29434	423794.21	55065829			27295	457992.50	49828321
TOTAL		50305	780040	83614362			50305	780040	83614362

Note: * The values complied from the Republic of Turkey Ministry of Natural Defense General Directorate of Mapping (2021).

Table 4. Distribution, number, area, and population of settlements by district and province types.

The city status to which the neighborhoods and villages are affiliated (numbers and proportions)							
Code	Nomenclature	Number	Ratio, %	Area	Ratio, %	Population	Ratio, %
MCD	Metropolitan Central District	5470	10.87	55391.00	7.10	27942170	33.42
MD	Metropolitan District	20392	40.54	343879.00	44.08	37214062	44.51
CCD	City Center District	1900	3.78	25681.58	3.29	7677970	9.18
CCDV	City Center District Village	3570	7.10	49969.00	6.41	1262423	1.51
CD	City District	4247	8.44	68300.71	8.76	5718451	6.84
CDV	City District Village	14726	29.27	236818.71	30.36	3799286	4.54
First three sum		40588	80.68	648998.42	83.20	72834202	87.11
TOTAL		50305	100.00	780040	100.00	83614362	100.00

The distance to the district center to which each settlement is connected, according to each option of the distance, travel time, and transportation speed (first three cases from "middle" to the most negative, shown in Fig. 5), according to the earthquake zone numbers (EQ+) and earthquake zones. (EQ-), corresponding to the limit values, the number of settlements in similar regions and geographical regions, the number of living population, settlement areas, their location (explained in Tables 3 and 4), and their rates according to Turkey overall (%) are given in Table 5. The results obtained by making the same process according to the provincial centers are given in Table 6.

According to the evaluation according to the district center, it is seen that EQ-: 8495 (EQ+: 7337, 14.59%) of the settlements (16.89%) are located more than 30 km away, they have an area of 163442 km² (20.95%) and 5604523 people live in this area (6.70%). It is seen that the number of settlements where the transportation time is more than 30 minutes is 28.69%, the area is 31.98% and the population is 12.70%, the number of settlements where the transportation speed is less than 50 km/h is 97.45%, the area is 96.53% and the population is 98.75%.

In similar regions more than 30 km away from the district center, the highest number of settlements are in the East (1722 units), according to geographical regions in Eastern Anatolia (1903 units), and according to the city type, the most are in the Metropolitan District Center (3231 units). The highest number of settlements in similar regions longer than 30 minutes are located in the East (3013 units), according to geographical regions in Eastern Anatolia (3165 units), and according to the city type, most are in the Metropolitan District Center (5583 units). It is seen that the number of settlements where the transportation speed is less than 50 km/h the most settlements are in the North (11403 units), according to geographical regions, it is seen in Eastern Anatolia (11098 units), according to the city type, it is mostly in the Metropolitan District Center (19902 units).

According to the evaluation according to the city center, it is seen that 38314 of the settlements (76.16%) are located more than 30 km away, they have an area of 648241 km² (83.10%) and 34680977 people live in this area (41.48%). It is seen that the number of settlements where the transportation time is more than 30 minutes is 79.54%, the area is 85.50% and the population is

46.82%, the number of settlements where the transportation speed is less than 50 km/h is 94.54%, the area is 96.23% and the population is 81.63%.

In similar regions more than 30 km away from the city center, the highest number of settlements are located in the North (8996 units), according to geographical regions in the Black Sea (8442 units), and according to the city type, the most are in the City District Village (18452 units). The highest number of settlements in similar regions longer than 30 minutes are located in the North (8628 units), according to geographical regions in the Black Sea (8986 units), and according to the city type, most are located in the Metropolitan District (18803). It is seen that the number of settlements where the transportation speed is less than 50 km/h the most settlements are in the North (11106 units), according to geographical regions, it is seen in the Black Sea (8423 units), according to the city type, it is mostly in the Metropolitan District (20179 units).

The altitudes of each settlement, earthquake zone numbers, and each option of the earthquake hazard map parameters (the first three cases, from "middle" to the most negative, shown in Fig. 5), according to the earthquake zone numbers (EQ+) and without considering the earthquake zones (EQ-), corresponding to the determined limit values, the number of settlements in similar regions and geographical regions, living population, settlement areas, location (explained in Table 3 and Table 4), their rates (%) and altitude compared to overall Turkey, tsunami risk assessment (ratios not given) findings for settlements with A > 5 are given in Table 7. The tsunami risk of Turkey is given as 4.71 m for the Mediterranean, including the Aegean Sea, depending on the fault movement (the time to reach the shore in 8 minutes, the advancement distance is 50 m) and 3 m for the Black Sea (BDTIM, 2017). For this reason, the altitude value to include both situations was determined as 5 m.

When the altitudes are evaluated, 19122 (38.01%) settlements are located at an elevation of more than 1000 m, 26757 (53.19%) settlements exist in 1., 2. or 3. earthquake zones (earthquake hazard map parameters have been evaluated separately) and it is seen that 49623348 people (59.35%) live in these settlements. According to the evaluation made for the medium-high risk zone, 26483 (52.64%) settlements are located in an area of 382395 km² (49.02%) and 49623348 people (59.35%) live in this area.

Table 5. Evaluation results of distance, transportation time, and transportation speed data according to the district center.

		Evaluation according to the district center								
		Distance >30 km	Location	%	Duration >30 min	Location	%	Speed <50 km/h	Location	%
Number of settlements (neighborhood-village)	EQ+	7337	-	14.59	12475	-	24.80	42589	-	84.66
	EQ-	8495	-	16.89	14435	-	28.69	49020	-	97.45
Area of settlements (km ²)	EQ+	135353	-	17.35	211582	-	27.12	641453	-	82.23
	EQ-	163442	-	20.95	249481	-	31.98	752965	-	96.53
Living population (person)	EQ+	4212404	-	5.04	8108594	-	9.70	71344012	-	85.33
	EQ-	5604523	-	6.70	10619290	-	12.70	82568950	-	98.75
Number of settlements and region (maximum) in a similar region	EQ+	1722	(E)	3.42	2894	(E)	5.75	10429	(B)	20.73
	EQ-	1722	(E)	3.42	3008	(B)	5.98	11403	(B)	22.67
Settlement in a similar region number and region (2nd most)	EQ+	1280	(B)	2.54	2675	(B)	5.32	10122	(A)	20.12
	EQ-	1456	(D)	2.89	2894	(E)	5.75	10502	(A)	20.88
Number of settlements in similar regions and regions (3rd most)	EQ+	1118	(A)	2.22	2138	(A)	4.25	6700	(E)	13.32
	EQ-	1386	(B)	2.76	2172	(A)	4.32	6731	(D)	13.38
Number of settlements in the geographical region and region (most)	EQ+	1903	(6)	3.78	3165	(6)	6.29	8756	(7)	17.41
	EQ-	1903	(6)	3.78	3185	(7)	6.33	11098	(7)	22.06
Number of settlements in the geographical area and region (2nd most)	EQ+	1245	(7)	2.47	2559	(7)	5.09	7248	(6)	14.41
	EQ-	1827	(4)	3.63	3165	(6)	6.29	8087	(4)	16.08
Settlement in the geographical region number and region (3rd most)	EQ+	1206	(5)	2.40	1840	(5)	3.66	6054	(2)	12.03
	EQ-	1414	(7)	2.81	2302	(4)	4.58	7248	(6)	14.41
Number of settlements and city type by city type (most)	EQ+	2673	MD	5.31	4720	MD	9.38	17170	MD	34.13
	EQ-	3231	MD	6.42	5583	MD	11.10	19902	MD	39.56
Number of settlements and city type by city type (2nd most)	EQ+	2635	CDV	5.24	4523	CDV	8.99	12569	CDV	24.99
	EQ-	2895	CDV	5.75	5079	CDV	10.10	14257	CDV	28.34
Number of settlements and city type by city type (3rd most)	EQ+	914	MCD	1.82	1502	MCD	2.99	4679	MCD	9.30
	EQ-	1073	MCD	2.13	1790	MCD	3.56	5362	MCD	10.66

From the altitude assessment, it is seen that 411010 people live in 148 settlements in an area of 1895.77 km² with an altitude of 5 m or less. According to similar regions, 55 of them are located in the West, while 63 according to geographical regions are in the Mediterranean. 118 of the 148 settlements are also located in settlements affiliated with Metropolitan District.

Limit values determined for earthquake hazard map parameters are given in Fig. 5. The values in Table 8 are calculated according to the ranges given in Table 2 and determined by 5 limit values obtained by dividing into 4 parts between the maximum and minimum values in Turkey. Since Turkey earthquake hazard map parameters were determined for locations that have equal increments of latitudes and longitudes in general, they do not correspond every time to settlements. For this reason, both the maximum and minimum values of Turkey in general and the maximum, minimum, and average values of the settlements are given together in the table. Here, as shown in Fig. 5, from "middle" to negative, the first

three cases where the earthquake zone degree is less than 3 (3rd, 2nd, 1st-degree earthquake zone) are taken into consideration.

The maximum value of the design earthquake $S_s - 475$ according to the settlements is 2.001, the minimum value is 0.137 and the average value is 0.717. The number of settlements where the $S_s - 475$ value is greater than 0.9 (approximately the same whether the earthquake zone is taken into account or not) is 13292. It has been observed that the area of these settlements is approximately 174380 km² and the living population is 28321962 people.

4. Discussion and Recommendations: Sampling for Turkey-Trabzon-Akçaabat

According to the findings obtained from the study, it is understood that intervention in disasters and emergencies from the central point cannot be as fast as neces-

sary. For this reason, it was concluded that a solution can be produced by establishing “core monitoring and response centers (CMICEN)” consisting of 2-4 people trained for possible disasters and emergencies for a quick solution. The recommended centers should be formed primarily from volunteers, and the necessary training should be provided for this team. Under the leadership of AFAD (DEMP-Disaster and Emergency Management Presidency), preparations and training programs are already provided voluntarily. Providing the necessary equipment for the team’s immediate response to be determined at the local level, evaluating if available volunteers, and providing uninterrupted com-

munication opportunities for the team at all times must be provided. The communication cycle of "public-112 Emergency Service- CMICEN (ÇEKMER)" is important for this. For areas where existing communication tools are not available, it is necessary to provide the opportunity to communicate immediately. The use of satellite-connected communication tools and radio equipment should also be considered as an alternative. For the success of the aforementioned studies, the condition that the volunteers permanently reside in the settlement where the center is established and that the public has access to these people together with the 112 Emergency Service should be observed.

Table 6. Evaluation results of distance, transportation time, and transportation speed data according to the city center.

		Evaluation according to the district center								
		Distance >30 km	Location	%	Duration >30 min	Location	%	Speed <50 km/h	Location	%
Number of settlements (neighborhood-village)	EQ+	33320	-	66.24	34849	-	69.28	41322	-	82.14
	EQ-	38314	-	76.16	40015	-	79.54	47559	-	94.54
Area of settlements (km ²)	EQ+	550468	-	70.57	567585	-	72.76	639331	-	81.96
	EQ-	648241	-	83.10	666913	-	85.50	750621	-	96.23
Living population (person)	EQ+	30843316	-	36.89	34897644	-	41.74	58826414	-	70.35
	EQ-	34680977	-	41.48	39148967	-	46.82	68252597	-	81.63
Number of settlements and region (maximum) in a similar region	EQ+	8230	(B)	16.36	8628	(B)	17.15	10146	(B)	20.17
	EQ-	8936	(B)	17.76	9379	(B)	18.64	11092	(B)	22.05
Settlement in a similar region number and region (2nd most)	EQ+	7692	(A)	15.29	8002	(A)	15.91	9646	(A)	19.18
	EQ-	8003	(A)	15.91	8312	(A)	16.52	10014	(A)	19.91
Number of settlements in similar regions and regions (3rd most)	EQ+	5524	(E)	10.98	5783	(E)	11.50	6662	(E)	13.24
	EQ-	5524	(E)	10.98	5783	(E)	11.50	6833	(D)	13.58
Number of settlements in the geographical region and region (most)	EQ+	6767	(7)	13.45	7189	(7)	14.29	8423	(7)	16.74
	EQ-	8442	(7)	16.78	8986	(7)	17.86	10636	(7)	21.14
Number of settlements in the geographical area and region (2nd most)	EQ+	5885	(6)	11.70	6169	(6)	12.26	7174	(6)	14.26
	EQ-	6689	(4)	13.30	6771	(4)	13.46	8121	(4)	16.14
Settlement in the geographical region number and region (3rd most)	EQ+	4964	(4)	9.87	5003	(4)	9.95	5905	(2)	11.74
	EQ-	5885	MD	11.70	6169	(6)	12.26	7174	(6)	14.26
Number of settlements and city type by city type (most)	EQ+	15759	MD	31.33	16057	MD	31.92	17344	MD	34.48
	EQ-	18452	CDV	36.68	18803	MD	37.38	20179	MD	40.11
Number of settlements and city type by city type (2nd most)	EQ+	12169	CDV	24.19	12431	CDV	24.71	12943	CDV	25.73
	EQ-	13706	CD	27.25	14009	CDV	27.85	14673	CDV	29.17
Number of settlements and city type by city type (3rd most)	EQ+	3106	CD	6.17	3065	CD	6.09	3631	MCD	7.22
	EQ-	3571	CD	7.10	3519	CD	7.00	4205	CD	8.36

Settlements in the coastal cities of Turkey are generally located in large river valleys flowing from the land to the sea, on the edges of small streams that are directed perpendicular to this stream, or on the plains in mountainous geography between small rivers. In the Black Sea

Region, this formation is in the form of large rivers flowing in the South-North direction (valley bottom line) and small streams in the vertical direction (perpendicular to the valley). The main mode of transportation is the highway and it is built right next to the largest river, parallel

to it and following the natural geographical structure. If these roads unite the provincial and district centers, they also have the standard of "state and provincial roads", while the curved roads with a 10-20 m curvature radius that are connected to them and provide access to settlements are of very low standard (village road, forest road). For this reason, besides not allowing fast transportation, it has very large slopes and very narrow sections. From this, it is concluded that central teams cannot

respond to disasters and emergencies as soon as necessary. For these reasons, it has been suggested to find CMICEN. Below, the centers determined for the Akçaabat district of Trabzon province (Metropolitan) are sampled. Fig. 6 shows the five centers proposed for Akçaabat and the geographical location and areas of responsibility of the AK4 center. If these centers are established based on an on-site examination, where all conditions are evaluated, their number and location may change.

Table 7. Altitude, earthquake, and tsunami assessment results of settlements.

		Altitude, earthquake parameters, and tsunami assessment, Altitude, Ground, Earthquake, Tsunami							
		Altitude >1000 m	Location	%	Earthquake EQ=1, 2, 3	Location	%	Tsunami A<5 m	Location
Number of settlements (neighborhood-village)	EQ+	16864	-	33.52	26483	-	52.64	148	-
	EQ-	19122	-	38.01	26757	-	53.19		
Area of settlements (km ²)	EQ+	326160	-	41.81	381785	-	48.94	1895.77	-
	EQ-	386888	-	49.60	387486	-	49.68		
Living population (person)	EQ+	12498796	-	14.95	49434238	-	59.12	411010	-
	EQ-	16564350	-	19.81	49623348	-	59.35		
Number of settlements and region (maximum) in a similar region	EQ+	5571	(E)	11.07	9735	(A)	19.35	55	(A)
	EQ-	5571	(E)	11.07	9866	(A)	19.61		
Settlement in a similar region number and region (2nd most)	EQ+	4320	(D)	8.59	5829	(B)	11.59	36	(G)
	EQ-	5275	(D)	10.49	5853	(B)	11.64		
Number of settlements in similar regions and regions (3rd most)	EQ+	2827	(B)	5.62	5492	(E)	10.92	28	(B)
	EQ-	2915	(B)	5.79	5492	(E)	10.92		
Number of settlements in the geo- graphical region and region (most)	EQ+	6811	(6)	13.54	5702	(2)	11.33	63	(3)
	EQ-	6811	(6)	13.54	5702	(2)	11.33		
Number of settlements in the geo- graphical area and region (2nd most)	EQ+	4336	(4)	8.62	5675	(6)	11.28	31	(2)
	EQ-	6287	(4)	12.50	5675	(6)	11.28		
Settlement in the geographical re- gion number and region (3rd most)	EQ+	2525	(7)	5.02	5271	(1)	10.48	27	(1)
	EQ-	2662	(7)	5.29	5402	(1)	10.74		
Number of settlements and city type by city type (most)	EQ+	7486	CDV	14.88	11327	MD	22.52	118	MD
	EQ-	7945	CDV	15.79	11368	MD	22.60		
Number of settlements and city type by city type (2nd most)	EQ+	4482	MD	8.91	7626	CDV	15.16	22	MCD
	EQ-	5420	MD	10.77	7798	CDV	15.50		
Number of settlements and city type by city type (3rd most)	EQ+	1769	CCDV	3.52	2576	MCD	5.12	5	CD
	EQ-	1952	CCDV	3.88	2577	MCD	5.12		

Akçaabat, which has 73 settlements (neighborhoods), is the largest district after Ortahisar, which is the city center, with a population of 127 331 people (surface area 385 km²) among 18 districts of Trabzon. The natural events that are likely to pose the most important disaster risk can be listed as floods, landslides, rock falls, avalanches on high altitudes, and fires in places with old-fashioned and collective housing. Sera Lake, which was formed in 1950 due to landslides, is located within the

boundaries of Akçaabat, just like Uzungöl, which is located in Çaykara and formed between 1610 and 1620. Yıldız, Söğütlü, Kireçhane, Kavaklı, Darıca, Zeytinlik, Çatalzeytin, Akçakale, and Taşlıca Creeks in the district are important streams flowing in the South-North direction. There are settlements among other small streams that are perpendicular to these streams. State and provincial roads are generally parallel to the large and long ones of these streams such as Söğütlü Creek. The roads

that provide access to the settlements are located from these main roads to the settlements as East-West on the left coast and West-East on the right coast. To reach the settlements in use, it is necessary to reach the main road by the big stream and then to go to the centers.

The number of roads providing a direct connection between settlements is both very few and of very low quality. For this reason, five centers have been estab-

lished for the Akçaabat district, which will provide geographical situation, location of roads, and ease of transportation. If these centers are established, transportation to all settlements will be possible in 20 minutes at the most. Otherwise, it may be possible for the central intervention teams to be located in Trabzon (city center), Akçaabat, or Düzköy (districts close to the sample area) to all settlements in the selected area only in hours.

Table 8. Evaluation results of earthquake hazard map parameters in settlements.

Probability of exceeding in 50 years		% 2	% 10	% 50	% 68	% 2	% 10	% 50	% 68
Earthquake Parameter		PGA 2475	PGA 475	PGA 72	PGA 43	S _s - 2475	S _s - 475	S _s - 72	S _s - 43
Turkey Earthquake Hazard Map Parameters	Max	1.354	0.811	0.356	0.208	3.439	2.005	0.845	0.468
	Min	0.130	0.061	0.016	0.010	0.297	0.134	0.035	0.021
	Mean	0.532	0.276	0.103	0.071	1.286	0.647	0.233	0.161
Settlements in Turkey	Max	1.352	0.811	0.355	0.207	3.439	2.001	0.845	0.468
	Min	0.131	0.064	0.018	0.010	0.302	0.137	0.054	0.023
	Mean	0.564	0.302	0.115	0.079	1.381	0.717	0.267	0.179
Earthquake Zone: 1, 2, 3 and Parameters		Limit value							
		PGA>0.5	PGA>0.25	PGA>0.15	PGA>0.08	S _s >1.5	S _s >0.9	S _s >0.25	S _s >0.2
... of settlements complying with the conditions	Average values	0.843	0.397	0.210	0.105	2.148	1.266	0.474	0.237
	Number	26483	28234	12074	17469	18930	13292	23209	18898
	Area	382394.74	408856.42	157620.79	234111.79	263975.98	174676.70	322342.82	251924.41
	Population	49434238	52408621	23350328	35451606	37404991	28321962	45207053	39086530
<u>Without taking into account the earthquake region</u>									
... of settlements complying with the conditions	Average	0.862	0.579	0.251	0.151	2.521	1.496	0.578	0.337
	Number	26757	28491	12113	17531	18997	13329	23303	18969
	Area	388105.27	413753.44	158325.71	235254.33	265239.12	175320.09	324074.39	253220.04
	Population	49	04	57	55	94	18	81	253220.04
Population	49623348	52589237	23370662	35487030	37440402	28334477	45306019	39164618	
Probability of Exceeding in 50 Years		% 2	% 10	% 50	% 68	% 2	% 10	% 50	% 68
Earthquake Parameter		S ₁ - 2475	S ₁ - 475	S ₁ - 72	S ₁ - 43	PGV 43	PGV 72	PGV 475	PGV 2475
Turkey Earthquake Hazard Map Parameters	Max	1.009	0.536	0.205	0.109	10.724	21.156	69.306	120.156
	Min	0.096	0.047	0.013	0.007	0.649	1.122	3.912	8.07296
	Mean	0.348	0.179	0.067	0.047	4.113	5.935	16.118	31.3627
Settlements in Turkey	Max	0.987	0.513	0.182	0.106	10.723	19.422	60.596	104.941
	Min	0.097	0.047	0.018	0.013	0.941	1.423	4.439	8.271
	Mean	0.380	0.201	0.077	0.053	4.817	7.054	22.002	35.432
Earthquake Zone: 1, 2, 3 and Parameters		Limit value							
		S ₁ >0.4	S ₁ >0.2	S ₁ >0.09	S ₁ >0.05	PGV>5	PGV>10	PGV>30	PGV>50
... of settlements complying with the conditions	Average values	0.843	0.397	0.210	0.105	2.148	1.266	0.474	0.237
	Number	19905	21659	15577	26824	21970	11171	8309	7572
	Area	262121.22	287961.62	199514.17	373445.56	292175.98	131751.06	97495.33	90831.36
	Population	41283061	43246858	35263434	47798524	42622483	26796006	18877263	14384817
<u>Without taking into account the earthquake region</u>									
... of settlements complying with the conditions	Average	0.862	0.579	0.251	0.151	2.521	1.496	0.578	0.337
	Number	19992	21755	15655	26972	22069	11246	8364	7629
	Area	263711.49	289726.84	200925.51	376263.89	294015.81	133120.14	98472.78	91850.25
	Population	41381753	43356035	35349910	47946343	42733727	26874339	18897017	14405522

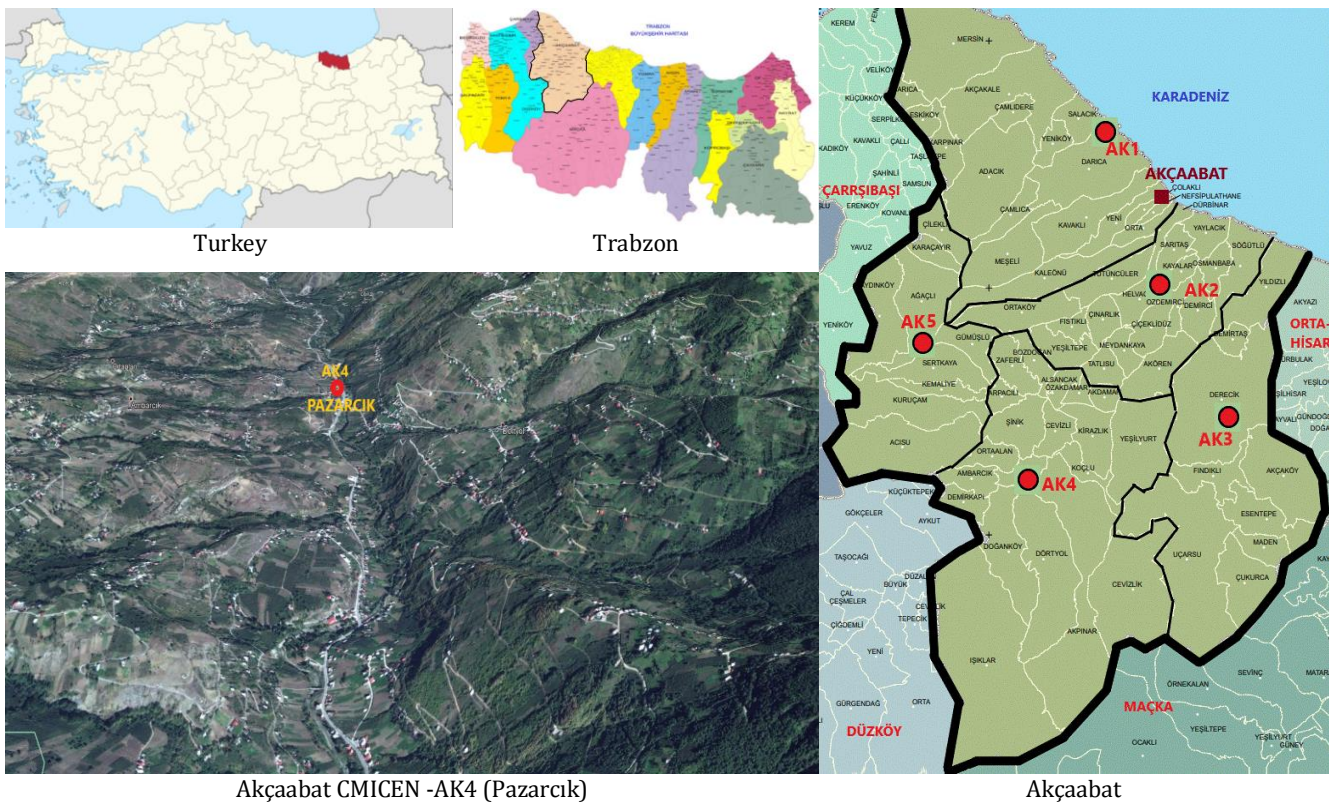


Fig. 6. Core monitoring and response centers-CMICEN sampling for Trabzon-Akçaabat.

5. Conclusions

For all disasters and emergencies caused by biological, earth-crust, and water events, atmospheric and climatic events, and human-related events, the distances of the place of disaster to the centers or intervention points, transportation times and speeds, and the altitudes of these places have a significant effect. In this study, settlements are approximately 18 km away, transportation time is approximately 23 minutes and transportation speed is at the level of 43 km/h according to Turkey and district centers. According to the provincial centers, the average distance is 63 km, the transportation time is 60 minutes and the transportation speed is 59 km/h. The average altitude of all settlements is a level of 830 m. This altitude information means that weather conditions are of great importance in the response and will have a significant impact on weather conditions. Therefore, it will be useful to use the results obtained from this study in all disaster and emergency macro planning.

The target of reaching disasters and emergencies in 30 minutes at most in rural areas and 10 minutes in the center should be revised as shorter periods. It is possible to achieve this by establishing a "CMICEN" in the middle of a circular area with a radius of 10-20 km or a rectangular area with the same dimensions, or at a starting point that will provide convenience for transportation, taking into account the standard, quality, and transportation speed of the transportation roads.

Thus, the duration of response to disasters and emergencies can be reduced to a maximum of 20 minutes in rural areas and 5 minutes in the center. By increasing the number of centers, these durations can be shortened for the whole country (local intervention). It is thought that possibility of uninterrupted communication with CMICEN teams (with tools such as 112 Emergency Service, satellite-connected communication, and use of radio), training of officers from amateur, volunteer, or professional teams, permanent residence in that settlement, sufficient equipment to be necessary and sufficient for the results.

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Conflict of Interest

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