Chapter 7

GIS-Based Evaluation of Disaster and Emergency Assembly Areas with AHP in Local Scale

Deniz Arca[1]

Hülya Keskin Çıtıroğlu[2]

Abstract

In an area that is tectonically active and has various fault zones, earthquakes of varying magnitudes have occurred in our country both in the past and today. Like in the rest of the world, various analyses and research are being conducted in our country to eliminate or minimize the loss of life and property caused by earthquakes. In this study, the locations of existing disaster and emergency assembly areas in the Ovacık district were determined and visualized on Google Earth. Furthermore, using Geographic Information Systems (GIS)-based analysis and weighted overlay method, a risk classification was conducted. To this end, basic inputs in the GIS environment, including slope, geology, distance to rivers, distance to roads, distance to settlements, elevation, distance to fault lines, land use, and population data layers, were used. Existing collection areas were digitized and incorporated into this framework as vector layers. The disaster and emergency assembly area sensitivity map of the study area is divided into 3 sensitivity classes. According to this map; regions of high, middle and low sensitivity were obtained as 8.35%, 76.23% and 15.42%, respectively. It is observed that both existing assembly areas are within the high sensitivity zone. The two existing assembly areas are geologically located within the Karabük formation (Teka). Because it contains coal levels, assembly areas on the Karabük formation require more detailed field studies and taking field measures. Apart from this, it has been observed that the existing assembly areas comply with the other parameters used.

1 Department of Architecture and Urban Planning, Izmir Vocational School, Dokuz Eylul University, Izmir, Türkiye, deniz.arca@deu.edu.tr Orcid: 0000-0002-0439-4938

2 Directorate of Investment Monitoring and Coordination, YIKOB, Aydın, Türkiye keskinhc@yahoo.com Orcid: 0000-0002-2999-9570

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1. Introduction

Disasters, which are natural or human-induced events that cause various losses affecting the whole or a specific part of society, disrupt normal life and activities. One of the most destructive natural disasters is earthquakes, which are prevalent worldwide and also affect Türkiye due to its geographical location. Earthquakes occur when vibrations generated by fractures in the Earth's crust propagate as waves, causing shaking (Özkılıç, 2020). Earthquakes lead to people becoming homeless due to the collapse or damage of structures, and shelter becomes one of the primary needs for affected individuals after an earthquake. The diminishing open and green spaces that individuals use for gathering and shelter day by day pose a significant problem. The absence of a well-established open and green space system resulting from unregulated urbanization nationwide poses a significant risk, especially during earthquakes and other disasters. Therefore, this issue has started to be addressed within the scope of disaster management (Aman, 2019). The fact that the issue of determining the post-disaster assembly and emergency shelter (tent-city) areas cannot be resolved and that this issue is always left to the post-disaster period prevents being prepared for disasters. Disaster and emergency assembly areas are pre-determined easily accessible, adequately sized, and capacity-equipped safe areas for individuals to feel secure after a disaster.

The determination of disaster and emergency assembly areas, evaluation of their capacities, and establishment of routes are carried out using Geographic Information Systems (GIS) in many studies conducted within the framework of disaster management. GIS allows data integration, querying, spatial analysis, and network analysis. Timely and effective post-disaster response is important in reducing losses. GIS plays an effective role in minimizing the potential losses caused by potential disasters (Turoğlu et al., 2010). Geographic Information Systems (GIS) capture spatial data obtained from various sources such as maps, digital images, and tabular data, extract specific features from the data, and combine them to produce new derived maps that are useful for decision-making and understanding spatial relationships (Carter, 1994). When multiple data need to be evaluated simultaneously in GIS-based analysis and their impact factors are not equal, the weighted overlay method can be used. Therefore, not evaluating all criteria equally will enable more realistic synthesis.

In this study, basic inputs in the GIS environment, including slope, geology, distance to rivers, distance to roads, distance to settlements, elevation, distance to fault lines, land use, and population data layers, were used. Existing collection areas were digitized and incorporated into this framework as vector layers.

Numerous studies have been conducted both in Türkiye and worldwide to determine disaster and emergency assembly areas, and it has been observed that different criteria are taken into account in each study. This indicates the lack of universal standards and criteria for determining disaster and emergency assembly areas. In the creation of assembly areas, issues such as population, accessibility, suitability for disabled and elderly transportation, unevenness of the land, proximity to structures where basic needs can be met, secondary hazards, distance from sea, river, liquefaction and fault lines have been put forward by the Disaster and Emergency Management Presidency (AFAD) (AFAD, 2023a; Şirin and Ocak, 2020). Despite the existence of studies aimed at establishing criteria and standards for determining assembly areas in Türkiye, the preferences for these areas are ultimately determined by the discretion of local authorities. Therefore, this study will contribute to the establishment of criteria and standards for determining collection areas specifically in the Ovacık district and the systematic approach to addressing collection areas through the academic work conducted in the Ovacık district.

2. Study Area

The district of Ovacık in the province of Karabük located in the region of Western Black Sea in Türkiye. The study area covers an area of 13,165 ha. The study area is sided by the provinces of Çankırı in the south, Kastamonu in the east and Karabük in the west and the district of Safranbolu in the north (Fig. 1).

Figure 1. Site position map (URL-1, 2020, Keskin Citiroglu and Arca, 2022).

Ovacık has a mountainous, forested and rough land structure. Although there are many small-scale streams that flow in winter and dry up in summer, the largest stream in the district is Soğanlı (Melan) river (Ovacık District Governorship, 2023). There are no industrial facilities in the district consisting of 42 villages and 1 central neighborhood. There are an electricity-operated flourmill and small-scale workshops (Ovacık Municipality, 2023).

According to the census based on address records system data of recent year, the population of the district of Ovacık was 3731 (Turkish Statistical Institute, 2023). When compared with the population figures of previous years, it has been observed that there is a continuous decrease in the population of the district. There are migrations out of the district towards mainly Karabük, Istanbul and Ankara in addition to other provinces, and thus, the population decreases in comparison to previous years (Ovacık Municipality, 2023). There are two disaster and emergency assembly areas in the Ovacık district, which is the study area (Karabük AFAD, 2023).

3. Importance of Assembly Areas after Earthquake

During an earthquake or in the first minutes of an earthquake, due to the panic among people, there is a need for publicly owned and easily accessible areas where people can easily notice and move from indoor spaces to open areas. These areas are defined as assembly areas (Kırçın et al., 2017). Assembly areas are the first stage of the evacuation process and serve multiple purposes in the context of disasters. Squares, open and green spaces, sports halls, marketplaces, school or public institution gardens are potential use areas during disasters. Assembly areas are important as they serve as short-term accommodation areas before transitioning to temporary shelter areas (Çelik et al., 2018).

After a disaster, the first 12 to 24 hours are crucial for disaster victims to access accurate information. In this environment of panic and chaos, it is essential not only to provide accurate information but also to ensure the evacuation and management of people towards safe areas without physical hazards, timely arrival of response teams at the scene, and prevention of chaos in the environment. Therefore, it is of utmost importance to determine safe assembly areas within the city, announce these areas to the public, especially on a neighborhood basis, assign trained personnel who are familiar with the community and direct citizens to these areas according to pre-prepared programs, and ensure the safe transportation of those who have survived the disaster to secure environments (Çiçekdağı and Kırış, 2012). When creating assembly area criteria, five factors are taken into consideration: accessibility, usability and multifunctionality, connection with road axes, property, and spatial size (JICA and IMM, 2002).

4. Establishment of Decision Criteria

The primary purpose of assembly areas is to reduce or eliminate risks in order to ensure the safety of individuals during emergencies. The factors influencing the determination of assembly areas in the Ovacık district center have been identified through national and international studies. These factors include slope, geology, distance to rivers, distance to roads, distance to settlements, elevation, distance to fault lines, land use, and population.

4.1. Slope

The criterion of slope is a factor that affects the accessibility of the assembly areas during the site selection process. It can contribute to drainage issues that may cause water accumulation or secondary hazards such as earthquake-induced landslides and soil erosion. Suitable slopes facilitate pedestrian access and provide convenience for the establishment of temporary shelters such as tents and container-like shelters. For pedestrian access, the preferred areas should have an average slope of 5% and a maximum slope of 8% (NZ Transport Agency, 2009). According to the Turkish Red Crescent, the maximum slope for potential assembly and shelter areas is determined as 7%, with a preference for slopes ranging from 2% to 4% (Kılcı et al., 2015). Areas with slopes steeper than 25% pose a high risk of mass movement and landslide hazards and are not suitable for pedestrian access. On the other hand, areas with slopes ranging from 2% to 8% are considered stable and safe (Soltani et al., 2014; Soltani et al., 2015). The slope map of the study area was derived from a 12.5m resolution DEM dataset specific to the region, using GIS (Fig. 2a).

4.2. Geology

From the bottom to the top, the study area stratigraphically includes the Ulus formation (Ku), Kışlaköy formation (Tek), Safranbolu formation (Tes), Karabük formation (Teka) and the Çerçen member of this formation (Tekaç), Soğanlı formation (Teso), Akçapınar formation (Tea), Yunuslar formation (Teyu) and alluvium (Qal). Ulus formation (Ku) consisting of alternations of claystone, shale, marl, sandstone, limestone, sandy limestone and conglomerate. The Kışlaköy formation (Tek) has alternations of marl, sandstone, conglomerate, limestone, siltstone and claystone. The Safranbolu formation (Tes) starts with a thin conglomerate-sandstone layer at the bottom and transitions to layers of carbonate sandstone, sandy limestone and limestone upwards. The Karabük formation (Teka) consists of marl at the bottom layers and alternations of claystone, sandstone and also thin coal levels upward. The Çerçen Member (Tekaç) of the Karabük formation consists of sandstone, conglomerate, claystone, siltstone and mudstone. The Soğanlı formation (Teso) consists of limestones and also marl layers among limestone layers. Limestones have joints and deep karst structures in the Soğanlı formation. The Akçapınar formation (Tea) has an alternations of dolomitic limestone, mudstone, claystone, marl, but mainly argillaceous limestone. The Yunuslar formation (Teyu) has an alternations of conglomerate, marl, mudstone, sandstone and shale. Alluvium (Qal) aged Quaternary consists of sand, gravel and mud sediments developing on riverbeds, old concavities and flat areas (Timur and Aksay, 2002). As alluvium has an uncemented and discretely grained unit structure, it is not suitable for assembly areas. As it contains deep karstic structures, assembly areas on the Soğanlı formation, and it contains coal levels, assembly areas on the Karabük formation require more detailed field studies. The other formations in the study area are to varying degrees suitable for assembly areas provided that detailed research. The geology map of the study area is given in Fig. 2b (Timur and Aksay, 2002).

4.3. Distance to River

Seasonal changes experienced in streams (floods and increased flow rates at certain points during the year) and long-term location changes experienced in the course of streams are among important factors that affect the locations of disaster and emergency assembly areas. For these reasons, for disaster and emergency assembly areas to not be affected by floods and for easy transportation to the assembly areas to be achieved, assembly areas need not to be too close to rivers (Fig. 2c). The largest stream in the district is Soğanlı (Melan) river in the study area.

4.4. Distance to Road

Accessibility has been the most repeated criterion in the determination of assembly areas location selection criteria. In the event of a disaster, people must be able to reach assembly or shelter areas safely. It is necessary to plan as evacuation routes and to be designed according to the rules determined by the laws and regulations so that the roads are not closed in case of emergency and allow people to remove. During a disaster, while people flee from closed areas, chaos occurs in traffic due to the simultaneous movement of pedestrians and vehicles (ECPFE and OASP, 2002). The distance from the building blocks to the assembly areas should be maximum 500 m or less, and the connection of the assembly areas with the main arteries should be established and their continuity with the other assembly areas should be ensured (Çınar et al., 2018). Buffer zones were created to investigate the effect of the road factor on the assembly areas (Fig. 2 d)

4.5. Distance to Settlement Areas

Another important point to be considered in the selection of assembly areas is that these areas are far enough away from the buildings to protect them from the dangers of falling debris, glass, etc. The larger the potential area, the less likely it is to be affected by the building collapse hazard. As it gets closer to the center of the assembly area, the rate of being affected by the danger of collapse of the building decreases. At the same time, it should be close enough to allow people to reach the assembly areas on foot. Buffer zones were created to investigate the effect of the residential areas factor on the assembly areas (Fig. 2e).

4.6. Elevation

When determining assembly areas, it is preferable to choose locations that are elevated above sea level in order to protect against tsunami and flood hazards. In order to utilize elevation data in the analyses, continuous data representing elevation values as surfaces are required, rather than discrete data that exhibits discontinuity (Demir, 2018). The elevation data for the study area has a resolution of 12.5 meters. The elevation map of the study area is shown in Figure 2f.

4.7. Distance to Fault Lines

Distance to fault lines is another determining parameter in assembly area assessment. In the neighborhoods established on the active fault, the emergency assembly areas on the faults will not be safe in case of an earthquake and will also receive the greatest damage (Aşıkkutlu et al., 2021). Moreover, there are no active faults in the study area, and the area is approximately 20 km far from the Northern Anatolia Fault Zone (NAFZ) (MTA, 2023; AFAD, 2023b; Timur and Aksay, 2002) (Fig. 2g).

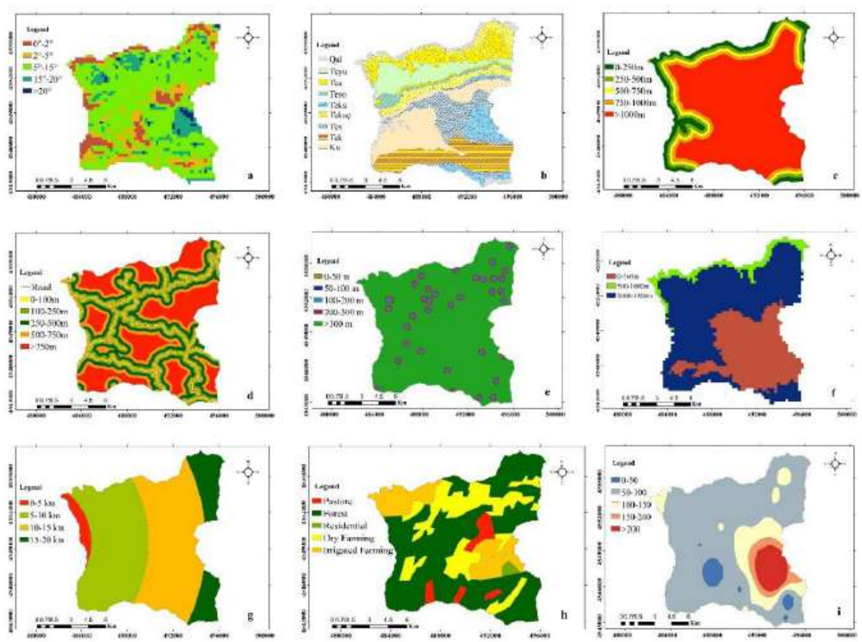
4.8. Land Use

Land use is an important factor in determining the most suitable locations for disaster and emergency assembly areas. It is essential to consider factors such as the gathering areas not being far from settlements and not being established on lands used for agriculture or forestry (Şirin and Ocak, 2020). In this study, land use was examined under 5 classes as pasture, forest, irrigated farming, dry farming and residential (MEUT, 2020) (Fig. 2h).

4.9. Population

The size of the assembly area is an important factor for the safety of the people staying. Evacuation areas should be planned to accommodate a large number of people after the disaster, so the location should be chosen to allow faster and more convenient transportation to areas with high population density in order to take into account the number of people served by the area (Chu and Su, 2011) According to the census based on address records system data of recent year, the population of the district of Ovacık was 3731 (Turkish Statistical Institute, 2023). The population map of the study area has been generated in a GIS environment using the interpolation method (Fig 2i)

Figure 2. Parameters. (a slope, b geology, c distance to rivers, d distance to roads, e distance to settlements, f elevation, g distance to fault lines, h land use, i population)



5. Method

The study utilized Geographic Information System (GIS) technology. Geographic Information Systems (GIS) is one of the effective methods used in disaster management and planning studies due to its capabilities in spatial data management, spatial analysis, and graphical visualization, enabling query and analysis. The reasons for the effective use of GIS in disaster management are its role as an efficient data sharing tool, the ability to collect and share data in the same format from different institutions that collect data in different formats, the ability to keep the data up-to-date, quick data analysis and providing easy solutions, and the versatility in visualizing data in the form of maps, graphs, and tables (Arca, 2012).

The Analytic Hierarchy Process (AHP) was used in determining the relative importance of criteria and scoring the identified potential areas according to the criteria in the process of creating the decision matrix for this study. Developed by Thomas Lorie Saaty in the 1970s, the Analytic Hierarchy Process (AHP) is fundamentally based on pairwise comparisons and seeks to answer the question "Which one?" (Ünal, 2011). AHP is a widely preferred method in comparing, evaluating, ranking, and selecting alternatives by expressing the relationship between objectives, criteria, sub-criteria, and alternatives in a complex problem faced by a decision-maker (Chandran et al., 2005). The most significant advantage of AHP compared to other multi-criteria decision-making methods is its ease of use and its ability to successfully handle complex decision problems that encompass both objective and subjective judgments (Yıldırım and Önder, 2015).

In his study, Turgut (2015) mentioned the reasons why AHP is chosen by many researchers. These reasons include:

a. Not requiring extensive technical knowledge to apply AHP.

b. Some data being created based on individuals' discretion.

c. Evaluating criteria individually and comparing them pairwise.

d. Having a simple process that allows different individuals with different opinions to reach a consensus.

e. Applicability to both qualitative and quantitative data.

The pairwise comparison method in AHP involves three main steps:

1. Developing the pairwise comparison matrix: This crucial step in AHP involves ranking the identified decision criteria. The pairwise comparison matrix uses a 1-9 scale developed by Saaty (1990).

Here, a score of 1 indicates equal importance between the two factors, while a score of 9 signifies that one row factor is much more important than the column factor it is compared to (Domakinis et al., 2008). Regarding the other scores, a score of 3 is assigned to weak importance, a score of 5 represents moderate preference, and a score of 7 is used for strong importance. Even numbers 2, 4, 6, and 8 are employed when a compromise is needed between odd-numbered scores (Mai Dang et al., 2011). Additionally, fractional values are used to indicate that one factor is less important than the matched factor. The determination of relative importance between two factors is often established by sending surveys to different experts, requesting them to compare the relative importance between the two factors concerning a specific objective (Mai Dang et al., 2011; Hayati et al., 2013; Lai et al., 2013). In rare cases, this comparison may be defined arbitrarily (Rozos, 2011).

2. Calculation of Weights: The calculation of weights is done in three stages. In the first stage, the values in each column of the matrix are summed. Then, each element in the matrix should be divided by the sum of its respective column. The resulting matrix represents the normalized pairwise comparison matrix. The calculation involves finding the average of the elements in each column of the normalized matrix. The obtained matrix involves summing the normalized scores for each element multiplied by the number of criteria considered. These averages enable the estimation of the relative weight value for each considered criterion.

3. Calculation of Consistency: One of the significant features of AHP is determining the consistency in comparisons (Yaralıoğlu, 2001). To ensure the consistency of subjective judgments and the accuracy of relative weights, two coefficients are used: Consistency Index (CI) and Consistency Ratio (CR). The CI value is calculated using the fundamental eigenvalue λ of the pairwise comparison matrix (Yıldırım and Önder, 2015). Therefore, when calculating the λ value, the pairwise comparison matrix is multiplied by the weight matrix W, and each element in each row is summed to obtain the column vector D. By taking the ratio of the corresponding elements in the obtained D column vector and the W weight matrix, the fundamental value matrix E for each evaluation criterion is obtained (Equation 1). The arithmetic average of these E values is taken

to find the fundamental value λ (Equation 2), and then the CI is calculated (Equation 3).

$$E_i = \frac{d_i}{w_i} \; (i = 1,2,3, \dots , n) \qquad \text{Eq (1)}$$

$$\lambda = \frac{\sum_{i=1}^{n} E_1}{n} \qquad \text{Eq (2)}$$

$$CI = \frac{\lambda - n}{n-1} \qquad \text{Eq (3)}$$

The consistency ratio (CR) can be determined using the following formula.

$$CR = \frac{CI}{RI}$$

Here, RI refers to the random index and is dependent on the number of elements being compared. In the study, since 9 criteria were used, RI was assumed to be 1.45 (Saaty, 1980).If CR<0.10, it can be stated that the consistency in pairwise comparisons is at an acceptable level. However, if CR>0.10, the ratio values indicate inconsistent judgments being made.

6. Findings

The data set components for generating the sensitivity map of collection areas using AHP include slope, geology, distance to rivers, distance to roads, distance to settlements, elevation, distance to fault lines, land use, and population. Firstly, using the AHP algorithm and mathematical formulas expressed by Saaty (1980) and Mai Dang et al. (2011), weights were calculated for all factors, and the results are shown in the Table 1.

After calculating the weights of the factors, the rasterized data sets were combined using the widely used Weighted Linear Combination (WLC) analysis within the framework of MCDA. WLC is based on the theory of a true utility function defined by the decision maker's desired set of possible solutions (Fishburn, 1967; Triantaphyllou and Mann, 1989). In WLC, all attribute values of an option are considered, and regular arithmetic operations such as addition and multiplication are used. In this method, attribute values and weights need to be numerical and comparable (Triantaphyllou and Mann, 1989).

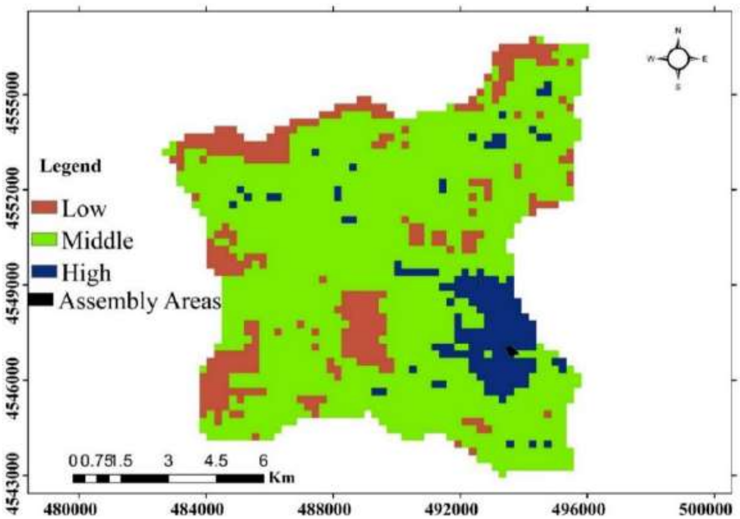
Table1. Pairwise comparison matrix and weights of parameters (a slope, b geology, c distance to rivers, d distance to roads, e distance to settlements, f elevation, g distance to fault lines, h land use, i population)

Parameters	a	b	c	d	e	f	g	h	i	Weights
a	1	3	5	2	5	9	7	4	2	0.27
b		1	3	1/2	3	7	5	3	1/3	0.13
c			1	1/3	1	3	2	1/2	1/5	0.05
d				1	3	5	4	3	1/2	0.15
e					1	3	2	1/2	1/4	0.05
f						1	1	1/3	1/5	0.02
g							1	1/3	1/4	0.03
h								1	1/3	0.09
i									1	0.21

The application of AHP indicates that the most important parameter in determining disaster and emergency assembly areas has a weight of 0.27, which is assigned to slope. The second significant parameter is the population with a weight of 0.21. The less important parameters, in descending order, are the distance to road (weight: 0.15), geology (weight: 0.13), land use (weight: 0.09), distance to river and distance to settlement (weight: 0.05), and distance to fault lines (weight: 0.03). Additionally, the Consistency Ratio (CR) value is calculated as 0.05. Since the CR value is significantly smaller than 0.1, it indicates that the weights of the factors influencing the determination of disaster and emergency gathering areas have been assessed well. After calculating the weights of the factors, the obtained weights are applied to the maps, and by combining the maps, suitable areas for disaster and emergency assembly areas is generated.

The disaster and emergency assembly area sensitivity map of the study area is divided into 3 sensitivity classes and the spatial distribution of this map is shown in Figure 3. According to this map; regions of high, middle and low sensitivity were obtained as 8.35%, 76.23% and 15.42%, respectively.

Figure 3. Disaster and emergency assembly area suitability map obtained by AHP method



The disaster and emergency assembly area of the study area was calculated as 1.10 ha in areas with high sensitivity and as 10.03 ha in areas with medium sensitivity. 2.03 ha of the study area has low sensitivity for the assembly area. When evaluated considering the location of the existing two disaster and emergency assembly areas in the study area (Karabük AFAD, 2023), it is determined that the assembly areas are located approximately 15 km away from the faults and about 20 km away from the KAFZ (Seismic Risk Zone), as well as being 300 m away from the settlement center and located in areas with a higher population. In terms of disaster and emergency assembly area sensitivity, it is observed that both existing assembly areas are within the high sensitivity zone.

7. Conclusions

Due to the sudden occurrence of earthquakes and their potential for causing significant loss of life, property, and socio-economic impacts, taking precautionary measures and actions before, during, and after earthquakes is of vital importance. Among these measures, the identification of pre-disaster assembly areas and temporary shelter locations is a crucial step in the preparation phase, considering their adequacy in terms of population at the provincial, district, and neighborhood levels, as well as their accessibility.

In this study, Geographic Information Systems (GIS) technology was employed to examine the existing two disaster and emergency assembly areas in Karabük Ovacık district and generate a sensitivity map for new assembly areas in the future. A comprehensive suitability analysis was conducted, considering spatial features such as slope, geology, distance to watercourses, distance to roads, distance to settlements, elevation, distance to fault lines, land use, and population parameters.

Urban open and green spaces are used as assembly and evacuation areas during and after earthquakes. Selecting the locations of these areas based on specific criteria is necessary to ensure the safety of individuals in these spaces. However, the decreasing availability of open and green spaces used by individuals for assembly and sheltering purposes after earthquakes poses a significant problem.

The two existing assembly areas are geologically located within the Karabük formation (Teka). Because it contains coal levels, assembly areas on the Karabük formation require more detailed field studies and taking field measures. Apart from this, it has been observed that the existing assembly areas comply with the other parameters used.

References

AFAD. (2023a). Afet ve Acil Durum Toplanma Alanları, https://www.afad.gov.tr/ kurumlar/afad.gov.tr/39521/xfiles/toplanma_alanlari.pdf (Visited on 25.04.2023).

AFAD. (2023b). Deprem Verileri, Afet ve Acil Durum Yönetim Başkanlığı, Deprem Dairesi Başkanlığı http://www.deprem.gov.tr/sarbis/Shared/Default.aspx (Visited on 23.04.2023).

Aman, D.D. (2019). Site location criteria of refuge areas for possible Marmara earthquake: case study of İstanbul Bağcilar. PhD thesis, Istanbul Technical University, Institute of Science, Landscape Architecture Department, Landscape Architecture Program.

Arca, D. (2012). Geographic Information System and Remote Sensing in Disaster Management, *Karaelmas Journal of Science and Engineering*, 2 (2), pp.53-61.

Aşıkkutlu, H.S., Aşık, Y., Yücedağ, C. and Kaya, L.G. (2021). Olası deprem durumunda mahalle ölçeğinde Burdur kenti acil toplanma alanlarının yeterliliğinin saptanması, *Mehmet Akif Ersoy İktisadi ve İdari Bilimler Fakültesi Dergisi*, 8(1):442-456.

Carter, G.F.B. (1994). Geographic Information Systems for Geoscientists: Modelling with GIS. *Computer Methods in the Geosciences*, 13, London, United Kingdom.

Chandran, B., Golden, B. and Wasil, E. (2005). Linear programming models for estimating weights in the analytic hierarchy process. *Computers & Operations Research*, 32(9), 2235-2254.

Chu, J. and Su, Y. (2011). Comprehensive Evaluation İndex System in the Application for Earthquake Emergency Shelter Site. *Advanced Materials Research*, (156-157), pp.79-83.

Çelik, H.Z., Aydın, B.S., Partigöç, N.S. and Erdin, H.E. (2018). Deprem Riskleri Bağlamında Toplanma Alanlarının Güvenlik Kriterleri Temelinde Değerlendirilmesi Bayraklı (izmir) Örneği. *International Symposium on Natural Hazards and Disaster Management*. Sakarya.

Çiçekdağı, H.İ. and Kırış, S. (2012). Site Selection for Disaster Station and Assembly Center and an Application, Dumlupınar University, *Journal of Science Institute*, Issue 28, August 2012 ISSN -1302-3055, Kütahya.

Çinar, A.K., Akgün, Y. and Maral, H. (2018). Investigation of Factors in Planning Post-Disaster Emergency Assembly and Temporary Shelter Areas: The Example of İzmir-Karşıyaka, *Journal of Planning*, 28(2):179-200, doi: 10.14744/planlama.2018.07088.

Demir G. (2018). Landslide susceptibility analysis by using GIS for Suşehri (Sivas), *GÜFBED/GUSTIJ*, 8 (1):96-112, https://doi.org/10.17714/gumusfenbil.299987

Domakinis, C., Oikonomidis, D. and Astaras,T. (2008). Landslide mapping in the coastal area between the Strymonic Gulf and Kavala (Macedonia, Greece) with the aid of remote sensing and geographical information systems, *Int J Remote Sens*, 29(23):6893–6915.

ECPFE (European Centre on Prevention and Forecasting of Earthquakes), OASP (Earthquake Planning And Protection Organization). (2002). Emergency Evacuation of the Population in Case of an Earthquake, Athens. http://Ecpfe.Oasp.Gr/Sites/Default/ Files/Eee_0.Pdf

Fishburn, P.C. (1967). Additive Utilities with Incomplete Product Set: Applications to Priorities and Assignments, *Operations Research Society of America (ORSA) Publication*, 15(3): 537-542. Baltimore, MD

Hayati, E., Majnounian, B., Abdi, E., Sessions, J. and Makhdoum, M. (2013). An expert-based approach to forest road network planning by combining Delphi and spatial multi-criteria evaluation, *Environ Monit Assess*, 185:1767–1776.

JICA (Japanese International Cooperation Agency) and IMM (Istanbul Metropolitan Municipality). (2002). Republic of Turkey Istanbul Province Disaster Prevention/Mitigation Basic Plan Study, Including Seismic Microzonation Final Report Volume V, Istanbul, Turkey. Access address http://www.ibb.gov.tr/tr-TR/SubSites/DepremSite/PublishingImages/JICA-TUR.pdf

Karabük AFAD. (2023). Karabük Toplanma Alanları, Karabük Valiliği, İl Afet ve Acil Durum Müdürlüğü. https://karabuk.afad.gov.tr/karabuk-toplanma-alanlari (Visited on 15.05.2023)

Keskin Citiroglu, H. and Arca, D. (2022). GIS-Based Determination of Solar Power Plant (SPP) Sites by the MCDA Method: Ovacık District, Karabük-Türkiye. *Environmental Engineering and Management Journal,* 21:1899-1910.

Kılcı, F., Yetiş Kara, B. and Bozkaya, B. (2015). Locating Temporary Shelter Areas after an Earthquake: A Case For Turkey, *European Journal of Operational Research*, 243:323–332.

Kırçın, P.N., Çabuk, S.N., Aksoy, K. and Çabuk, A. (2017). A Research on Increasing the Possibilities of Using Green Areas as Post-Disaster Gathering Areas in Our Country. *4th International Conference on Earthquake Engineering and Seismology*. Eskisehir: Anadolu University

Lai, T., Dragic´evic´. S. and Schmidt, M, (2013). Integration of multicriteria evaluation and cellular automata methods for landslide simulation modelling", *Geomat Nat Hazards Risk*, 4(4):355–375.

Mai Dang, N., Babel, M. and Luong, H. (2011). Evaluation of food risk parameters in the Day River Flood Diversion Area, Red River Delta, Vietnam, *Nat Hazards*, 56:169–194.

MEUT. (2020). Karabük Zonguldak Bartın Provinces Environmental Status Assessment. 264 p. Ministry of Environment and Urbanization of Turkey, Environment and Urban Library, http://www.cevresehirkutuphanesi.com/basili-yayinlar/detay/karabuk-zonguldak-bartin-illeri-cevresel-durum-degerlendirmesi (Visited on 02.11.2020).

MTA. (2023). Yer Bilimleri Harita Görüntüleyici ve Çizim Editörü, MTA Genel Müdürlüğü, http://yerbilimleri.mta.gov.tr/anasayfa.aspx (Visited on 23.04.2023).

NZ Transport Agency. (2009). Pedestrian Planning and Design Guide, October 2009 NZ Transport Agency, ISBN 978-0-478-35228-3.

Ovacık District Governorship. (2023). Geographical structure, Online at: http://www.ovacik.gov.tr/ilcemizin-cografi-yapisi (Visited on 28.05.2023).

Ovacık Municipality. (2023). General introduction of the district, Online at: http://www.ovacik.bel.tr/?pnum=12&pt=Ovac%C4%B1k+Tarih%C3%A7e (Visited on 28.05.2023).

Özkılıç, E.N. (2020). Analysis and evaluation of capacity and accessibility of after earthquake assembly areas in Istanbul by GIS. Master's thesis, Istanbul technical university, institute of sciences, Geomatics Engineering Department, Geomatics Engineering Program

Rozos, D., Bathrellos, G.D. and Skillodimou, H.D. (2011). Comparison of the implementation of rock engineering system and analytic hierarchy process methods, upon landslide susceptibility mapping, using GIS: a case study from the Eastern Achaia County of Peloponnesus, Greece, *Environ Earth Sci*, 63:49–63.

Saaty, T.L. (1980). *The analytical hierarchy process*. New York: Mc Grow-Hill Company.

Saaty, T.L. (1990). How to make a decision: the analytic hierarchy process. *European Journal of Operational Research*, 48(1): 9-26.

Soltani, A., Ardalan, A., Darvishi Boloorani, A., Haghdoost, A., Hosseinzadeh-Attar, M.J. (2014). Site Selection Criteria for Sheltering after Earthquakes: A Systematic Review. *PLOS Currents Disasters*, Edition 1. doi:10.1371/currents.dis.17ad1f98fb85be80785d0a81ced6a7a6.

Soltani, A., Ardalan, A., Darvishi Boloorani, A., Haghdoost, A., Hosseinzadeh-Attar, M.J. (2015). Criteria for Site Selection of Temporary Shelters after Earthquakes: a Delphi Panel. *PLOS Currents Disasters*, Edition 1. doi:10.1371/currents.dis.07ae4415115b4b3d71f99ba8b304b807

Şirin, M., Ocak, F. (2020). Evaluation of Disaster and Emergency Meeting Areas in the City of Gümüşhane in the Geographical Information Systems Environment. *Eastern Geographical Rewiew*, 25(44):85-106.

Timur, E. and Aksay, A. (2002). 1:100 000 scale geological map of Turkey No:30 Zonguldak F–29 section, Geological Studies Office, General Directorate of Mineral Research and Exploration MTA, Ankara, Turkey, pp. 23.

Triantaphyllou, E. and Mann, S.H. (1989). An examination of the effectiveness of multi-dimensional decision-making methods: A decision-making paradox, *International Journal of Decision Support Systems*, 5:303-312.

Turgut, E.C. (2015). Measuring the performance of suppliers using AHP and fuzzy AHP methods in supply chain management, new method suggestions and applications. Unpublished Master's Thesis, Dokuz Eylul University Institute of Social Sciences, Izmir.

Turkish Statistical Institute. (2023). Address based population registration system results, Turkish Statistical Institute, Online at: https://biruni.tuik.gov.tr/medas/?kn=95&locale=tr (Visited on 26.05.2023).

Turoğlu, H., Döker, F. and Bayrakdar, C. (2010). Importance of UZAL and GIS Technologies for Istanbul in Post-Disaster Response. *Istanbul Disaster Vulnerability Symposium*, p.293-297, Istanbul.

URL-1. (2020). Civil administration maps of Turkey, CografyaHarita, Online at: http://cografyaharita.com/turkiye_mulki_idare_haritalari.html (Visited on 06.09.2020).

Ünal, O.F. (2011). Analytical hierarchy process and its applications in personnel selection. *Akdeniz University Journal of International Alanya Business Faculty*, 3(2):18-38.

Yaralıoğlu, K. (2001). Analytical hierarchy process in performance evaluation. *Journal of D.E.U.İ.İ.B.F*, 16(1):129-142.

Yıldırım, B.F. and Önder, E. (2015). *Multi-criteria decision making methods*. Bursa: Dora Publishing and Distribution.