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Selection of Emergency Shelter Areas Using Multi-Criteria Decision-Making Techniques: An Assessment of the Case of Erciş-Van, Turkey

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Abstract

Emergency shelter areas, which are important in terms of gathering the survivors in a safe place during and after a devastating disaster, should be properly evaluated and determined before the disaster occurs. This study, it is aimed to develop a model that will allow the evaluation of existing emergency shelter areas and guide the area determination processes for new regulations. In line with the purpose, emergency shelter areas in Erciş-Van, affected by many potential natural disasters such as the 7.1 earthquake in 2011 and the flood in 2021, were evaluated. The proposed solution approach for the problem of selecting emergency shelter area consists of three primary stages. In the first stage, problem hierarchy and the criteria in the selection and evaluation of the emergency shelter areas were determined. Three main criteria and ten sub-criteria were determined for the evaluation of emergency shelter areas with content analysis. Then, the criteria weights were calculated using the AHP method, which shows the importance of the relevant criteria. At the last stage, 12 alternative emergency meeting areas in Erciş are evaluated using the TOPSIS method and ranked according to their priorities. The Field Properties Criteria were determined to be a high-weighted criterion, and Kışla Shelter Area was determined as the best alternative. This study presents a guide model that will help governments to determine new emergency shelter areas within the scope of disaster management, with evaluations for emergency shelter areas, and determined criteria weights.

Keywords

selection of shelter areas, disaster management, Erciş, AHP, topsis

1 Introduction

Disasters are the consequences of events that people must make extraordinary efforts to deal with as a result of a major ecological collapse, whether for natural, technological, or humanitarian reasons. The disaster resulting in the highest number of deaths and the most significant structural damage is the earthquake. The most active fault causing seismicity in Turkey is the Northern Anatolian Fault Line, which is a dextral fault zone where majority of the movements between the Eurasian plate and Anatolian Peninsula combine (Işık, 1992). Extending from Marmara on the west to the Lake Van on the east, this fault line is approximately 1200 kilometers long (Şengör et al., 2005).

Due to the movements in the Northern Anatolian Fault Line, an earthquake with a magnitude of 7.1 occurred in Van on 23 October 2011. Approximately 15 days later, another earthquake with a magnitude of 5.7 occurred in Edremit, 16 kilometers away from the central locations of Van, on 9 November 2011. The most significant number of deaths and greatest structural damage occurred in Erciş because of these two earthquakes. Consequently, 644 people lost their lives, 1966 were injured, and 252 were saved from the wreck. Besides, thousands of houses were destroyed or were damaged irreparably, causing thousands of people to lose their homes (AFAD, 2020a; Utkucu et al., 2014).

Both individuals and governments create pre-disaster and post-disaster scenarios which are highly important to be prepared for any sorts of disasters such as earthquakes. Considering the opinions and warnings of experts from many disciplines will help the disaster management process to be successful. One of the measures should be taken following an earthquake is to evacuate people from the affected buildings in case of a secondary disaster risk and the danger of a potential collapse. Following the evacuation process, people urgently move to locations where they

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can meet their relatives and overcome the initial shock they suffered from the disaster. These locations are called "emergency shelter areas" (Aman, 2019).

Emergency shelter areas are the safe locations where people can gather following an evacuation process to overcome the panic and ensure proper information exchange in a period of time needed by authorities to prepare the temporary shelters following a disaster or emergency (Coburn and Spence, 2002). Local authorities define these areas as suitable locations that can be comfortably accessed by people, particularly those with disabilities, and the elderly. These areas should be close to housing zones on flat lands away from fault lines. Here, people can meet their basic needs and receive first aid services based on population density. There are approximately 15984 emergency shelter areas defined in Turkey (AFAD, 2020b).

1.1 Literature review

Selection of emergency shelters is a difficult process. Disasters such as collapses, floods, or landslides can occur as a result of the mistakes in selecting these areas. Many criteria affect the problem of selecting an emergency shelter area, and selection process among the alternatives should be assessed systematically. A review on the literature of disaster management indicated that MCDM methods were used in defining and solving various issues in disaster management such as urgent selection of a logistic location, assessment of the earthquake emergency shelters, or selection of a temporary shelter (Aman, 2019; Cheng and Yang, 2012; Chu and Su, 2010; Omidvar et al., 2013; Yavuz Kumlu and Tüdeş, 2019).

For instance, the study by Cheng and Yang aimed to develop a model to assess the earthquake emergency shelters. There were three assessment criteria in their study: sheltering capacity, facility quality, and accessibility. They calculated each weighted criterion using the Analytical Hierarchical Process (AHP) and conducted a case study to confirm the validity and usability of the model (Cheng and Yang, 2012). Omidvar et al. (2013) conducted a study on selecting appropriate locations for temporary shelters. They proposed a model where Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination Et Choix Traduisant la Realité (ELECTRE), Simple Additive Weighting (SAW), and AHP methods were used to select appropriate locations for temporary shelters. The selection was based on a geographical information system and earthquake damage assessment. The problem-specific criteria were determined and then applied for the Municipality Region 1 in Tehran, Iran. Fourteen regions were proposed for the necessary shelter areas at the end of the study (Omidvar et al., 2013).

Chu and Su's study aimed to select locations for earthquake emergency shelters and to establish a system for assessing these locations. They used the analytic hierarchical process management method (Chu and Su, 2010). To determine the locations posing a risk in case of earthquake in the central parts of Yalova, Turkey, Yavuz Kumlu and Tüdeş used TOPSIS and AHP in their study. They performed an AHP analysis in terms of geologic and superstructure/infrastructure criteria. In the results of their study, they obtained a general earthquake risk map that can reduce harmness of disasters (Yavuz Kumlu and Tüdeş, 2019). In a similar study, Aman (2019) determined the selection criteria regarding the safe shelter areas and calculated the weighted values. Aman performed open and green area analyses in seven neighborhoods in Bağcılar, İstanbul, and found 230 potential sheltering locations in these seven neighborhoods. The potential locations of these areas were analyzed in terms of the pre-determined criteria and ordered using TOPSIS. The locations that could potentially provide sufficient space for the population of the neighborhood were marked on the map, starting from the sheltering locations with high scores (Aman, 2019).

In the light of the literature review, it is seen that researchers applied the MCDM methodology in various studies within the scope of disaster and disaster management. As can be understood from the literature review, the problem has been examined from different aspects and different techniques have been used. Even the papers that use the same solution technique take into account different criteria because of the disaster types. In this study, it is aimed to create a preliminary assessment model prepared with an integrated scale for regions with multiple disaster risks. An application-oriented model is proposed by answering the question of how to reduce the possibility of being affected by all risk factors with the content analysis method. In addition to being a real-life decision problem, the problem under consideration is influenced by many criteria that must be evaluated simultaneously.

2 Material and method

This study is based on a real problem in emergency shelter areas in Erciş district of Van province. Erciş is a district of Turkey located at latitude 39.0311, longitude 43.3597 39° 1′ 52″ N and 43° 21′ 35″ E, surrounded by fault lines showing compression and contraction in the north-south direction. Due to the effects of fault lines in this region, Erciş experienced earthquakes, landslides, floods, and many other disasters.

For example, the earthquake that hit Van on 23 October 2011 occurred on Sunday at 13:41, meaning many people experienced the tragic event in their homes. In such a disaster, proximity of emergency shelter areas to the residential areas becomes much more important. In addition, victims may suffer from psychological issues such as depression that arise from the idea of losing or being separated from the family. Therefore, emergency shelter areas built close to victims' houses provide physical and psychological help to victims following a disaster.

Therefore, within the scope of the study, emergency shelter areas determined by the Disaster and Emergency Management Presidency in Erciş were examined (Fig. 1). The characteristics of these regions were obtained from the 1/5000 Scale Master Development Plan of Erciş District of Van Province (2018). Then, 12 shelter areas were evaluated by applying the proposed model steps.

2.1 Method

The proposed solution approach for the problem of selecting emergency shelter area consists of three primary stages. In the first stage, problem hierarchy and the criteria in the selection and evaluation of the emergency shelter areas are determined. Then, the criteria weights are calculated using the AHP method, which shows the importance of the relevant criteria. At this stage, the binary comparison matrices are constructed using the expert assessments along with the importance scale presented in Table 1. At the last stage, alternative emergency shelter areas are evaluated using the TOPSIS method and ranked according to their priorities. The flow chart for the explained algorithm is shown in Fig. 2.

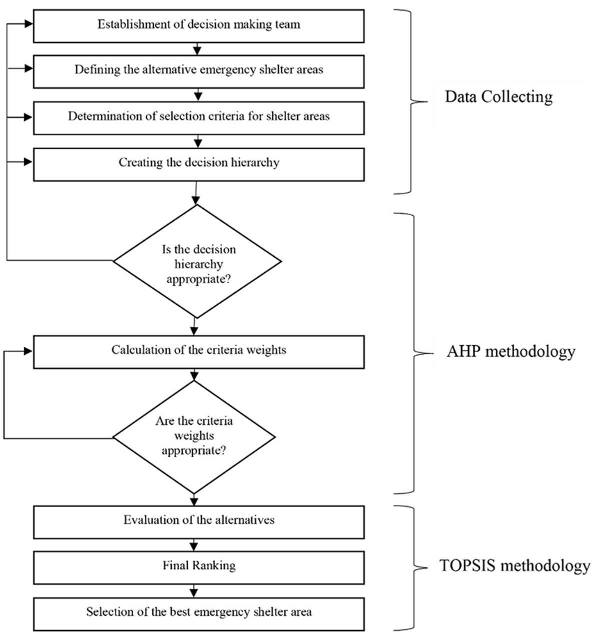

Fig. 1 Flow chart of the emergency shelter area selection algorithm

In order to ensure the clarity of the presentation, it is necessary to provide a brief summary of the two methods used in this study, the AHP and TOPSIS methods.

2.1.1 Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) is one of the MCDM methods developed by Thomas L. Saaty in the 1970s to be used in selection and decision problems (Saaty, 2008). AHP is a mathematical method that considers all priorities (Yılmaz and Dağdeviren, 2010).

The most basic form used in a decision problem consists of three hierarchical levels: the highest level representing the decision goal, followed by a second level composing of related criteria, which are used to consider the alternatives given at the third level. Factors affecting the decision are regulated gradually. The purpose of the structure is to determine the importance of the elements at a certain level according to some or all the elements at the level mentioned above (Saaty and Vargas, 2001).

The main steps of AHP method are presented below (Saaty and Kearns, 1985):

- Step 1: At this stage, the decision problem is defined, and the model is constructed.
- Step 2: Binary comparison matrices are arranged for the criteria defined in the model. In these comparisons, 1-9 scale is used. In this context, AHP importance levels are presented in Table 1.
- Step 3: Criterion weights are calculated using the binary comparison matrix. Once the binary comparison matrix is obtained, the column elements in the binary comparison matrices are summed up, and C matrix (normalized binary comparison matrix) is obtained using Eq. (1). Then, the average values are obtained, resulting in the ***W*** column vector called "Priority Vector", using Eq. (2).

Table 1 The 1–9 fundamental scale

Intensity of importance	Definition
1	Equally important
3	Moderately more important
5	Strongly more important
7	Very strongly more important
9	Extremely more important
2, 4, 6, 8	Intermediate values

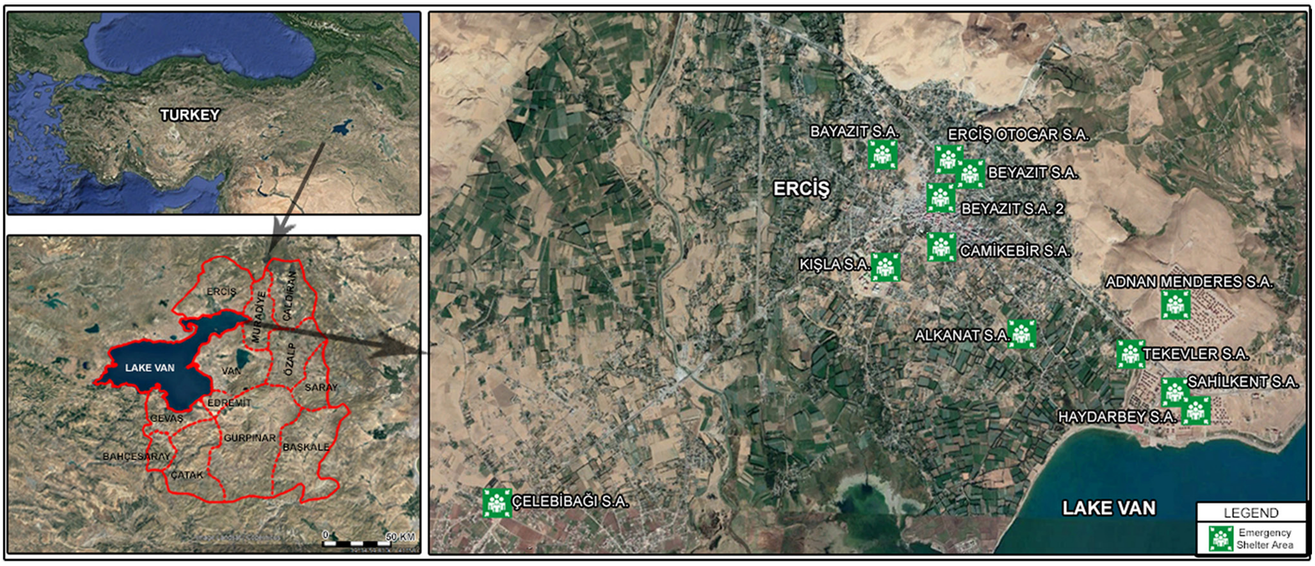

Fig. 2 Emergency shelter areas of Erciş District of Van Province

$$\boldsymbol{b}_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{1}$$

$$\boldsymbol{C} = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ c_{n1} & c_{n2} & \dots & c_{nn} \end{bmatrix}$$

$$\boldsymbol{w}_i = \frac{\sum_{j=1}^{n} c_{ij}}{n} \tag{2}$$

- Step 4: Consistency is checked for criteria comparisons.

Considering the AHP method, the fact that decision makers perform a subjective evaluation may cause inconsistencies in the results. These inconsistencies can be measured using the Consistency Index (CI). CI value is divided by the Consistency Index (RI), and the Consistency Ratio (CR) is obtained for the same size matrix. To be acceptable, the CR value must be approximately 10% or less. Up to 20% can be tolerated but higher values cannot be tolerated. If CR is not in this range, participants should review the problem and their evaluations.

2.1.2 Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS is a technique developed by Hwang and Yoon in the 1980s, providing the best choice among alternatives (Hwang and Yoon, 1981). The standard TOPSIS method aims to select alternatives with the shortest distance from the positive ideal solution, and the farthest distance from the negative ideal solution at the same time. According to Yoon and Hwang (1995), the ideal solution is often unattainable or impossible to achieve. Therefore, being as close to an ideal solution as possible is the logic of human choices (Yoon and Hwang, 1995). The positive ideal solution maximizes the benefit criteria while minimizing the cost criteria. The negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. TOPSIS method provides the basic ranking of the alternatives by reviewing the effects of the criteria on the alternatives (Behzadian et al., 2012; Dağdeviren et al., 2009).

Application steps of the method are presented below (Hwang and Yoon, 1981):

- Step 1: The decision matrix ($\boldsymbol{A} = [a_{ij}]$) related to the problem is created first. In the decision matrix, the rows show the alternatives, and the columns show the criteria.

$$\boldsymbol{A}_{ij} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & \dots & . \\ . & . & \dots & . \\ . & . & \dots & . \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix} \tag{3}$$

- Step 2: Normalized decision matrix ($\boldsymbol{R} = [\boldsymbol{r}_{ij}]$) is calculated by using the elements of matrix $\boldsymbol{A}$ and Eq. (4).

$$\boldsymbol{r}_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \tag{4}$$

$$\boldsymbol{R}_{ij} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix}$$

- Step 3. Calculation of the weighted normalized decision matrix ($\boldsymbol{V} = [v_{ij}]$) using Eq. (5).

$$\boldsymbol{V}_{ij} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ . & . & \cdots & . \\ . & . & \cdots & . \\ . & . & \cdots & . \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix} \tag{5}$$

- Step 4: Determination of the positive ideal ($\boldsymbol{A}^*$) and negative ideal ($\boldsymbol{A}^-$) solutions using Eqs. (6) and (7).

$$\boldsymbol{A}^* = \left\{ \left(\max_i v_{ij} \middle| j \in J \right), \left(\min_i v_{ij} \middle| j \in J' \right) \right\} \tag{6}$$

$$\boldsymbol{A}^- = \left\{ \left(\max_i v_{ij} \middle| j \in J \right), \left(\min_i v_{ij} \middle| j \in J' \right) \right\} \tag{7}$$

- Step 5: Calculation of the separation measures. At this step, two different measures exist: positive ideal separation $\left(\boldsymbol{S}_i^*\right)$ and negative ideal separation $\left(\boldsymbol{S}_i^-\right)$ for each alternative, which are calculated using Eqs. (8) and (9), respectively. This calculation uses the Euclidean Distance Approach.

$$\boldsymbol{S}_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^* \right)^2} \tag{8}$$

$$\boldsymbol{S}_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^- \right)^2} \tag{9}$$

- Step 6: In the last step, the relative closeness of each alternative is found by using Eq. (10). Alternatives are ranked according to the relative closeness values that are ranked in descending order.

$$\boldsymbol{C}_j + = \frac{\boldsymbol{S}_i^-}{\boldsymbol{S}_i^- + \boldsymbol{S}_i^+},\ 1 \geq \boldsymbol{C}_i \geq 0 \tag{10}$$

2.2 Determining the criteria for selecting emergency shelter areas

The criteria used for selecting the emergency shelter areas were collected from the literature on disasters, disaster management, emergency shelter areas, location selection, and from the experts' opinions to implement the method containing a hierarchy. Ten criteria were determined for the selection of the emergency shelter areas. The studies in the literature related to these criteria were gathered under three main titles by associating them with each other:

1. field properties,
2. geological properties,
3. transportation and accessibility (Table 2).

Each of the decided criteria will be examined within the scope of the selection of emergency shelter areas, and the evaluation definition of each criterion will be presented below in order to evaluate the emergency shelter areas in Erciş district of Van province.

The size, capacity, and infrastructure of emergency shelter areas are crucially important for the safety of the lives of victims during and after disasters. These qualities constitute the "field properties". In addition to the field properties, "geological properties" that affect the durability of emergency shelter areas are substantial in terms of life and property safety. Shortly after disasters, victims need to abandon their locations and gather in a safe area that should also be accessed by the authorities. Accordingly, "transportation and accessibility" is also a critical concept for the emergency shelter areas. These afore-mentioned criteria were accepted as the main criteria in terms of selecting the emergency shelter areas for this study.

The field properties criteria consist of areal size and infrastructure. Areal size is an essential criterion in selecting and setting temporary shelter areas where many disaster victims can gather with their relatives after a disaster. The sizes of emergency shelter areas should permit hosting over ten people. This size is defined as 10 square meters (m^2) per person in development plans. Accordingly, emergency shelter areas are expected to be larger than 100 m^2. Çelik et al. stated that an ideal emergency shelter area should be 5000 m^2, or a single extensive area of 50,000 m^2, which can be used by many disaster victims, and should be planned in place of small areas (Çelik et al., 2017). Accordingly, it is fair to state that shelter areas should be minimum of 100 m^2, and the ideal shelter areas cover 50,000 m^2 or more. Besides, the

Table 2 List of criteria and sub-criteria

	Criteria	Reference		Criteria	Reference
Field properties criteria	Areal size	Aksoy et al. (2009) Cheng and Yang (2012) Chu and Su (2010) Çelik et al. (2017) Çınar et al. (2018) Omidvar et al. (2013) UNHCR (2007)	Geological properties criteria	Geologic structure	Chu and Su (2010) Kelly (2005) Omidvar et al. (2013) UNHCR (2007) Yavuz Kumlu and Tüdeş (2019)
Field properties criteria	Infrastructure	Çelik et al. (2017) Chu and Su (2010) Çınar et al. (2018) Kara (2007) Kelly (2005) Liu et al. (2011) Ministry of Public Works and Settlement (2007) Omidvar et al. (2013)	Geological properties criteria	Slope	AFAD (2013) Chalinder (1998) Chu and Su (2010) Çelik et al. (2017) Kelly (2005) Liu et al. (2011) Wei et al. (2012)
Transportation and accessibility criteria	Proximity to the road	Aksoy et al. (2009) Chu and Su (2010) Çınar et al. (2018) Yavuz Kumlu and Tüdeş (2019) Wei et al. (2012)	Geological properties criteria	Soil liquefaction	Çelik et al. (2017) Akın et al. (2015) Wei et al. (2012) Xu et al. (2016)
Transportation and accessibility criteria	Proximity to health facilities	Cheng and Yang (2012) Chu and Su (2010) Omidvar et al. (2013) Yavuz Kumlu and Tüdeş (2019)	Geological properties criteria	Groundwater level	Ada and Ergin (1993) Özşahin and Değerliyurt (2013)
Transportation and accessibility criteria	Proximity to residential areas	Cheng and Yang (2012) Chu and Su (2010) Omidvar et al. (2013) Wei et al. (2012)	Geological properties criteria	Elevation zone	Chalinder (1998) Chu and Su (2010) Liu et al. (2011) Omidvar et al. (2013) UNHCR (2007)

infrastructure systems in emergency shelters that will meet victims' needs are also critical. Post-disaster infrastructure performance targets were set in Ministry of Public Works and Settlement (2007). These targets include providing full support to all areas and protecting water supply and quality after an earthquake even under winter conditions. In a potential earthquake scenario, minimum 70% of the reservoirs should be available, 70% of service areas should work, and 70% of winter-related requests should be met (Ministry of Public Works and Settlement, 2007). In addition, the targets also include supplying drinking water in 72 hours to central locations and providing service to all regions for a month.

"Geological Properties Criteria" has five sub-headings. Strength of the ground is critical for the emergency shelter areas. Soils with low capacity are both vulnerable to earthquakes and risky for housing. Drilling activities were performed in Erciş by Directorate General for State Hydraulic Works (DSI), and geological properties were revealed. According to the results, the geological structure of Erciş comprises the accumulation of different geological materials carried by lakes and rivers. The soil liquefaction criteria, which cause specific effects such as collapses and slides, are essential in selecting emergency shelter areas (Akın et al., 2015). The examinations conducted in Erciş by the Middle East Technical University (2011) following an earthquake indicated that collapses, slides, and lateral deformations occurred as a result of soil liquefaction (Özacar et al., 2011). The high groundwater level is another important factor that increases earthquake damage and affects sensitivity in this regard (Ada and Ergin, 1993; Korkmaz, 2006; Özşahin and

Değerliyurt, 2013). According to Plan Investigation and Explanation Report (2018) for Erciş, the groundwater level was found to range from 0.5 to 10 meters (m) during the measurements performed in March 2012 (Ministry of Public Works and Settlement, 2018). The mean groundwater level was approximately 4.18 m. The groundwater level decreased around the parent rocks on the northern and eastern regions of Erciş. Considering these reasons, the locations where the groundwater level is low should be selected as the emergency shelter areas.

The "topographic slope values" were provided under the title of disaster management within the Geological Etude Report issued by the Disaster and Emergency Management Presidency (AFAD, 2013). Accordingly, the topographic slope value was categorized as 0–5% for the flat and almost flat areas, 5–15% for the areas with low slope, 15–30% for the areas with moderate slope, 30–40% for the areas with high slope, and 45% or above for the areas with very high slope (AFAD, 2013). The slope of emergency shelter areas should be 0–5%, that is, the area should be flat or almost flat to ensure accessibility and prevent the possibility for ground-related problems in a disaster. The last sub-heading of the geological criteria, Elevation Zones are defined in the Law on Transformation of Areas at Risk of Natural Disaster (Ministry of Public Works and Settlement, 2012). According to the Plan Investigation and Explanation Report for Erciş, the elevation zone values in the region are 1679–1685 m, 1686–1690 m, 1691–1695 m and 1696–1700 m. Emergency shelter areas should be on the locations that have high elevations since disasters such as floods or tsunami are more devastating at the locations within lower elevation zones. If shelter locations are flooded after a disaster, a worse tragedy and significant damages may occur (Chu and Su, 2010).

During the disasters such as an earthquake that result in the loss of life and property, transportation and accessibility become important as victims need to safely reach the emergency shelter areas. After such disasters, roads should be open so that people can escape from the scene (Aman, 2019). The sub-criteria of this main criterion are Proximity to the Road, Proximity to Health Facilities, and Proximity to Residential Areas. Proximity to the Road is important for the victims to access the shelter area and health facilities, and for the medical services to reach the area. Proximity to the Health Facilities is critical in decreasing the medical risks from potential disasters (Yavuz Kumlu and Tüdeş, 2019). A walking distance lasting 15 minutes or shorter is an expected property for the proximity to health facilities. Fifteen minutes mean the maximum duration of distance in terms of the mental and physical limit (Aksoy et al., 2009). The literature shows that there is a relationship between increasing distance to healthcare facility and risk of death. An increase of 10 km means approximately a 1% increase in the death risk (Nicholl et al., 2007). Besides, the physical effect of the distance to health facilities also has a psychological effect. Emergency psychological help should be provided to the victims in the disaster area as soon as possible (Shoygu, 2014). Therefore, the distance to the health facilities is critical for shelter areas.

In the light of these explanations, 12 alternative areas were assessed according to mentioned sub-criteria under each main criterion. The decision hierarchy used in this study is presented in Fig. 3.

3 Findings

3.1 Determination of the criteria weights

AHP method was used to determine the weights of the predefined criteria with the evaluations of five specialists who

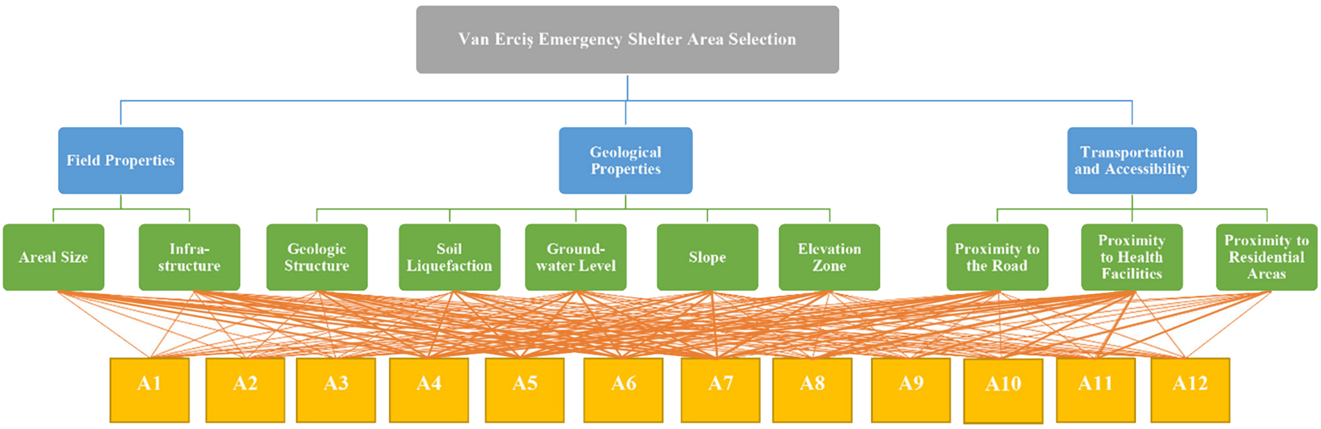

Fig. 3 Decision hierarchy

were Architect, Civil Engineer, City Regional Planner, and Geologist. These experts are the researchers on natural disasters and faculty members in relevant departments of universities. At this stage, the expert team was asked to create individual binary comparison matrices using the AHP importance scale given in Table 1. Geometric averages of these values were taken to obtain the binary comparison matrix with a consensus on it. Inconsistency rates of the criteria were then calculated, and cases where this value is less than 0.2 were considered inconsistent. The results obtained at this stage are presented in Table 3.

According to the analysis results in terms of main and sub-criteria, "Field Properties Criteria" have the highest impact in selecting the emergency shelter areas. This result emphasizes the importance of emergency shelter areas having sufficient size in terms of the number of people they will accommodate after a disaster, meeting their basic needs, and having sufficient infrastructure to prevent non-disaster deaths/diseases.

"Transportation and Accessibility Criteria", has the second place in terms of the assessment based on main and sub-criteria. The proximity of emergency shelters to the road is essential considering the escape of victims from the tragic scene, arrival of assistance to the area, and transporting injured victims to the health facilities. Victims desire to meet their families in a safe environment during and after the disasters. Therefore, proximity of emergency shelter areas to residential areas is highly important. Proximity to Health Facilities is critical for victims to access the medical services following a disaster.

"Geological Properties Criteria" have the least impact on the assessment based on main and sub-criteria. The

Table 3 Local and global weight

Criteria	Local weight	Sub-criteria	Local weight	Global weight
Field properties	0.453	Areal size	0.800	0.363
		Infrastructure	0.200	0.090
Geological properties	0.225	Geologic structure	0.390	0.088
		Soil liquefaction	0.329	0.074
		Groundwater level	0.171	0.038
		Slope	0.069	0.015
		Elevation zone	0.038	0.008
Transportation and accessibility	0.320	Proximity to the road	0.493	0.158
		Proximity to health facilities	0.138	0.044
		Proximity to residential areas	0.368	0.118

geological qualities of emergency shelter areas reflect the strength of these areas in general. The areal and accessibility-related properties of emergency shelter areas are found to be more important than the geological and should be prioritized. Properties of emergency shelter areas can be determined in accordance with the importance level.

3.2 Selecting the best shelter area alternative

The criteria weights calculated in the AHP method were used as the inputs of TOPSIS in the selection and ranking process. According to the TOPSIS methodology, the weighted normalized decision matrix (V) was obtained (Table 4).

Positive and negative ideal solutions calculated by Eqs. (6) and (7) are shown in Table 4. While the criteria were scored, they were converted into utility criteria. Therefore, all criteria were evaluated in terms of maximization for benefit to obtain the positive ideal solution sets. The ideal solution separation measure values calculated by Eqs. (8) and (9) and corresponding rankings of alternatives are shown in Table 5.

As can be seen from Table 5, Kışla Shelter Area is the best ranked shelter area in Erciş District of Van Province. It has the highest score due to the following reasons: an areal size of 13,000 m^2, sufficient infrastructure, presence on a solid, flat, or almost flat ground with 0-5% slope rate, presence in a high elevation zone which ensures protection from the impacts of disasters such as floods following a potential earthquake, and proximity to road, health facilities and residential areas. The liquefaction potential of the shelter area is quite due to presence of high ground water.

Bayazıt, Camıkebir and Adnan Menderes shelter areas, which are the last in the order, have common deficiencies. Bayazıt Shelter Area does not have the desired value in terms of "Areal Size", and the distance between Bayazıt emergency shelter area and health facilities is high. However, the ground water level and liquefaction potential of Bayazıt Shelter Area are better compared to those of Kışla Shelter Area. As another alternative, Camıkebir Shelter Area, which is the closest to Kışla Shelter Area, has an average areal size but lacks necessary infrastructure. This emergency shelter area was found to have a low liquefaction potential and average ground water level. The Slope and Elevation Zone values were close to the desired values. Despite these positive properties, the distance to the health facilities was found to be high. Similarly, Adnan Menderes Shelter Area was examined based on the "Field Properties" criterion with the highest weight value, and it ranked the last in the emergency shelter area list

Table 4 The weighted normalized decision matrix (V) for the selection criteria

Emergency Shelter Areas	Field properties (0.453)		Geological properties criteria (0.225)					Transportation and accessibility criteria (0.321)		
	Areal Size (0.363)	Infrastructure (0.091)	Geologic Structure (0.088)	Soil Liquefaction (0.074)	Groundwater Level (0.038)	Slope (0.015)	Elevation Zone (0.008)	Prox. to the Road (0.158)	Prox. to Health Facilities (0.044)	Prox. to Resi-dential Areas (0.118)
Bayazıt S. Area	0.107	0.030	0.033	0.011	0.003	0.001	0.004	0.047	0.006	0.036
Erciş Otogar S. A.	0.107	0.030	0.033	0.022	0.019	0.003	0.004	0.047	0.006	0.036
Beyazıt S. A.	0.066	0.030	0.033	0.033	0.019	0.003	0.004	0.047	0.006	0.036
Beyazıt S. Area 2	0.107	0.030	0.016	0.033	0.019	0.003	0.004	0.047	0.018	0.036
Camıkebir S. Area	0.064	0.030	0.033	0.033	0.011	0.005	0.001	0.047	0.006	0.036
Kışla S.Area	0.107	0.030	0.033	0.022	0.007	0.005	0.001	0.047	0.030	0.036
Erciş Alkanat S. Area	0.107	0.006	0.016	0.022	0.007	0.005	0.001	0.047	0.006	0.036
Erciş Tekevler S. Area	0.107	0.006	0.016	0.011	0.007	0.005	0.001	0.047	0.006	0.036
Adnan Menderes S. Area	0.107	0.030	0.016	0.011	0.003	0.005	0.001	0.009	0.006	0.036
Erciş Sahilkent S. Area	0.107	0.030	0.016	0.011	0.003	0.005	0.001	0.047	0.018	0.021
Erciş Hayderbey S. Area	0.107	0.030	0.016	0.011	0.003	0.005	0.001	0.047	0.006	0.036
Çelebibağı S. Area	0.107	0.006	0.016	0.011	0.003	0.005	0.001	0.047	0.006	0.021
Positive Ideal and Negative Ideal Solutions										
A^*	0.111	0.030	0.034	0.033	0.019	0.005	0.004	0.048	0.031	0.036
A^-	0.067	0.006	0.017	0.011	0.004	0.001	0.001	0.010	0.006	0.022

Table 5 Positive and negative ideal separation measures

Emergency Shelter Areas	S^*	S^-	C^*	Ranking
Bayazıt Shelter Area	0.037	0.067	0.646	10
Erciş Otogar Shelter Area	0.027	0.070	0.720	3
Beyazıt Shelter Area	0.051	0.057	0.529	4
Beyazıt Shelter Area 2	0.021	0.071	0.772	2
Camıkebir Shelter Area	0.051	0.056	0.520	11
Kışla Shelter Area	0.016	0.072	0.817	1
Erciş Alkanat Shelter Area	0.042	0.061	0.596	7
Erciş Tekevler Shelter Area	0.046	0.060	0.568	8
Adnan Menderes Shelter Area	0.056	0.053	0.487	12
Erciş Sahilkent Shelter Area	0.037	0.065	0.634	5
Erciş Hayderbey Shelter Area	0.040	0.065	0.617	6
Çelebibağı Shelter Area	0.049	0.059	0.544	9

although it had the necessary areal size and infrastructure. According to the assessment made in accordance with the "Transportation and Accessibility" criterion, which had the highest weight value after "Field Properties", the emergency shelter area that is close to the residential areas is not different from the shelter areas on the top of the list, and the distance to the health facilities is high. When analyzed in the context of "Geological Properties Criteria", it is seen that the geological features are undesirable in terms of shelter areas. The underground water level and liquefaction potential are high. Since collapses can occur in places where this type of liquefaction is high, these areas are not suitable for shelter areas.

The characteristics of these emergency shelter areas indicated that properties of areal size and infrastructure are close in all shelter areas and those differences arise from the "Transportation and Accessibility" and "Geological Properties" criteria. Regarding the "Transportation and Accessibility Criteria", the distance between the shelter areas at the end of the list and health facilities is high. The distance to the health facilities is important in reducing the mental and physical risks after disasters. Thus, the emergency shelter areas are adversely affected as the distance between the health facilities and these areas increases.

The differences arising from the "Geological Properties Criteria" causes people to question the proximity of the shelter areas in the list to Lake Van. The appropriate shelter areas are 3.5 km (min.) away from Lake Van while the inappropriate ones are 0.5 km (min.) away. Accordingly, as the distance to the lake decreases, the suitability of shelter areas also decreases in a direct proportion. The reason is that geological properties differ as the distance to the lake changes. As the distance to the lake decreases, the criteria such as Geologic Structure, liquefaction or underground water level show a negative acceleration. The formation of the ground consisting of young alluvial soil and high liquefaction rates regarding such grounds indicate that the ground is loose in these areas. Loose grounds show devastating effects in disasters, so areas with such grounds are reflected as inappropriate in the list of emergency shelter areas. Good or poor geological properties do not solely have a determinative impact in the order. Instead, all assessment criteria have an impact.

4 Conclusions

Emergency shelter areas play a decisive role in reducing human casualties by enabling disaster survivors to come together in a safe place during and after a devastating disaster. Therefore, in this study, we tried to evaluate the applications of emergency meeting areas in Van (in Turkey), which has many potential disaster risks such as the earthquake in 2011. To do this, we reviewed the literature on emergency shelter areas, and following this review, we determined certain criteria for the evaluation of relevant areas. The literature on this topic reinforces the importance of the study in using the Multi-Criteria Decision Making (MCDM) methodology. For this reason, a model using MCDM methods AHP and TOPSIS was created to evaluate and rank emergency assembly areas with the determined criteria. The created model has been evaluated by experts who have experience in the application of the model and the subject.

As a result of the AHP evaluation, which is the first step of the created model, the Area Characteristics Criterion was found to be the most important criterion for emergency shelter areas. The area characteristics criterion has achieved this result because it is an effective criterion that shows the reliability of the emergency meeting area. However, it should be noted that the fact that the Area Characteristics criterion is in the first place in the study does not mean that other criteria are not important. After the criterion weights were calculated, TOPSIS, the other step of the model, which allows the ranking and evaluation of the selected emergency meeting areas, was used. The evaluated shelter areas were determined from the shelter areas system of AFAD and were evaluated by the expert group. As a result of the evaluation, we found that Kışla Shelter Area, one of the emergency shelter areas, was the most suitable. When this area was examined, it was concluded that there were some negative aspects. However, it was also concluded that it performed well in the most effective criteria in the selection of emergency meeting areas. Therefore, its overall performance is good.

A general assessment toward the data indicates that emergency shelter areas do not have the pre-determined shelter area properties. As a result, while choosing emergency shelter areas, the application of the Multiple Criteria Decision Making (MCDM) with Analytical Hierarchy Process (AHP) and TOPSIS methods will help both the local and central authorities. Reassessment and repositioning of existing and new emergency shelter areas, considering the above-mentioned criteria weights, will increase the effectiveness of use in possible disasters. In addition, it is thought that the frequent use of "decision making" methodologies to take concrete and correct steps for the authorities will contribute both materially and morally in emergencies and disasters.

5 Future work

This research focuses on emergency shelter areas in Van / Erciş, where emergency shelter areas are of great importance due to many disasters. The results are universal, but the results obtained within the scope of the study may not be generalizable to the population due to the limited sample size. This research can be carried forward by incorporating the stated limitations of this study.

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