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Evaluation of Emergency Preparedness of Airports Located in Türkiye

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Abstract

This study deals with the earthquake preparedness of airports in Türkiye. Türkiye is in an earthquake zone and suffered major losses in two consecutive earthquakes in the south on February 6, 2023. As a result of these major disasters, it has begun to investigate how prepared the provinces on the fault line are for earthquakes. In this context, seven provinces located on the North Anatolian Fault Line were examined according to the determined criteria, paying attention to airports that are of great importance in emergencies such as earthquakes. Five main criteria and thirteen sub-criteria have been determined to examine whether the airports in the selected provinces are working systematically after the disaster. AHP (Analytic Hierarchy Process) and Fuzzy AHP, which are among the Multi-Criteria Decision Making (MDCM) methods, were used. The fact that Istanbul stands out as the highest value among alternatives in both methods shows that this airport is better equipped according to determined criteria in emergencies such as earthquake. Moreover, more specific importance weight ratios with Fuzzy AHP method can contribute to the development of strategic planning by providing clearer information. As a result, this study is expected to support the development of airport earthquake disaster preparedness planning and emergency management strategies. Future studies are expected to further deepen these findings and increase the crisis management capacity of the aviation sector.

1. Introduction

Earthquakes occur as a result of seismic waves created as a result of unexpected energy in the earth's crust and shake the earth [1]. Earthquakes are one of the most frequent and most dangerous natural disasters that affect millions of people around the world every year and can result in deaths. A large earthquake in an urban area can be one of the most devastating natural disasters. Unprepared low- and middle-income countries may face serious problems from major disasters [2]. Türkiye is one of the countries located in the earthquake zone and Türkiye is classified according to various earthquake zones [3]. Figure 1 shows the map of Türkiye located in the earthquake zone. As can be understood from the figure, there are fault lines almost all over Türkiye [4].

Türkiye has experienced many earthquakes in its history due to its location. Among these, two major earthquakes that occurred consecutively in the southeast of Türkiye and the north of Syria on February 6, 2023 [5], which are the biggest earthquakes of the last 84 years [6] caused the whole world to worry [7]. These earthquakes caused the death of thousands of people, injuries to tens of thousands of people, financial losses and psychological damage. For this reason, to prevent the irreparable consequences of an earthquake, it is necessary to implement procedures to increase earthquake sensitivity throughout a society, to reduce earthquake damage, and to prevent the negative effects of earthquake hazards (mitigation and preparedness) [6]. That's why different strategies are being implemented in many countries. At Narita Airport in Japan, early warning systems can detect earthquakes so flights can be delayed, and passengers can be evacuated to a safe area [8]. Narita Airport in Tokyo begins using drone technology for post-earthquake emergency response [9]. San Francisco Airport is a notable example of an earthquake-resistant facility that has been made earthquake-resistant through structural reinforcement [10]. At major airports like Istanbul Airport, staff receive training on various emergency scenarios every year [11]. At Haneda Airport in Tokyo, evacuation routes in terminal buildings are constantly revised [12]. At major airports such as Los Angeles Airport, air traffic control provides the necessary coordination to safely reorganize flights after an earthquake. Los Angeles Airport manages necessary post-earthquake medical and rescue operations by liaising with the regional emergency coordination center [13]. In newly constructed airports, seismic isolation technology can reduce the impact of ground movements on the building, thus preventing damage to the structure [14]. It is expected that these strategies will reduce the damage that earthquakes may cause.

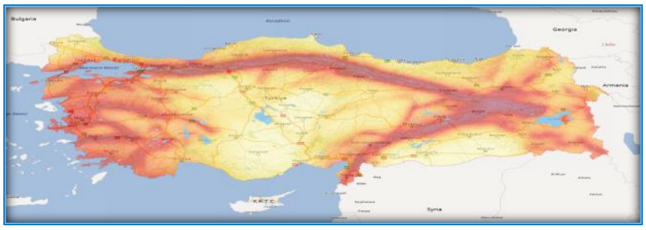

Figure 1. Türkiye fault line map [4]

Earthquakes can directly affect living areas as well as transportation systems. In the February 6 Earthquakes, railway, highway and seaway systems were rendered unusable due to great destruction depending on cracking, spreading, burning and collapsing [15]. But, ensuring uninterrupted transportation after a disaster is one of the most important factor in disasters and emergencies [16]. Therefore, when a natural disaster such as earthquake occurs, transportation systems in the affected area must quickly adapt to provide regular service to passengers and become a humanitarian center responding to a large increase in the number of passengers and cargo [17].

Air transportation which plays an important role in humanitarian aid operations [18], and it has a great advantage in terms of speed compared to other transportation systems [19]. Thus, it is of great importance to be able to provide fast transportation for purposes such as material supply, personnel support and passenger evacuation in situations that may cause congestion in transportation systems such as land, sea and railway [19]. It is recommended that airports, which are referred to as a base for carrying out various humanitarian activities such as providing emergency medical care, relief supplies and other cargo with temporary or permanent airport facilities, play a proactive role at every stage of disaster management [20]. Air transportation, which is critical in the emergency disaster response phase, is heavily dependent on the emergency response phase (the first 72 hours after a disaster). Although an airport in a disaster area becomes a base supporting various humanitarian activities in the affected area, the use of available space at airports for post-disaster activities may face restrictions due to insufficient parking space for aircraft, limited storage space, and lack of space prepared for the establishment of maintenance units [21]. As a result of determining the infrastructure of airports for disaster operations and realizing their adaptation potential, they can have the function of providing long-term shelter during disasters and transporting vital materials after disasters. Thus, many lives can be saved thanks to airports. So, airport infrastructure needs to be further developed so that airports can provide additional roles in mitigating the onset and negative consequences of a disaster [22].

This study was prepared to evaluate the emergency management at airports in case of a possible earthquake [23] expected on the North Anatolian Fault Line. An earthquake on Türkiye's North Anatolian Fault Line would affect millions of people, especially Istanbul, Türkiye's most populous city with a population of around 16 million [24]. The aim of this study is to examine the preparedness of the airports belonging to the alternatives determined, to investigate their deficiencies in emergencies and to make recommendations for future studies in this area. There is a gap in this regard as no study has been conducted on the earthquake probability of airlines in Türkiye before. This study was prepared to fill this gap and strengthen air transportation in the event of a possible earthquake. In this scope, the earthquake and emergency preparedness of seven provinces with airports located on the north Anatolian Fault Line in Türkiye were examined in this study. Five main criteria and thirteen sub-criteria were evaluated in accordance with the experiences and opinions of experts. Data for each alternative province is obtained from General Directorate of State Airports Authority [25] which is the relevant institution. Fuzzy AHP and AHP were used for the analysis. At the end of the study, the preparation of the selected provinces for earthquakes and risky situations was listed. The following part of the study includes the methods used for analysis, literature review, results, conclusion and finally limitations and future research direction.

2. Method

In this study, to evaluate preparedness of airports in North Anatolian Fault Line of Türkiye, Analytical Hierarchy Process (AHP) and Fuzzy Analytical Hierarchy Process (Fuzzy AHP) methods, which are among the Multi Criteria Decision Making Methods, were used separately. Information about the procedure of these methods is taken below.

2.1. Analytic hierarchy process (AHP)

AHP, which is a structurally quantitative and qualitative method developed by Saaty, helps in Multi-Criteria Decision Making (MCDM) problems under uncertainty by including the decision maker's experiences, knowledge and intuition into the decision [26]. AHP is a mathematical technique that takes into account the priorities of the group or individual in decision-making and can evaluate qualitative or quantitative variables together [27-29]. The stages of the AHP are as follows:

Step 1: The analysis hierarchy is created. In AHP, a hierarchical structure is first created for the solution of the problem [30]. At the top of the created hierarchy is the ultimate goal of the problem [31]. Under the purpose, the criteria necessary to achieve that purpose; at the lowest level of the hierarchy, alternatives are included [32].

Step 2: Pairwise comparison matrices between criteria are prepared. After the hierarchical structure is created, a pairwise comparison matrix (superiorities are determined) showing the relative importance of the criteria is calculated [33, 34]. The 1-9 importance scale used for pairwise comparison in the AHP method is given in Table 1. [35, 36].

Table 1. AHP importance scale

Values of Importance	Definitions of Value
1	Equally Important
3	A Little More Important
5	Strongly Important
7	Very Strongly Important
9	Extremely Important
2, 4, 6 ve 8	Intermediate (Average) Values

Step 3: The weights of the main criteria and sub-criteria are calculated.

Step 4: The consistency ratio for criterion comparisons is calculated. After determining the relative importance of the criteria by calculating the eigenvector, what needs to be done is to calculate the consistency (CR) of the comparison matrix [37]. Whether the values in the matrix are consistent or not is checked by determining the consistency ratio [38]. How much the closer the CR is to zero, the consistency of the decision matrix is the higher [39].

The following formula is used to determine the consistency ratio [40, 41]:

$$CR = \frac{CI}{RI} \quad (1)$$

If CR ≤ 0.1, it is expressed as sufficiently consistent.

The consistency indicator (CI) is calculated by the following formula [40]:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

The maximum eigenvalue (λmax) is calculated with the following formula [42]:

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} \frac{(AW)_i}{W_i} \quad (3)$$

Randomness indicators according to matrix size are shown in Table 2. [43, 44].

Table 2. Randomness indicators

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,54	1,56	1,57	1,59

The RI value is obtained from Table 2 according to the number of criteria used in the study.

2.2. Fuzzy analytical hierarchy process

Fuzzy AHP is an extension of Saaty theory and can provide a more adequate explanation in the decision-making process [45]. The stages of the Fuzzy AHP Method are as follows:

Step 1: The analysis hierarchy is created [46], shown in Figure 2. According to Figure 2, there is goal in top of hierarchy, secondly criteria are found, and then alternatives.

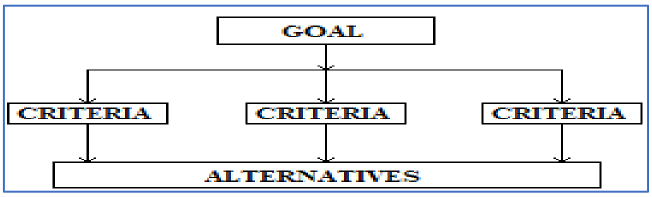

Figure 2. Fuzzy AHP hierarchy

Step 2: Pairwise comparison matrices of alternatives are prepared for each criterion. The linguistic variables used for pairwise comparisons in the Fuzzy AHP method and the fuzzy numbers assigned to these variables are shown in Table 3 [47]:

Table 3. Linguistic parameters and triangular fuzzy numbers

Scale	Linguistic Variables	Triangular Fuzzy Numbers
1	Equal Important	(1,1,1)
3	A Little More Important	(2,3,4)
5	Strongly Important	(4,5,6)
7	Very Strongly Important	(6,7,8)
9	Extremely Important	(9,9,9)
2	Intermediate (Average) Values	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

Step 3: The relative weights of the alternatives are determined for each criterion. Step 4: The overall score of each alternative is calculated.

2.3. Literature review

In this study, MCDM methods were used to evaluate preparedness of airports to the earhquake disaster. In this direction, some studies related to MCDM and criteria about earthquake disasters are given in this part.

2.3.1. Literature related to methods used in the study

When the literature is examined related to airports, various studies are found in which Multi-Criteria Decision Making methods such as AHP, TOPSIS, VIKOR, FUZZY, COPRAS, BORDA, Genetic Algorithm, ENTROPY, BWM are used [48]. In the study conducted by Altin, Karaatli and Budak in 2022, based on the years 2010-2015, the weights of the criteria for 20 airports were first calculated with the ENTROPI method, and then the performance ranking was made with the COPRAS and Gray Relational Analysis methods [49].

In the study conducted by Ahmad, Akram, Tabassum and Kausar in 2019, the Fuzzy Simple Additive

Weighting (FSAW) method, one of the Multi-Criteria Decision Making Methods (MCDM), was used to analyze the operational performance of airports. These weights, which are assigned by decision makers and are in linguistic form, have been converted into triangular fuzzy numbers. The three airports in the study are; It was evaluated by four decision makers in a fuzzy environment in terms of performance according to 15 criteria. The FSAW method yielded similar decision results at airports, indicating that this method is effective and reliable [50].

Ssamula aimed to investigate the use of Multi-Criteria Decision Analysis (MCDA) tools as a method for the selection of hub airports in a study conducted in 2010. The important findings in this study show that since Africa has a sparse network, the choice of hub location is highly dependent on the cost of routing passengers through the hub airport [51]. In a study conducted by Belbag, Deveci and Uludag in 2013, Fuzzy TOPSIS and Fuzzy ELECTRE were proposed to overcome the problem of facility location selection. In this study, it is aimed to determine the potential facility location for a second airport within the borders of Ankara, the capital of Türkiye, by using Fuzzy TOPSIS and Fuzzy ELECTRE I separately. The criteria for airport location selection and potential locations for the airport have been determined. As a result, both methods proposed a very similar solution to the problem of choosing a facility location for the second airport in Ankara [52]. In his study conducted in 2019, Dožić examined 166 articles published between 2000 and 2018. He divided the articles into four groups according to the field of application: airlines, airports, air traffic management and others. He has systematically analyzed these application areas and presented the results in the article. The results of this research showed that multi-criteria decision-making methods are mostly used in airlines, the most common theme is evaluation, Fuzzy is included in 50% of publications, and the Analytical Hierarchy Process is applied in about 40% of the articles reviewed [53].

2.3.2. Literature related to criteria

When the literature is examined within the scope of disaster and emergency management at airports, various studies are found. Among these studies, Arreeras and Arimura's study in 2022 aimed to determine how to choose an airport as a safe place to land during the evacuation of the aircraft in the event of a volcanic eruption in Hakoneyama, Japan. Researchers used data such as airport type, type of affected aircraft, and number of daily aircraft flights from previous years as criteria to design the shelter airport selection model, and used this model to discover an approximate solution for aircraft evacuation using the genetic algorithm (GA) method [48]. In a study conducted by Agrawal et al. in 2023, a Probability-Based Double Indeterminate Fuzzy (PDHF) Algorithm was proposed. This algorithm has been used to evaluate emergency action plans for aviation accidents. Comparison of the results obtained from the TOPSIS and VIKOR decision-making algorithms showed that the proposed PDHF algorithm works well and can be reliable for multi-feature group decision-making problems in unstable fuzzy environments [54]. In the study conducted by Tanriverdi, Ecer and Durak in 2022, a broadly flexible, triangular fuzzy Dombi-Bonferroni Best-Worst Method (BWM) framework is recommended to determine the priority preferences of the factors taken into account in the selection of airports for air cargo carriers during the COVID-19 period. The study emphasizes eighteen sub-criteria based on five main criteria: location, physical characteristics, performance, costs and reputation. Findings show that the most important criteria are location and costs; revealed that the most important sub-criteria are airport fees and service fees [55]. In the study conducted by Rangsaritvorakarn, Fakkhong and Iamchuen in 2023, the Analytical Hierarchy Process (AHP) method was used with a Map Layout Model to determine the appropriate evaluation criteria for the establishment of a second airport in Chiang Mai province, Thailand [56]. When the literature is examined, it is seen that Multi-Criteria Decision-Making Methods are used in other areas besides airports. For example, in a study conducted by Barrios et al. in 2020, it was tried to determine the disaster preparedness levels of hospitals by using Multi-Criteria Decision-Making methods. In the study, a hybrid fuzzy decision-making model was proposed in order to evaluate the disaster preparedness status of four selected hospitals in Türkiye. This model was developed using FAHP, FDEMATEL and TOPSIS techniques and aimed to determine the disaster preparedness ranking of the hospitals in question. The results revealed that personnel is the most important factor when evaluating the readiness of hospitals, while flexibility is of the greatest importance [57]. In the study conducted by Atmaca, Aktas and Ozturk in 2023, four Multi-Criteria Decision-Making Techniques AHP, TOPSIS, COPRAS and BORDA were used to evaluate the selection and suitability of emergency assembly areas in Golbasi district of Ankara. According to the findings obtained, the Sacrificial Slaughter Area, the Green Area, the City Park, the Muhsin Yazicioglu Sports Complex and the Turkish Association of Accountants were identified as the five most effective emergency gathering areas in Golbasi district [58]. The performances of the 20 largest airports in Europe were examined in terms of passenger numbers, number of terminals, parking capacity, number of runways [49]. In the study by Guarini et al. criteria for airport systems were determined as structural requirements, service requirements and regional requirements [59]. In the study by Kanyi et al. criteria related to aviation risks were determined as land size, runway width, average daily flights, fire department personnel, ambulances, car parking spaces and night flights [60].

3. Results

The results obtained in the analyses carried out in accordance with the selected criteria and alternative provinces, as well as the opinions of experts and data obtained from the operating organization are summarized in this section.

3.1. Criteria used in the study

The main and sub-criteria used in this study are given in this part. Five main criteria and thirteen sub-criteria are determined for airport's preparation to the disaster and risky situation in the study. All data about these criteria are taken from General Directorate of State Airports Authority [25]. Criteria used in the study are given below.

"Personnel" main criteria: It's sub-criterion is "Number of Personnel" *which* is includes personnel number of the airports in this study.

"Equipment and Systems" main criteria: It consists of sub-criteria which are "Terminal and Security Systems", "Rescue and Fire Fighting Vehicles", "Operating Fuel Quota" and "Communication Wireless Devices". These sub-criteria which are contain technique team of airports.

"Area" main criteria: It consists of sub-criteria which are "Station", "Runway", "Apron" and "Taxirut". These sub-criteria cover parts of airports in m^2.

"Transportation" main criteria: It consists of sub-criteria which are "Distance to the city", "Openness to Traffic" and "Parking Capacity" sub-criterias. These sub-criteria handle parametres related to transportation.

"Probability of Earthquake Disaster" main criteria: It consists of sub-criteria which are "Earthquake" sub-criterion. This criteria cover earthquakes frequency for each airports in the study.

3.2. Alternative provinces

In this study, Kastamonu, Amasya and Tokat in the Black Sea Region, İstanbul and Kocaeli in the Marmara Region, Bingöl and Erzincan in the Eastern Anatolia Region were selected among the provinces with airports located on the North Anatolian Fault Line in Türkiye and their earthquake preparedness of these provinces was evaluated.

3.3. Importance weights of criteria

Each criterion were evaluated by experts in Ministry of Transportation and academicians in universities. According to the evaluations, AHP and Fuzzy AHP methods were applied. The importance weight belongs to criteria are given below.

3.3.1. Importance weights of main criteria

After experts evaluated the relative status of the criteria, the methods were applied. The weight values of the main criteria obtained with the AHP and Fuzzy AHP methods are given in Table 4.

Table 4. Weight values of main criteria

Main Criteria		
Criteria	AHP	Fuzzy AHP
Personnel	0,500	0,535
Equipment and Systems	0,110	0,118
Area	0,080	0,084
Transportation	0,060	0,065
Probability of Earthquake Disaster	0,250	0,259

According to the results obtained in Table 4, the main criterion of "Personnel" was found to be higher for both methods compared to the others. The main criterion of "Transportation" was found to be the lowest for both methods.

3.3.2. Importance weights of sub-criteria

In this section of study, importance weights of sub-criteria belong to "Equipment and Systems", "Area" and "Transportation" main criteria are given. Also, the importance weights of provinces for each criterion are also included.

Weight values of "Equipment and Systems" sub-criteria are given in Table 5. According to Table 5, the highest importance value of sub-criteria is seen belong to "Terminal and Security Systems". The "Communication and Wireless Equipment" sub-criterion was found to have the lowest importance weight.

Table 5. Weight values of "Equipment and Systems" sub-criteria

Equipment and Systems		
Criteria	AHP	Fuzzy AHP
Terminal and Security Systems	0,636	0,665
Rescue and Fire Fighting Vehicles	0,166	0,174
Operating Fuel Quota	0,117	0,123
Commnunication and Wireless Devices	0,081	0,092

Table 6 gives the importance weights of the sub-criteria of the "Area" main criterion.

Table 6. Weight values of "Area" sub-criteria

Area		
Criteria	AHP	Fuzzy AHP
Terminal	0,612	0,648
Runway	0,080	0,086
Apron	0,186	0,187
Taxirut	0,123	0,132

According to Table 6, among these sub-criteria, the "Terminal" sub-criterion was found to have the highest value. The "Runway" sub-criterion was found the smallest value. In Table 7, the importance weights of the sub-criteria belonging to the main criterion of "Transportation" are included.

Table 7. Weight values for "Transportation" sub-criteria

Transportation		
Criteria	AHP	Fuzzy AHP
Distance to the City	0,724	0,744
Openness to Traffic	0,083	0,085
Parking Capacity	0,193	0,194

In the sub-criteria within the main criterion of transportation, the sub-criterion "Distance to the City" was found the highest value and the "Openness to Traffic" sub-criterion was found the smallest value in Table 7.

In Table 8, There are importance weights of criteria which are obtained AHP and Fuzzy AHP methods depend on provinces.

Table 8. Ranking of Alternative Provinces According Criteria

Alternative Provinces	Equipment and Systems							
	Terminal and Security Systems		Rescue and Fire Fighting Vehicles		Business Fuel Quota		Communication and Wireless Vehicles	
	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP
Amasya	0,111	0,113	0,088	0,103	0,039	0,041	0,085	0,092
Bingöl	0,111	0,113	0,151	0,164	0,238	0,256	0,052	0,058
Erzincan	0,111	0,113	0,335	0,353	0,058	0,061	0,14	0,147
İstanbul	0,333	0,343	0,022	0,023	0,027	0,028	0,476	0,494
Kastamonu	0,111	0,113	0,151	0,164	0,424	0,444	0,072	0,092
Kocaeli	0,111	0,113	0,101	0,117	0,087	0,092	0,035	0,038
Tokat	0,111	0,113	0,151	0,164	0,126	0,133	0,14	0,147

Alternative Provinces	Area							
	Terminal		Runway		Apron		Taxirut	
	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP
Amasya	0,029	0,035	0,131	0,133	0,029	0,029	0,207	0,21
Bingöl	0,067	0,078	0,061	0,062	0,061	0,061	0,044	0,045
Erzincan	0,127	0,149	0,061	0,062	0,118	0,118	0,111	0,11
İstanbul	0,351	0,43	0,463	0,486	0,457	0,489	0,506	0,517
Kastamonu	0,045	0,054	0,029	0,03	0,031	0,033	0,044	0,045
Kocaeli	0,029	0,035	0,194	0,201	0,157	0,152	0,044	0,045
Tokat	0,351	0,238	0,062	0,065	0,146	0,148	0,044	0,045

Alternative Provinces	Transportation						Personnel		Probability of Earthquake Disaster	
	Distance to City		Opennes to Traffic		Parking Capacity		Number of Personnel		Earthquake	
	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP	AHP	Fuzzy AHP
Amasya	0,029	0,032	0,053	0,054	0,041	0,043	0,033	0,037	0,025	0,023
Bingöl	0,256	0,272	0,053	0,054	0,041	0,043	0,033	0,037	0,115	0,136
Erzincan	0,372	0,393	0,263	0,267	0,109	0,111	0,062	0,067	0,052	0,048
İstanbul	0,026	0,025	0,263	0,267	0,491	0,507	0,230	0,246	0,008	0,007
Kastamonu	0,147	0,159	0,053	0,054	0,07	0,073	0,052	0,048	0,008	0,007
Kocaeli	0,084	0,083	0,263	0,267	0,041	0,043	0,029	0,029	0,025	0,023
Tokat	0,084	0,083	0,053	0,054	0,207	0,211	0,062	0,067	0,017	0,016

According to "Equipment and Systems" main criterion, the provinces with the highest importance weight belonging to the sub-criteria which are "Terminal and Security Systems", "Rescue and Firefighting Vehicles", "Operating Fuel Quota" and "Communication and Wireless Devices" were found as "Istanbul", "Erzincan", "Kastamonu" and "Istanbul" respectively.

Among the sub-criteria within the main criterion of "Area", the province with the highest importance weight was found to be "Istanbul" for all sub-criteria which are "Terminal", "Runway", "Apron" and "Taxirut".

The provinces with the highest importance weight in the "Distance to the City", "Openness to Traffic" and "Parking Capacity" sub-criteria of "Transportation" main criterion were found "Erzincan", "Erzincan, Istanbul and Kocaeli with the same value" and "Istanbul", respectively.

For the "Number of Personnel" sub-criterion of the "Personnel" main criterion, the province of "Istanbul" was found to have the highest importance weight.

For the "Earthquake" sub-criterion of the "Earthquake Disaster Probability" main criterion, the importance weight of "Bingöl" province was found to be the highest among other alternative provinces.

3.4. Ranking of alternative provinces

The ranking of alternative provinces was obtained in line with evaluating the criteria by experts and the received data from the relevant institution of the provinces for each criterion using AHP and Fuzzy AHP methods. The results of alternative provinces in each criterion are given in Table 9.

Table 9. Ranking of provinces

Alternative Provinces	AHP	Fuzzy AHP
İstanbul	0,30635	0,39527
Bingöl	0,17889	0,13219
Erzincan	0,15768	0,16667
Tokat	0,11831	0,13815
Kastamonu	0,08703	0,11378
Kocaeli	0,07588	0,08282
Amasya	0,07587	0,0817

Table 9 lists earthquake preparation of the provinces in line with the importance weights of the obtained criteria. According to the results obtained, Istanbul province took the first place in both methods. Changes were observed in the ranking obtained from the AHP and Fuzzy AHP methods for the Bingöl and Erzincan alternative provinces, but there was no change in the rankings of other alternative provinces.

4. Conclusion

After two major earthquakes that occurred in the southern part of Türkiye, which is located on the fault lines, earthquake precautions and strategies that should be taken for the provinces on the fault lines in the northern region have come to the agenda again.

It is very important to take precautions and develop strategies in advance for situations that deeply affect human life, such as earthquakes, and to provide uninterrupted assistance and human resources to the people living in the area after the earthquake occurs. This study, which covers such an important issue, focuses on air transportation, which can provide uninterrupted transportation because of the destruction of road, rail and sea transportation in situations such as earthquakes.

Emergency and earthquake disaster management at airports is vital to ensure passenger safety and respond effectively to crisis situations. Airport security can be maximized by focusing on issues such as emergency planning, earthquake disaster preparedness, awareness training, communication and coordination. It is important for the aviation industry to constantly follow current technologies and improve airport's emergency and earthquake disaster plans. The more and the more attention for airport emergency planning should be get because even a small event have a great impact on the finances of the airport operator [61]. For this reason, there are studies in the literature that examine procedures and safety methods for evacuation plans in cases such as earthquakes [62], and emergency planning in airports [63]. For emergencies such as earthquakes, management can be developed under the headings of "Prevention", "Preparation", "Respond" and "Recovery" [64]. Coordination and collaboration between airports and emergency management agencies is a powerful and cost-effective way to improve disaster preparedness, response and recovery [65]. Due to the fact that there is enough time, an almost perfect preparation is an important opportunity to respond to an emergency [61]. Therefore, this study addresses the earthquake preparedness of airports located on the North Anatolian Fault Line in Türkiye. In this context, seven provinces, which have airports, located on the North Anatolian Fault Line in Türkiye have been selected as alternatives. The earthquake preparedness status of these airports was analysed according to the criteria determined for each province, the evaluation of these criteria by experts and the data obtained from General Directorate of State Airports Authority which is the relevant institution. In order to evaluate the preparedness of these provinces for earthquakes, analysis was made using AHP and Fuzzy AHP methods, which Multi Criteria Decision Method (MCDM). These methods are used lots of area such as supplier selection [66], logistic planning [67], route planning [68] , health [69], education [70] etc. In this study, it was used to obtain location selection.

When the importance weights of the main criteria are examined, it is observed that the "Personnel" criterion has a high importance weight in both methods. When the sub-criteria of "Equipment and Systems" were examined, it was revealed that the most important sub-criteria was "Terminal and Security Systems", when the "Area" sub-criteria were examined, the most important sub-criteria was "Terminal", and when the "Transportation" sub-criteria were examined, it was revealed that the most important sub-criteria was "Distance to the City".

When investigating the weight of alternative provinces according to the criteria, it is seen that the

"Istanbul" alternative stands out in general. But there are differences in second and third ranks according to AHP and Fuzzy AHP methods. According to results of AHP method, Bingöl and Erzincan provinces take place 2nd and 3th ranks respectively, but in Fuzzy AHP method is the exact opposite. Erzincan and Bingöl provinces take place 2nd and 3th ranks in Fuzzy AHP method. There is no differences among the other alternative provinces.

As a result, when the ranking of the alternative provinces according to their criterion weights is examined, it has been determined that in the Fuzzy AHP method, unlike the AHP method, the difference in the importance of the best alternative with the other alternatives emerges more clearly. In the study, Istanbul province, located on the North Anatolian Fault Line, was found to be more ready for emergency and earthquake disaster compared to other provinces in terms of airport in this study.

5. Limitations and future research direction

Earthquakes that do not give any symptoms before can cause great loss of life and property [71].

Management activities are vital in emergency situations such as earthquakes. Numerous studies have been conducted at airports in this regard [72-73]. Taking precautions before earthquake disasters occur is much more economical than the cost of repairing the damage caused by the disaster. In this context, measures that can be taken for disasters can save thousands of lives and also alleviate the financial burden of countries after earthquake disasters. In this study prepared in this direction, it is aimed to investigate the earthquake preparedness status of the selected airlines according to the determined criteria and to ensure that measures are taken in advance by taking into account the situations that are evaluated as deficient. Determined criteria is among limitations of studies. Preparedness for emergency comprise of lots of factors like population density. For this reason, paying attention to different criteria too is important for information about preparedness for emergencies, especially provinces on the fault line. For earthquakes that have the potential to affect millions of people, conducting more comprehensive studies and taking precautions plays a major role in preventing possible losses. For this reason, in addition to the criteria, the opinions and suggestions of experts from different disciplines should also be taken into account in the disaster preparedness of the provinces in the earthquake area.

Thousands of people have lost their lives, people became homeless, and millions of people have been directly affected by two successive earthquakes in southern Türkiye, which is in an earthquake zone [74]. These earthquakes also caused huge losses to the country's economy [74] and also, damaged historical buildings [75]. According to the Earthquake Hazard Map of Türkiye, it is known that 92 percent of the country is in earthquake zones and 98 percent of the population lives under earthquake risk [76]. For these reasons, what plans have been made for possible earthquakes that may occur in Türkiye, which is in an earthquake zone? Are the strategies for such situations adequate or do they need to be improved? What changes are there in inspections before and after the earthquakes that occurred on February 6, 2023? These and similar research questions can be examined in future studies.

For emergency and earthquake disaster situations, factors such as other transportation systems, the reliability of structures, earthquake history of the provinces in the region should also be taken into account. Studies on this subject should be made more sensitive. This study, prepared to raise awareness in this regard, is expected to be useful.

Author contributions

Halise Ataseven: Conceptualization, Methodology, Software. **Burçin Paçacı:** Data curation, Writing-Original draft preparation, Software, Validation. **M. Kürşat Çubuk:** Visualization, Investigation, Writing-Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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