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Prioritization of Earthquake Relief Using a Hybrid Two-Phase Approach

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Abstract

One of the stages of crisis management is planning and initial preparation to deal with the crisis. During natural disasters, one of the main activities is the logistics of relief groups and the activities of relief teams to save the lives of the victims of the accident. A review of past events shows that the chances of rescuing the injured decrease and that a quick and correct decision is important in this situation. This paper presents a two-phase hybrid approach to decision-making and prioritization of affected regions to send relief teams. In this approach, multi-criteria decision-making methods in two phases are used to consider different indicators in achieving the optimal solution. In the first phase, with the help of the primary decision matrix, the AHP, TOPSIS and AHP-TOPSIS methods are used. And in the second phase, according to the results obtained from the first phase, the secondary decision matrix is created. With the CoCoSo method's help, one of the newest methods in this field, areas are prioritized for relief. In order to implement the proposed approach, the city of Amol has been studied.

Keywords: Crisis logistics, Decision making, Crisis management, Relief.

1 | Introduction

Iran is among the ten countries prone to disaster and is ranked sixth in the world in terms of earthquakes. Although disaster damage is irreparable in many ways, it can be minimized by taking appropriate precautions as well as developing programs to deal with the effects of such disasters. Therefore, the supply chain in crisis situations is a necessary and vital issue in supply chain management [1], [2]. Natural phenomena have unique features and characteristics that knowledge of earthquake-associated phenomena, recognition of faults and their types is important in determining the seismic pattern and seismic regime of different regions [3]. The lack of pre-determined programs to deal with post-earthquake crises in some countries has increased the damage rate of this natural phenomenon. Therefore, there is a special need to provide an optimal plan for sending relief teams and deciding on the priority of relief to the affected regions [4].

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Unfortunately, there is little research in the field of prioritization and response to demand points before and during the accident (two stages), which we review in *Table 1* of some of these similar studies. Many types of researches have been done in the field of crisis management. An important part of the research conducted in this field is in line with the earthquake crisis, which has been studied from different perspectives, such as prioritizing post-earthquake relief, locating relief centers, routing relief vehicles, etc. [5]. Some of these problems can be seen in *Table 4*.

Table 1. The research in the field of crisis management.

Author (Year)	Problem	Method	Case Study
Yariyan et al. [6]	Earthquake risk assessment	Integrated Fuzzy Analytic Hierarchy Process with Artificial Neural Networks	Sanandaj
Jahangiri et al. [7]	People's perspectives and expectations on preparedness against earthquakes	Cross-sectional study and a door-to-door survey	Tehran
Khalili et al. [8]	Relief supply location in post-disaster environment	Proposing a bi-objective nonlinear mixed integer and using Reservation Level driven Tchebycheff Procedure	Iran
Su et al. [9]	Classification method of emergency supplies	AHP and cluster analysis	Numerical instances
Boostani et al. [10]	Optimal location selection of temporary accommodation sites	Hybrid fuzzy multiple-criteria decision making	Iran
Fiedrich et al. [11]	Optimized resource allocation for emergency response after earthquake disasters	Mathematical modeling, Heuristics, Computer-based decision-support systems	Numerical instances
Salmerón and Apte [12]	Stochastic optimization for natural disaster asset prepositioning	A two-stage stochastic optimization model	Numerical instances
Rawls and Turnquist [13]	Pre-positioning planning for emergency response	Two-stage stochastic optimization	Southeastern America Storm
Gero et al. [14]	Dispositional Optimism and Disaster Resilience	Multiple logistic regression models	Japan
Ortuño et al. [15]	logistics of Humanitarian Aid	A lexicographical goal programming based decision support system	Nigeria
Bhandari et al. [16]	Disaster risk understanding of local people after the Earthquake	Histogram analysis, distribution analysis, bivariate correlations and independent sample t-tests	Pokhara City, Nepal
Abdollahian and Mahmoudzadeh [17]	Define and prioritize the criteria for locating accommodation and relief centers	TOPSIS	Sabzevar
Yarmohammadian et al. [18]	Investigation of the status of preparedness and crisis management restrictions	Descriptive-analytical	Hospitals of Isfahan University of Medical Sciences
Hallak and Pınar [19]	The Evaluation of Humanitarian Relief Warehouses	Fuzzy AHP and MULTIMOORA technique	Syria
Abazari et al. [20]	Prepositioning and distributing relief items in humanitarian logistics	Grasshopper Optimization Algorithm	Iran's flood
Sarma et al. [21]	Resource Allocation Model for Disaster Relief Operations	MCDM Approach	Numerical instances
Dachyar and Nilasari [22]	The Improvement of Disaster Relief Distribution	Internet of Things	Numerical instances

One of the problems in the field of earthquake crisis management is the prioritization of relief to earthquake-stricken areas, and various methods have been implemented to address this. In the reference [23], Shannon entropy and TOPSIS method have been used to rank residential areas against earthquake hazards. For this purpose, 8 criteria have been studied for 27 areas of Amol city, which include released energy, earthquakes of the last 20 years in terms of TNT, building quality, residential density, building density, population density, network permeability, urban open space and groundwater depth are after construction. To rank the vulnerability, 5 categories of "very high", "high", "medium", "low" and "very low" were used and according to the city map, the vulnerability of Amol was prepared. The results showed that the central regions are very vulnerable.

Therefore, it is expected that the vulnerability of areas in the future construction of the city will be considered. Emergency logistics play a prominent role in reducing the consequences of disasters. The reference [24] evaluates the performance of emergency supplies based on the establishment of a comprehensive evaluation system that includes emergency preparation, response and recovery, and the TOPSIS-EW method. This study was used to evaluate the performance of emergency supplies in the Wenchuan earthquake and identified the five areas with the highest vulnerability. Finally, based on the results of the comprehensive evaluation, some specific management suggestions have been made to improve the capacity of emergency supplies. Relief logistics centers and the quality of their services become very important in the event of a natural disaster. In other words, choosing the right locations for relief logistics centers has a direct impact on operating costs and timely response to demands. The reference [25] provides a decision support system for prioritizing the locations of relief logistics centers in the event of a natural disaster.

Nyimbili et al. [26] considered the criteria of availability, risk, technical issues, cost and coverage at the location of relief logistics centers. In this paper, using the AHP method, the location of these centers has been done. In this paper, two methods of decision making, goal programming and two-stage logarithmic goal planning have been used. This paper has been reviewed for Tehran city data. Around the world, earthquakes and their resulting catastrophes have consistently had severely negative impacts on human livelihoods and have caused widespread economic and environmental damage. The severity of these disasters has necessitated a comprehensive effort to manage emergencies. In this regard, multi-criteria decision analysis methods are widely used by emergency managers to improve the quality of the decision process. In one study, integrated AHP and TOPSIS methods were used to generate earthquake hazard maps [26].

Istanbul city was surveyed and the five main criteria that have the greatest impact on earthquakes in the study area were identified, including topography, distance to the epicenter, soil classification, fluidization and fault-focal mechanisms. AHP was used to determine the weight of these parameters and these weights were given as input by the TOPSIS method to be used to produce earthquake hazard maps. The combination of decision-making tools has been used in various papers in which different methods such as simple average weighed, ε-constraint, response surface methodology, data envelopment analysis and AHP have been used [27]-[36]. As it has been observed, so far, TOPSIS, AHP and AHP-TOPSIS methods have been used separately in different papers in the field of selecting the location of the earthquake relief center. Each of these methods has many advantages and is very practical. However, no study has used all three of these methods simultaneously. In this paper, in the proposed two-phase approach, all three of these methods are implemented in the first phase, and in the second phase, the results of all three methods are combined to create the final result. Therefore, the most important advantage of the proposed two-phase approach is to use the advantages of all three methods, which will lead to more accurate results.

On the other hand, in the second phase, to integrate the results, one of the new and accurate methods in the field of multi-criteria decision-making (CoCoSo method) has been used. Due to the importance of selecting a relief center after the earthquake, the proposed two-phase approach for this problem has been implemented and the data of Amol city has been used for this purpose. In this paper, the factors affecting the priority of relief have been identified and then according to these criteria and the use of the proposed approach to the affected areas to send relief teams is prioritized.

In the following, first, the hybrid two-phase approach of the paper and the tools used in it are introduced. Then, the hierarchical structure of the problem and the criteria and options of the decision matrix for selecting the relief center is examined. Finally, the proposed approach for the city of Amol will be implemented and the results will be presented.

2 | The Proposed Hybrid Two-Phase Approach

Multi-criteria decision-making methods are used in various areas of management and planning problems. In this paper, a proposed approach according to *Fig. 1* is presented. This proposed approach combines four multi-criteria decision-making methods, including AHP, TOPSIS, AHP-TOPSIS and the new CoCoSo method. In the first phase, using the initial decision matrix, AHP, TOPSIS and AHP-TOPSIS methods are used to prioritize the regions separately. The initial decision matrix contains information about the problem and different relief reigns are considered as alternatives and different relief parameters are considered as criteria. Then in the second phase, considering the different results of these three methods from the first phase, the secondary decision matrix is created. In this matrix, decision methods (AHP, TOPSIS and AHP-TOPSIS) are considered as criteria and relief reigns as alternatives. In fact, the secondary matrix data is created according to the findings of the first phase of the problem. In the second phase, the CoCoSo method, which is one of the newest decision-making methods, is used for the secondary decision matrix. Relief reigns are ranked with the help of the CoCoSo method and according to the best alternative, the most important reign for relief is determined. The selected reign will be used to establish a relief center.

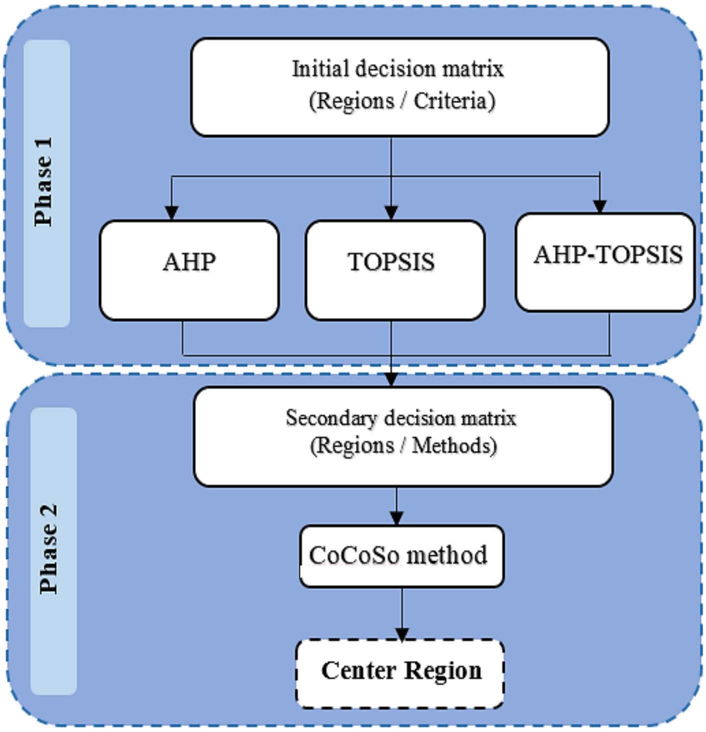

Fig. 1. The flowchart of the hybrid two-phase approach.

3 | Introduction of the Tools Used in the Proposed Approach

The AHP method was first introduced by Wind and Saaty in 1980 [37]. This method facilitates problem ranking by hierarchical structure and the use of pairwise comparisons. The hierarchical structure reduces the complexity of problem understanding and pairwise comparisons lead to more accurate information from the decision-maker. The AHP method has been used in various papers [38]-[40].

The word TOPSIS means the technique for order of preference by similarity to ideal solution. This model was introduced by Huang and Yoon in 1981 [41]. The logic of this method is to define the ideal

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alternative (positive) and the ideal alternative (negative). A positive ideal alternative is one that increases the profit criterion and decreases the cost criterion. The optimal alternative has the shortest distance from the ideal alternative and, at the same time, the farthest distance from the negative ideal alternative. The TOPSIS method has been used in many papers to identify the best alternative, which can be referred to [39], [42]-[44].

CoCoSo method is one of the new multi-criteria decision-making techniques that was presented by Yazdani et al. [45]. This method provides a compromise combination solution for ranking alternatives. This method is an integrated model of simple weight addition method and multiplication model, the steps of which are given below.

Step 1 (formation the decision matrix). In fact, the first step in all multi-criteria decision-making methods is the formation of the decision matrix, which is given in the following. In this regard, (X_{mn}) is actually evaluating the (m) alternative based on the (n) criterion *Eq. (1)*.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}, \quad i = 1,2,\dots,m, \quad j = 1,2,\dots,n. \tag{1}$$

Step 2 (normalization of the decision matrix). Normalization occurs in almost all multi-criteria decision-making methods. In this step, based on *Eqs. (2)* and *(3)*, the decision matrix becomes normal.

$$r_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}}, \text{For profit criteria}. \tag{2}$$

$$r_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}}, \text{For cost criteria}. \tag{3}$$

Step 3 (calculate the values of weighted sum and weighted multiplication). In this step, based on *Eqs. (4)* and *(5)*, the values of weighted sum (S) and weighted multiplication (P) for each alternative are calculated.

$$S_i = \sum_{j=1}^{n} \left(w_j r_{ij}\right). \tag{4}$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j}. \tag{5}$$

Step 4 (determine the evaluation score of the alternatives based on the three strategies). In this section, the score of the alternatives based on the three strategies is obtained through *Eqs. (6)-(8)*. *Eq. (6)* expresses the arithmetic mean of the scores, while *Eq. (7)* expresses the relative scores compared to the best. *Eq. (8)* is a compromise between the previous two calculated scores. In this relation λ is determined by the decision-maker but in 0.5 mode it has a lot of flexibility.

$$k_{ia} = \frac{S_i + P_i}{\sum_{i=1}^{m}(S_i + P_i)}. \tag{6}$$

$$k_{ib} = \frac{S_i}{\min S_i} + \frac{P_i}{\min P_i}. \tag{7}$$

$$k_{ic} = \frac{\lambda S_i + (1-\lambda)P_i}{\lambda \max S_i + (1-\lambda)\max P_i}, 0 \le \lambda \le 1. \tag{8}$$

Step 5 (determining the final score and ranking the alternatives). In this section, the final score is calculated based on *Eq. (9)*. In fact, this relationship represents the sum of the geometric mean and arithmetic mean of the three strategies of the previous stage. The higher the score (k) of any alternative, the better it is.

$$K_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}). \tag{8}$$

4 | Determining the Priority Criteria of Relief Center to the Demand Points

There are always many restrictions in the event of an accident that prevents the delivery of relief to all points of demand with the best quality and quantity, some of these restrictions include the following: breakdown of relief centers due to the high severity of the accident, lack of rescue vehicles, lack of necessary knowledge of rescue forces, failure of rescue teams for reasons such as lack of knowledge of family or loss of relatives in the accident, weather and environmental conditions and so on. *Fig. 2* shows the relationship between these criteria and alternatives, which are given below the reasons for these relationships.

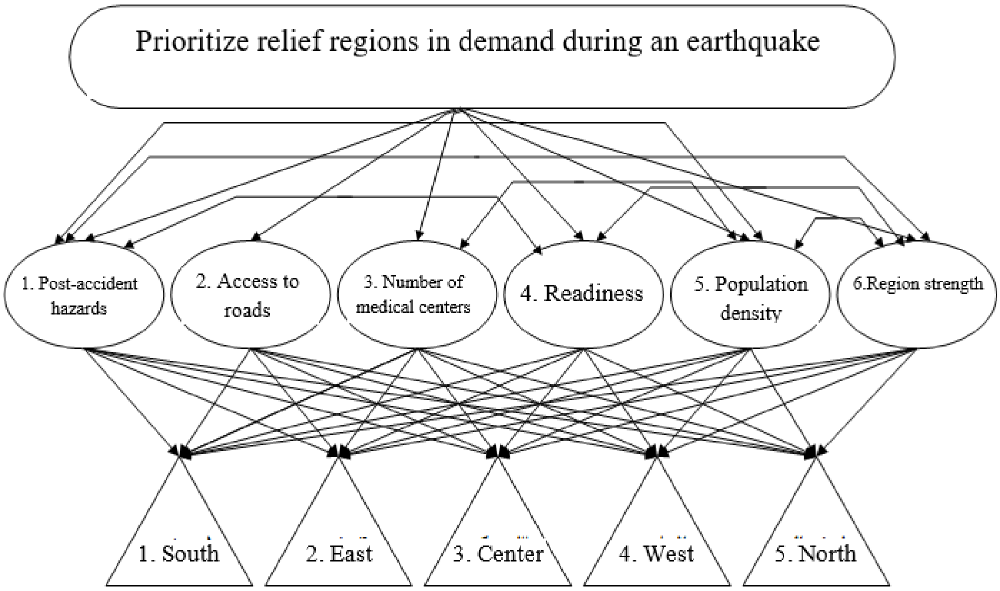

Fig. 2. Internal and external dependence of demand point prioritization network.

The stronger region and the number of buildings built according to the building standard; the more people are prepared for the accident. The higher the regional strength and the more standard the buildings, the lower the risk of post-accident hazards such as fire, explosion, drift, etc. The higher the population density, the more medical centers have been built in that region. As the population density increases, the likelihood of post-accident hazards will increase, especially in densely populated buildings. The greater the level of preparedness, the lower the risk of post-accident hazards. The higher the risk of post-accident risk, the lower the population density. Any region where the risk is greater is expected to be more prepared but, unfortunately, what is evident is that the preparedness is lower in such regions.

5 | Prioritize the Damaged Regions of Amol City Using a New Combined Approach

Mazandaran is one of the northern provinces of Iran, which is located near the Alborz mountain range and has a special location due to its location on the North Alborz fault. For this reason, Mazandaran province is considered as one of the earthquake-prone regions of Iran. Mazandaran is divided into three regions: east, west and center. Studies have shown that the central region has more faults than its two adjacent regions. In this study, the city of Amol, one of the central cities of Mazandaran province, is studied. Amol city is limited to Mahmudabad city from the north, Babol city from the east, Noor city from the west and Tehran province from the south and has a population of 376,056 people. Due to its proximity to Damavand Peak (the highest mountain in Iran and the Middle East and the highest volcanic peak in Asia), the city is always at risk of small and large earthquakes. The last deadly earthquake in this city is related to the village of Sangchal, which occurred in 1,336 with a magnitude of 6.7 Richter occurred, and about 133 people died and 260 people were injured. In this study, Amol city is divided into five regions, northwest, center east and south based on urban structure, which are numbered in *Fig.*

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3, respectively. In this study, it is assumed that there is only one relief center in the city center and relief teams are sent from this center to the demand centers as a specified point. In the following, the proposed approach of the paper for the city of Amol is examined. The initial decision matrix that has been collected according to environmental information for the city of Amol is as shown in *Table 2*.

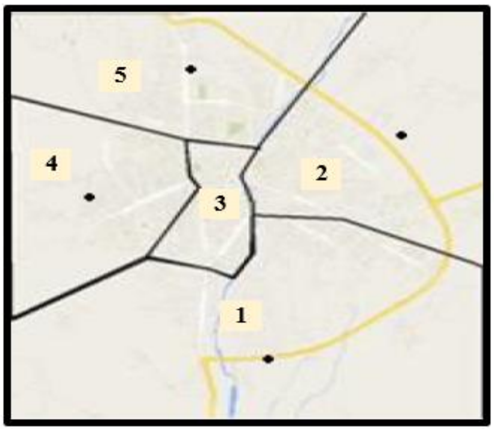

Fig. 3. Regions studied in Amol city to establish a relief center.

Table 2. Initial decision-making matrix.

Alternatives	Region Strength	Population Density	Number of Medical Centers	Post-Accident Hazards	Access to Roads	Readiness
South	0.66	0.5	2	0.4	0.8	0.5
North	1	1	1	1	1	1
East	0.33	1.5	2	1.2	1	1.25
West	1.33	1.75	3	1.61	0.5	0.75
Center	1	2.5	4	2	0.5	1.75

5.1 | The First Phase of the Proposed Approach

In this phase, the AHP method is first implemented on the problem, which is the solution process according to *Tables 4* to *6*. Paired comparison tables are based on collected data and expert preferences. Also, in order to grade the importance, the scoring of *Table 3* has been used. Since all matrices of pairwise comparisons are incompatible, in order to calculate the weights, special methods of this category must be used. In this paper, the approximate method of the geometric mean is used, which is one of the good methods in this category. Then local weights are calculated and finally used to calculate the total weights and scores of each region. In *Table 7*, the final results of the AHP method show the desirability of the northern region of the city for the construction of a relief center.

Table 3. Scoring of the importance.

The Degree of Importance	Very Low	Low	Medium	Much	Very Much
	1	3	5	7	9

Table 4. Matrixes of pairwise comparisons of regions based on: a. population density; b. region strength; c. readiness; d. number of medical centers; e. post-accident hazards; f. access to roads.

Population Density	West	South	Center	East	North
West	1	0.33	0.5	0.28	0.2
South	-	1	1.5	0.85	0.85
Center	-	-	1	0.57	4
East	-	-	-	1	0.7
North	-	-	-	-	1

a.

Region Strength	West	South	Center	East	North
West	1	2	1.33	4	1.33
South	-	1	0.67	2	0.66
Center	-	-	1	3	1
East	-	-	-	1	0.33
North	-	-	-	-	1

b.

Readiness	West	South	Center	East	North
West	1	0.4	0.5	0.66	0.28
South	-	1	1.25	1.66	1.71
Center	-	-	1	1.33	0.57
East	-	-	-	1	0.42
North	-	-	-	-	1

c.

Number of Medical Centers	West	South	Center	East	North
West	1	1	2	0.66	0.5
South	-	1	2	0.66	0.5
Center	-	-	1	0.33	0.25
East	-	-	-	1	0.75
North	-	-	-	-	1

d.

Post-Accident Hazards	West	South	Center	East	North
West	1	0.33	0.4	0.25	0.2
South	-	1	1.2	0.75	0.6
Center	-	-	1	0.62	0.5
East	-	-	-	1	0.8
North	-	-	-	-	1

e.

Access to Roads	West	South	Center	East	North
West	1	0.8	0.8	1.6	1.6
South	-	1	1	2	2
Center	-	-	1	2	2
East	-	-	-	1	1
North	-	-	-	-	1

f.

In the next step of the first phase, the TOPSIS method will be implemented on the problem. Given that there are six criteria in the problem and assuming the weights are the same for the criteria, the weight of each criterion will be equal to $\frac{1}{6}$. The final results of this method in *Table 8* show the desirability of the Amol city center region for the construction of a relief center.

Table 5. Matrixes of pairwise comparison of criteria: a. all criteria; b. post-accident hazards; c. Readiness; d. Population density.

Matrix of Pairwise Comparisons of Criteria	Region Strength	Population Density	Number of Medical Centers	Post-Accident Hazards	Access to Roads	Readiness
Region strength	1	5	3	1	5	3
population density		1	7	3	5	7
Number of medical centers			1	5	7	5
Post-accident hazards				1	9	7
Access to roads					1	5
Readiness						1

a.

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Post-Accident Hazards	Region Strength	Population Density	Readiness
Region strength	1	4.5	1.8
Population density	-	1	0.4
Readiness	-	-	1

b.

Readiness	Region Strength	Post-Accident Hazards
Region strength	1	2
Post-accident hazards	-	1

c.

Population Density	Region Strength	Post-Accident Hazards
Region strength	1	0.25
Post-accident hazards	-	1

d.

Table 6. Calculation of local weights.

Criteria	Weight	Weights in Access to Roads		Weights in Post-Accident Hazards		Weights in Number of Medical Centers		Weights in Population Density		Weights in Region Strength		Weights in the Degree of Readiness	
Region strength	0.325814	West	0.25	West	0.0663033	West	0.155632	West	0.067981	West	0.272545	West	0.097861
population density	0.288027	South	0.25	South	0.218657	South	0.155632	South	0.252752	South	0.136272	South	0.243335
Number of medical centers	0.174951	Center	0.25	Center	0.131724	Center	0.0827188	Center	0.133146	Center	0.257247	Center	0.213429
Post-accident hazards	0.140492	East	0.125	East	0.263449	East	0.294753	East	0.266291	East	0.0766884	East	0.140891
Access to roads	0.041791	North	0.125	North	0.319867	North	0.311264	North	0.27983	North	0.257247	North	0.304484
Readiness	0.028925												

Table 7. The final results of the AHP method.

Regions	Results of AHP Method
West	0.158200757
South	0.192632352
Center	0.171763299
East	0.199564038
North	0.277838895

Table 8. The results of the TOPSIS method.

Regions	The Distance from the Negative Ideal	The Distance from the Positive Ideal	TOPSIS Score
South	0.136831	0.11513	1.115129805
North	0.118664	0.110051	1.110051464
East	0.097764	0.122019	1.122019064
West	0.107966	0.113771	1.113771319
Center	0.13033	0.130803	1.130803292

As the last part of the first phase, the AHP-TOPSIS hybrid method is implemented on the problem. The purpose of this method is to use the weights obtained for the criteria from the AHP method (the results of *Table 6*) and to apply the TOPSIS method. The results of *Table 9* show the superiority of the western region as a relief center.

Table 9. The results of AHP-TOPSIS hybrid method.

Regions	The Distance from the Negative Ideal	The Distance from the Positive Ideal	AHP-TOPSIS Score
South	0.187155	0.121959	1.121958517
North	0.168411	0.127946	1.127945977
East	0.096095	0.100761	1.100760816
West	0.181026	0.133384	1.133383686
Center	0.138982	0.123656	1.123656085

5.2 | The Second Phase of the Proposed Approach

Due to the different results of the three methods used in the first phase (*Fig. 4.*), the best center is examined using the new CoCoSo method and the secondary decision matrix of *Table 11*. Also, the weights required for this method are extracted from the paper of Sharma et al. [46]. In their paper, three methods AHP, TOPSIS and AHP-TOPSIS are compared. In the end, the best method was AHP-TOPSIS and the worst method was TOPSIS. Therefore, according to the results of this paper, the weights of *Table 10* are considered for each of them according to the superiority of the method. The CoCoSo method is implemented on the secondary matrix according to the steps mentioned and the final result of the second phase in *Table 12* shows the desirability of the center as a relief center.

Table 10. The weights of three methods AHP, TOPSIS and AHP-TOPSIS.

Method	AHP	TOPSIS	AHP-TOPSIS
Weight	0.335	0.225	0.44

Table 11. The secondary decision matrix.

Regions	AHP	AHP-TOPSIS	TOPSIS
South	0.192632352	1.1219585	1.11513
North	0.277838895	1.127946	1.110051
East	0.199564038	1.1007608	1.122019
West	0.158200757	1.1333837	1.113771
Center	0.171763299	1.1236561	1.130803

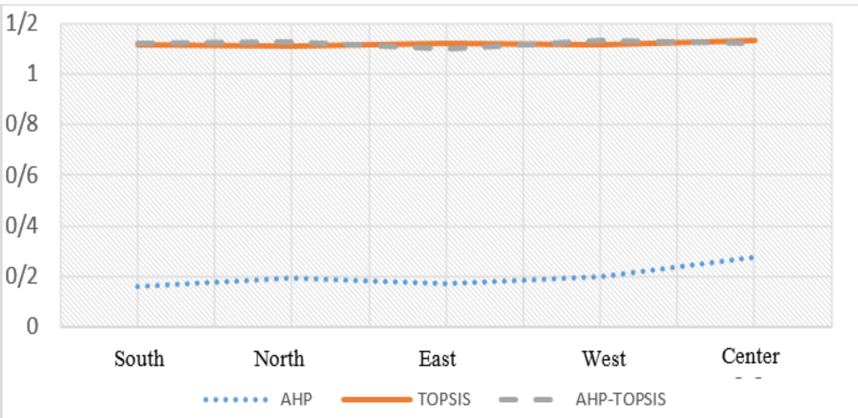

Fig. 4. Different results of the three methods used in the first phase.

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Table 12. The results of CoCoSo method.

Regions	s_i	p_i	k_a	k_b	k_c	K_i (CoCoSo score)
South	0.340965	1.555747	0.15578	3.171893	0.509248	1.910299
North	0.463071	1.581765	0.167946	3.918919	0.549018	2.257558
East	0.167734	1.365738	0.125947	2	0.411722	1.315719
West	0.596154	2.379867	0.244426	5.296706	0.799032	3.124747
Center	0.868799	2.855733	0.305902	7.270597	1	4.164154

6 | Conclusion

Because of the lack of relief resources in the event of a high-intensity accident, it is very important to prioritize the demand points. In this paper, a relief model was developed considering the priority of the accident regions. The novelty of this paper is to present a hybrid and two-phase approach of decision-making methods. Initially, the accident regions were prioritized with six criteria, then the decision matrix was created with the collected data. Therefore, in order to evaluate the proposed approach, a study was conducted on the city of Amol and the results investigated. Due to the different results of the methods used in the first phase, the second phase was implemented to determine the best region. Finally, the center of Amol city was considered as a place to build a relief center. The most important advantage of the proposed approach is the simultaneous use of the performance of four applied decision-making methods. Also, due to the use of the results of the three methods in the fourth method, the accuracy of the results should be increased. This research provides a valuable insight framework for supply chain managers in critical situations, who face similar problems in other environments. The proposed approach can be used for all service organs of the fire department, crisis management, Red Crescent, and so on. Due to the fact that the proposed method has the following shortcomings, as future research can be done to eliminate them: 1) considering different scenarios of the accident and uncertainty in problem, 2) the occurrence of disruption in the provision of relief teams and relief route, 3) considering the other criteria such as the ability of injured people in the problem and 4) considering the time of the accident and its effect on how to provide relief. One of the practical and management areas that this paper that will be implemented, use the proposed approach in locating a rescue helicopter. Due to the fact that the number of rescue helicopters is very small, it must be located in a suitable place in order to be able to serve all points of demand properly.

Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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