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Assessing the Location of Relief Centers Using a Combination of Multi-Criteria Decision-Making Methods and GIS (Case Study: District 18 of Tehran)

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Abstract

All governments especially those having a high risk of natural disasters must have a comprehensive and implementable plan. In Iran, the placement of relief centers for the injured is usually done experimentally by relief organizations without considering the necessary standards. In this research, according to the crisis management standard, the criteria are classified and determined as layers of information in the Geographic Information System (GIS). Then, the selected relief centers in the study area were evaluated according to the standard criteria and using the obtained matrix, the research criteria were weighed by entropy method. Finally, using net flows, performance scores and research constraints, the optimal options were identified by the PROMETHEE 5 method. The strengths and weaknesses of each of these options were also assessed. The results showed that half of the relief centers considered in the region were not optimal and had poor performance in most of the effective and important criteria for locating relief centers. Criteria of population density and distance from worn tissue were the most important criteria in this study.

Keywords: Location, PROMETHEE method, Geographical information system, Relief centers.

1 | Introduction

Natural disasters, especially earthquakes, have long been considered as the most destructive factors affecting humans, society and habitat. Given the high importance of housing and shelter, the provision of places for temporary accommodation of the injured is an inevitable but a top priority. One of the essential tasks of crisis management planners in any planning and the organizational system is to make serious predictions for emergency and temporary housing. The injured person without traditional shelter is on the verge of serious physical, mental and psychological injuries. For this reason, the role of location is very important in urban planning. In this research, we have tried to evaluate the selected places by the Crisis Management of Tehran Region 18 in terms of optimality and to evaluate the performance of each of these places in terms of observing the considered criteria.

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The difference between optimal options and efficient options is in their evaluation process. Efficient options are the result of comparing the input and output streams of the criteria classification. This is similar to the input/output model used in Data Envelopment Analysis (DEA). DEA is a linear programming approach for evaluating relative efficiency or calculating the efficiency of the finite number of similar decision-making units. When measuring the efficiency of operational units, it is common to compare input criteria to output criteria and to look for some kind of best output/input ratio. This evaluation approach has attracted the attention of many researchers [12], [18], [19], [23].

In recent years, a great deal of research has been done on the location of relief centers. Ateş and Mutlu [5] used TOPSIS and multi-criteria to identify suitable areas for temporary accommodation in Duzce, Turkey. Ali et al. [4], using Geographic Information System (GIS) and Multi-Criteria Decision Making (MCDM), developed a framework for identifying flood-prone areas of the Tolp'a River, Slovakia. The purpose of this plan is to prepare for this natural disaster. Abdollahian and Mahmoudzadeh [1] have evaluated and ranked the standard criteria for determining accommodation and relief centers for disaster victims using the TOPSIS method. Kangi et al. [16], using GIS and identifying the areas using the Hierarchical Analysis method for weighting, presented a plan to find a suitable place to rescue the injured through the airlines.

This project aims to help the injured in the shortest possible time in Yazd, Iran. Chen et al. [10] designed a system theory-based planning framework and GIS in China for urban emergency shelters in disaster times. They used the opinions of local experts and citizens to build 11 temporary shelters in Guangzhou. The results showed that this framework is a suitable method for planning urban emergency shelters. Saeidian et al. [21] used GIS, the TOPSIS method, a simple clustering method and two meta-heuristic algorithms Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) to locate relief centers. Baharmand et al. [6] have developed a spatial allocation model and determine the application and response of the Nepal earthquake using the actual data set. Long [17] using GIS and online information, evaluated emergency transportation in China in order to achieve the fastest arrival of emergency relief forces. The results show the superiority of air transport, namely airplanes and helicopters. Hewaidy et al. [13] examined the conditions of the Wadia degla in terms of flood risk. They concluded with the GIS method and several other methods that three dams should be built in this area. Rahman et al. [20] identified and evaluated optimal evacuation centers to improve emergency planning in flood conditions. For this purpose, using MCDM method and GIS and several other methods, it was concluded that the designated centers were not properly distributed. Hossain et al. [14] have developed a new system to assist existing emergency response measures after a massive earthquake. This system can integrate smartwatch data using the exposed population with the GIS to assess post-earthquake conditions observe. Dabbagh and Ahmadi Choukolaei [11] evaluated and prioritized the locations designated by the Urmia City Crisis Management using ANP and Pramati 1 methods. They have been more important and the top options have performed better in keeping the distance set by crisis management experts. Ahmadi Choukolaei et al. [2] evaluated the relief centers considered by crisis management and the optimal centers extracted by the GIS in terms of efficiency using GIS and multi-criteria decision methods. The results showed that among the research options, only 4 options were both optimal and efficient.

Given the issues in reviewing the literature and reviewing and analyzing the information gathered, the research gap is as follows:

- *Failure to pay attention to the limitations of location.*
- *Use weighting methods by applying the opinion of experts that there will be a possibility of human error.*

Given the research gap mentioned, the research contributions are listed as follows:

– *Use PROMETHEE V to consider the limitations in selecting the optimal locations. PROMETHEE V combines the results obtained from the original PROMETHEE-GAIA method with a partial linear program (0-1) to integrate these constraints.*

- *Apply new constraints such as restrictions on the choice of close options (meaning that centers that are close to each other) and restrictions on distances with dangerous criteria that lead to clearer and more reliable results.*
- *Weighing the criteria through the available information from the evaluation of the available places by the GIS and the classified criteria.*

The research method is described in the following section. The criteria are classified and evaluated by the GIS in the third section. Section 4 describes the weighting criteria and evaluation results. In the fifth section, the conclusion is presented. Also, in *Table 1*, the highlights of this article were compared to a review of the existing literature. For example, one of the highlights of this paper is the use of standard constraints and the combination of MCDM with GIS.

Table 1. Literature review comparison.

		Location - Location of the facility			**Numerical examples**				**Is there Limitations?**		**Planning levels**		
NO	**Reference**	**Warehouses**	**Supplier**	**Relief centers**	**A real example**	**Randomly generated**	**Adapted from literature**	**Solving method**	**YES**	**NO**	**Operational**	**Tactical**	**Strategic**
1	Ateş and Mutlu [5]			þ			þ	TOPSIS	þ		þ		
2	Ali et al. [4]			þ	þ			DEMETAL-ANP, GIS	þ		þ		
3	Abdollahian and Mahmoudzadeh [1]				þ		þ	TOPSIS		þ			þ
4	Kangi et al. [16]			þ	þ			Spatial information system	þ				þ
5	Chen et al. [10]			þ	þ			GIS	þ		þ		
6	Baharmand et al. [6]		þ				þ	Monte carlo simulation	þ		þ		
7	Long [17]		þ			þ		GIS		þ		þ	
8	Hewaidy et al. [13]			þ	þ			ASTER Digital Elevation Model (DEM), GIS, and geomorphic		þ	þ		
9	Rahman et al. [20]			þ	þ			GIS, Levenberg-Marquardt Neural Network		þ	þ		
10	Dabbagh and Ahmadi Choukolaei [11]			þ	þ			ANP, GIS, PROMETHEE 1		þ			þ
11	Ahmadi Choukolaei et al. [2]			þ	þ			GIS, MCDM,PROMETHEE V	þ				þ
12	This study			þ	þ			GIS, entropy method , PROMETHEE V	þ	þ			þ

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2 | Research Design and Methodology

The information required for research has been collected in the study of documentary library studies, previous studies, and disaster management experts' cooperation. First, standard criteria for the optimal relief bases are defined intermittently, and information layers are prepared in ArcGIS. Residential areas in critical conditions were assessed based on research criteria. Arc Toolbox was used to analyze the collected layers in ArcGIS software. The weight of the criteria was calculated using the entropy method and using the matrix obtained from the evaluation of options. Finally, each of the proposed points was evaluated by the PROMETHEE method. MCDM has been used because of its advantage in balancing the positive and negative ranking streams of criteria and the clarity and reliability of its results compared to other MCDM methods. *Fig. 1* shows the general structure of the research. The purpose of this article is to evaluate the selected disaster management centers in Tehran, Iran.

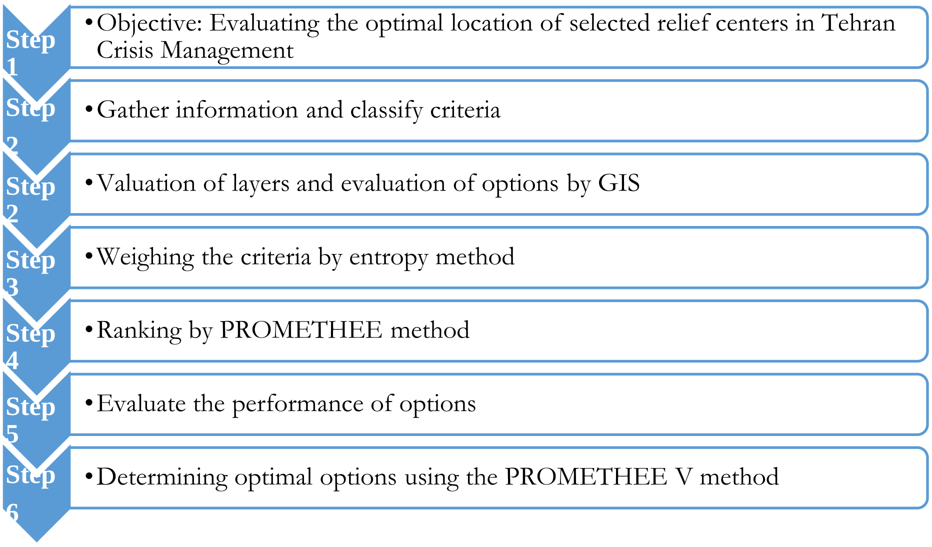

Fig. 1. The general structure of the research.

2.1 | Geographic Information System

In general, a GIS is used to collect, store, and analyze data whose geographic location is a major and important feature. In other words, these systems are used to collect and analyze all information that is somehow related to geographical location [7]. The ultimate goal of a GIS is to support decisions based on geographic data, and its primary function is to obtain information that is obtained by combining different layers of data in different ways and with different perspectives. With the help of GIS, all kinds of processing and analysis can be done with cost and time savings.

2.2 | Entropy Mathematical Method

The entropy method is one of the MCDM methods using the criterion selection matrix. The entropy shows the uncertainty in the probability distribution that is continuous with its values first —divided the values of each cell of the matrix by the sum of the column values (simple normalization).

$$n_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}. \quad (1)$$

The entropy value of the characteristic *j* is calculated as follows:

$$E_j = -K \sum_{i=1}^{M} n_{ij} \ln(n_{ij}) \ , \qquad K = \frac{1}{\ln M}. \tag{2}$$

M: Is the number of options?

With the help of $E_j$the values of $d_j$are calculated for each attribute:

$$d_j = 1 - E_j. \tag{3}$$

By normalizing the values of $d_j$the characteristic weight of *j* is obtained [22]:

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j}. \tag{4}$$

2.3 | PROMETHEE Mathematical Method

The PROMETHEE method can perform the evaluation process on a limited set of finite alternatives in a partial or complete ranking. The apparent effect of each of the criteria and their weight in this method has made this method very simple and flexible. The ranking of this method consists of three steps [9]:

Step 1. The priority function is set for each of the criteria. Which is usually between zero and one. The PROMETHEE method proposes six generalized criteria for the preference function to the decision-maker.

Step 2. The absolute priority $\pi(a, b)$ for option a is calculated on option b. Although $\pi(a, b)$ is higher, option a is more preferred $\pi(a, b)$ calculated this way [8].

$$\pi(a،b) = \sum_{j=1}^{K} wjpj(a،b)،(\sum_{j=1}^{K} wj = 1). \tag{5}$$

Step 3. $\pi\ (a.b)$ indicates the degree of priority of option *a* over *b* option. To calculate the total preference power of *a* option over other options, the output current is calculated. Positive flow is the most substantial option, negative flow is the weakest option, and net flow, which is the balance between positive and negative flow, is the best option if each option has a higher net flow. The formula for all three flows is as follows [3] and [24].

Positive ranking flow:

$$\varnothing^{+}(a) = \frac{1}{n-1} \sum_{x \epsilon A} \pi(x.a). \tag{6}$$

Negative ranking flow:

$$\varnothing^{-}(a) = \frac{1}{n-1} \sum_{x \epsilon A} \pi(x.a). \tag{7}$$

Net flow:

$$\emptyset(a) = \varnothing^{+}(a) - \varnothing^{-}(a). \tag{8}$$

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2.4 | PROMETHEE V Method

PROMETHEE V works in two steps:

I. A PROMETHEE II analysis of the data is made. The multi-criteria net flow f ϕ (Phi) provides with a global evaluation of the actions taking into account all the criteria.
II. A 0-1 linear program is then defined as follows in order to solve the multiple selection problem:

A binary (0-1) variable xi is associated to each action ai: xi = 1 means that action ai is selected while xi = 0 means it is not. The objective is to select actions in such a way that the sum of the f (Phi) values of the selected actions is as large as possible:

$$\max \sum_{j=1}^{n} \phi(a_i)x_i. \tag{9}$$

Number of actions to select: if exactly m actions have to be selected, the following constraint will be added to the linear program:

$$\sum_{i=1}^{n} x_i = m. \tag{10}$$

Maximum value Constraint: if the maximum value is B and each action ai has a corresponding cost equal to bi.

$$\sum_{i=1}^{n} b_i . x_i \leq B. \tag{11}$$

Incompatibility between two actions: if actions ai and al cannot be selected at the same time, the following constraint can be used:

$$Xi + XL \leq \tag{12}$$

3 | Case Study Implementation

The city of Tehran is located in the foothills of the Alborz Mountains and has a high seismic risk and has many active faults. In the twentieth century, urban planning operations in Tehran accelerated without a proper crisis management system for severe earthquakes, and such an earthquake is predicted to cause an unprecedented catastrophe. Due to such issues, the Iranian government signed a cooperation agreement with the JICA team (Japan International Cooperation Agency) in 2011 to investigate the Tehran earthquake and the damage to infrastructure and management measures to reduce the damage. *Fig. 2* shows the results of the assessments of the scattered weak buildings. As can be seen, the southern regions are the most scattered of weak buildings [15]. District 18, located southwest of Tehran (*Fig. 3*). According to the building distribution map, this area is one of the most dangerous areas. In this study, the relief centers considered by crisis management in crisis situations will be evaluated.

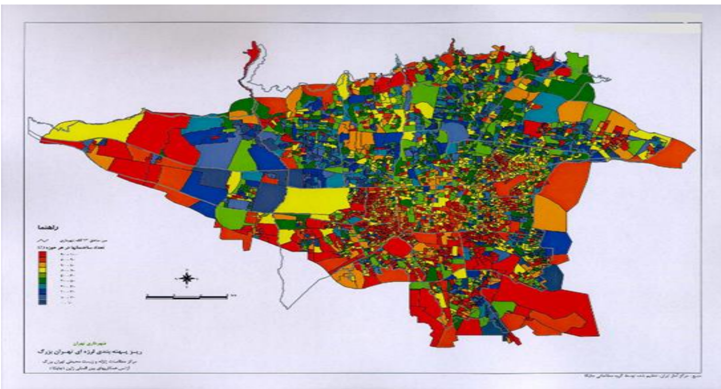

Fig. 2. Dispersion of poorly assessed buildings in Tehran.

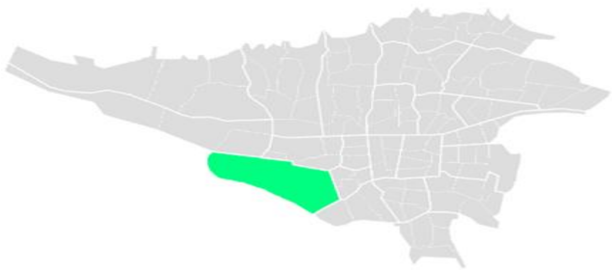

Fig. 3. District 18 of Tehran Municipality.

3.1 | Classification of Criteria

The criteria and options for determining the optimal relief centers in this study are based on previous studies and other additional criteria in collaboration with disaster management experts, which are shown in *Table 2*. This table also introduces the number of class classes and the value of each class for each of the criteria.

Table 2. Classification and evaluation of criteria.

C A	Very good	Good	Average	Bad	Very bad
Area	more than 2000	1500-2000	1250-1500	1000-1250	less than1000
Worn texture	0-100	100-200	200-300	300-400	more than 400
Main ways	0-100		100-200	200-300	more than 300
Security	0-100	100-200	200-300	300-400	more than 400
Gas station	250-1100	200-250	150-200	100-150	0-100
CNG & fuel station	more than 250	200-250	150-200	100-150	0-100
Rivers	more than 700	500-700	300-500	100-300	0-100
Hospital	0-300	300-500	500-700	700-1000	more than1000
Fire station	0-500	500-1000	1000-1250	1250-1500	more than 1500
Electricity post	more than 100	75-100	50-75	25-50	0-25
Gas post	more than100	75-100	50-75	25-50	0-25
Population	more than 1200	900-1200	600-900	300-600	0-300
Subway	more than 200	150-200	100-150	50-100	more than 50
Fault	more than 200	150-200	100-150	less than 100	

3.2 | Layer Valuation and GIS Output Evaluation

GIS is cohesive hardware, software, and data system that allows computer-generated data to be stored, analyzed, transmitted, evaluated, retrieved, and distributed geographically as maps, tabular information, and models. By GIS, all kinds of processing and analysis can be done with cost and time savings. Different layers were drawn at the study area level and were stored as layers using the capabilities of GIS. In order to unify and compare the uses and the amount of impact, the layers have been evaluated based on the buffer created in ArcGIS software as an interval (*Table 3*). After the formation of information layers, the locations determined by the Tehran Disaster Management have been evaluated in terms of distance status and the ratio of indicators evaluated in *Table 3* and considering the classification and evaluation of the criteria, they have been evaluated qualitatively (Very bad - Good - Average - Bad Very good) so that Very good had the highest score and Very bad had the lowest score, which is abbreviated here as VG, G, A, B and VB are placed and mean very good, good, average, bad and very bad, respectively. After being evaluated by the GIS about the criteria, each location in the area is in one of the mentioned scoring intervals. For example, Shams Park is in the range of 100-150 in terms of distance from the fault after evaluation. According to *Table 1*, it is in the Average range.

Table 3. Results for places relative to indicators.

	Area	**Hospital**	**Main Ways**	**Security**	**Gas Station**	**CNG & Fuel Station**	**Rivers**	**Worn Texture**	**Fire Station**	**Population**	**Subway**	**Fault**	**Electricity Post**	**Gas Post**
Shams Park	VG	VB	VG	VB	VG	VG	VG	AV	B	AV	VG	AV	VG	VG
Arvand Park	B	VB	VG	VB	VG	VG	VG	VB	VB	VB	VG	AV	VG	VG
Khordad Park	VG	VB	VG	VB	VG	VG	VG	AV	AV	VG	VG	G	VG	VG
Kargar park	VG	VB	VG	VB	VG	VG	VB	G	AV	VG	AV	AV	VG	VG
Narges Park	G	VB	VG	VB	VG	VG	VG	VG	VB	AV	VG	AV	VG	VG
Laleh Park	VG	VB	VG	VB	VG	VG	VG	B	AV	G	AV	AV	VG	VG
Qaem Park	VG	VB	VG	VG	VG	B	VG	AV	VG	AV	VG	AV	VG	VG
Orkideh Park	VG	VB	VG	VB	VG	VG	VG	G	B	G	VG	AV	VG	VG
Roudaki Park	VG	VB	VG	VB	VG	VG	B	G	B	VG	VG	AV	VG	VG
Valiasr Park	VG	VB	VG	G	B	VG	VB	AV	G	G	B	G	G	VG
Niloufar Park	G	VG	VG	VB	VG	VG	B	VG	G	AV	VG	G	VG	VG
Bahman Park	G	VB	VG	VB	VG	VG	VG	G	AV	G	VG	G	VG	G
Golestaneh Park	VG	VG	VG	VB	VG	VG	VB	VG	G	AV	G	G	VG	VG
Mina Park	VG	VB	VG	VB	VG	VG	B	VG	VB	B	VG	AV	VG	VG
Nowrooz Park	VG	VB	G	G	VG	VG	VG	VB	B	VB	VG	VB	VG	VG

4 | Evaluate the Results

After evaluating the relief sites considered by the regional disaster management and forming a pairwise comparison matrix, the criteria are weighted and prioritized. There are different methods for estimating the weights of the criteria; here, the Entropy method is used to determine the weight of the criteria.

After evaluating and measuring the region's locations about the research criteria (*Table 3*), using the Likert scale, qualitative values were converted into small values and criteria were weighed using the entropy method. *Table 4* shows the weights of the criteria calculated by the Shannon entropy method.

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Table 4. Weight criteria.

Criteria	W_j
Area	0.075
Hospital	0.063
Main ways	0.073
Security	0.065
Gas station	0.072
CNG & fuel station	0.072
Rivers	0.068
Worn texture	0.074
Fire station	0.072
Population	0.074
Subway	0.072
Fault	0.073
Electricity post	0.073
Gas post	0.073

After weighing the criteria, the research options were ranked and evaluated using the PROMETHEE method and the information in *Table 3*. In the options evaluation stage, the qualitative values of the optimal data input options are Visual PROMETHEE software. The qualitative values obtained in *Table 3* are considered as a pairwise comparison matrix for options and criteria. *Table 5* shows the output of Visual PROMETHEE software, which shows positive flows $\varnothing^+$ (a) and negative flow $\varnothing^-$ (a) and net flow $\varnothing$ values. As can be seen in *Table 5*, the 15Khordad Park option with a net flow of 0.1789 is in the ranking, and Bostan Morvarid with a net flow of -0.1860 and Arvand Park with a net flow of -0.2425 and -0.1570 are at the bottom of the ranking. PROMETHEE ranking results shows other options (*Table 4*).

Table 5. PROMETHEE ranking results.

Actions	Phi	Phi+	Phi-	RANK
Bahman Park	0.0308	0.2435	0.2126	7
Orkideh Park	0.0699	0.1972	0.1273	5
Merges Park	-0.0465	0.1604	0.2068	11
Nowrooz Park	-0.1754	0.1632	0.3386	14
Niloufar Park	0.1491	0.3080	0.1589	2
Roudaki Park	0.0486	0.2038	0.1552	6
15Khordad Park	0.1789	0.2648	0.0859	1
Mina Park	-0.0615	0.1566	0.2181	12
Valiasr Park	-0.0927	0.2598	0.3526	13
Kargar park	-0.0166	0.1943	0.2109	8
Arvand Park	-0.2425	0.0809	0.3235	15
Shams Park	-0.0200	0.1496	0.1696	9
Golestaneh Park	0.1332	0.3043	0.1711	3
Qaem Park	0.0796	0.2661	0.1865	4
Laleh Park	-0.0349	0.1759	0.2108	10

In *Fig. 4*, the options are specified from left to right based on the ranking of the PROMETHEE method (1- (15Khordad Park) 2- (Niloufar Park) 3- (Golestaneh Park) ... 14- (Nowrooz Park) 15- (Arvand Park)). For each option, the rectangular area determines the performance of the criteria of that option and the score and order of the essential properties of each option. At the top of the rectangle, the positive criteria of the options are specified, whereas the negative criteria of those options are specified at the bottom. For instance, 15Khordad Park has the first rank and has a much better performance in 11 of the 14 research criteria and did not perform well only in the distance from the hospital, safety, and distance to lean tissue. On the other hand, the Park Arvand option, which is ranked last, has performed poorly in half of the essential criteria of the research.

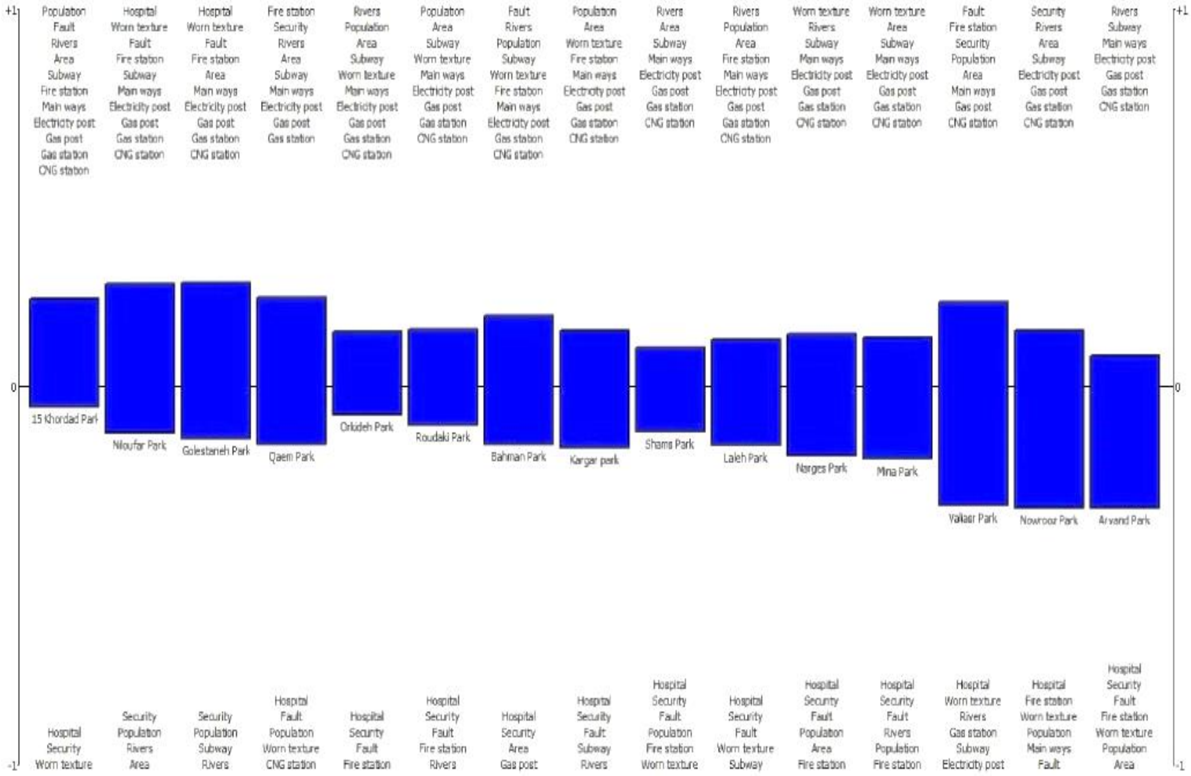

Fig. 4. PROMETHEE rainbow.

Fig. 5 is the GAYA diagram where the options are shown with black dots and the criteria with blue dots. The length of the axis shows the relative strength of a criterion, so the longer it is, the more critical that criterion is. On the other hand, the direction of an axis indicates where the best possible options for this criterion are located. In the GAYA form, options that are similar to each other are closer to each other and options that conflict with each other is farther apart. For example, the options of Kargar Park, Roudaki Park and 15Khordad Park performed very well in terms of population criteria. However, they performed very poorly in terms of security criteria (due to being in the opposite direction of the population density criteria).

Figs. 6 and *7* are the GAIA web diagrams. This chart is a graphical representation of options based on net flow. The shape of this spider diagram depends on the strength and weakness of the criteria. The axes of the criteria that are closer to each other have a significant relationship. In this diagram, the decision axis specifies the location of each criterion in green (if $\varnothing^{+}$ positive) and red (if $\varnothing^{-}$ negative). Option 15Khordad Park as the first rank and option Arvand Park as the last rank has been examined. Option 15Khordad Park has a positive net flow and has a positive operating radius in most of the options. However, on the other hand, the Arvand Park option has a suitable operating radius only in the criteria of distance from the subway and distance from the river and has performed poorly in other criteria.

Finally, according to the flows obtained from the calculations and the applied constraints, the optimal options for housing were identified using the PROMETHEE V method. *Table 6* shows the results of this evaluation. These actions are displayed from top to bottom in the PROMETHEE II rank. The "Optimal" column shows the optimal solution, and the "Total" rows show the value of the objective function for both choices. PROMETHEE V offers 15Khordad Park, Qaem Park, Orkideh Park, Roudaki Park, Niloufar Park, Bahman Park and Golestaneh Park as optimal options the overall flow of 0.6901.

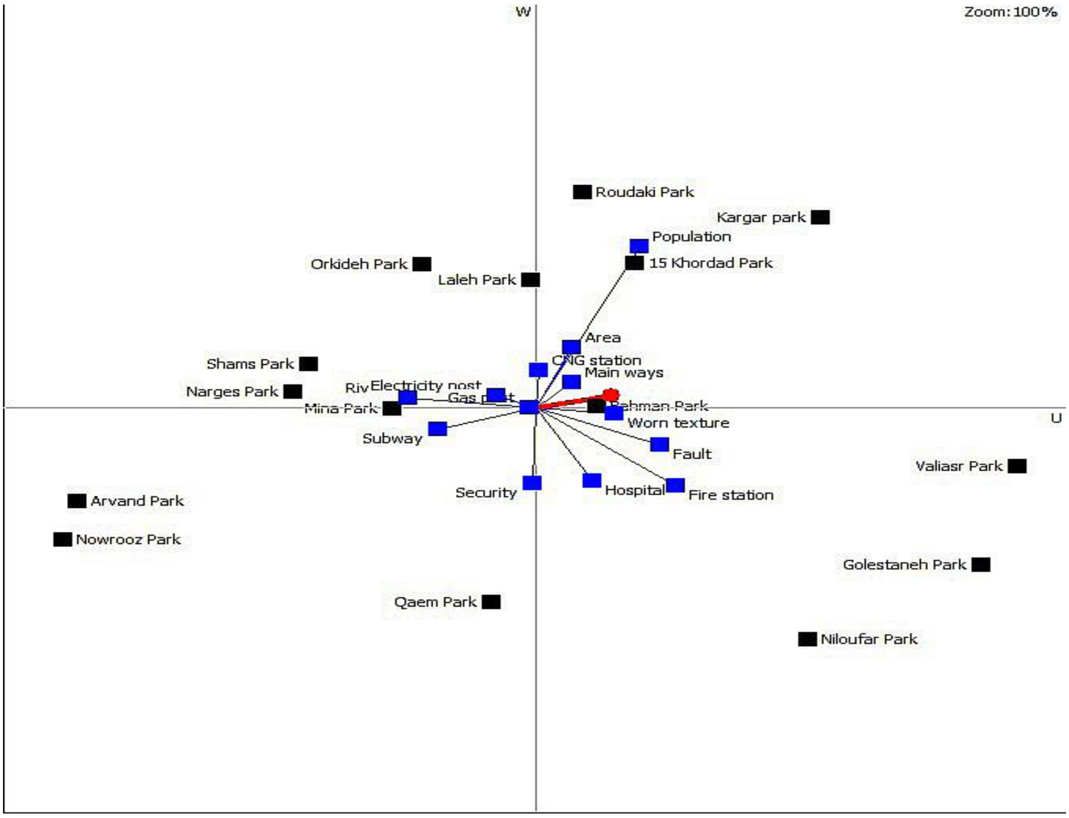

Fig. 5. GAYA diagram of the output of the PROMETHEE.

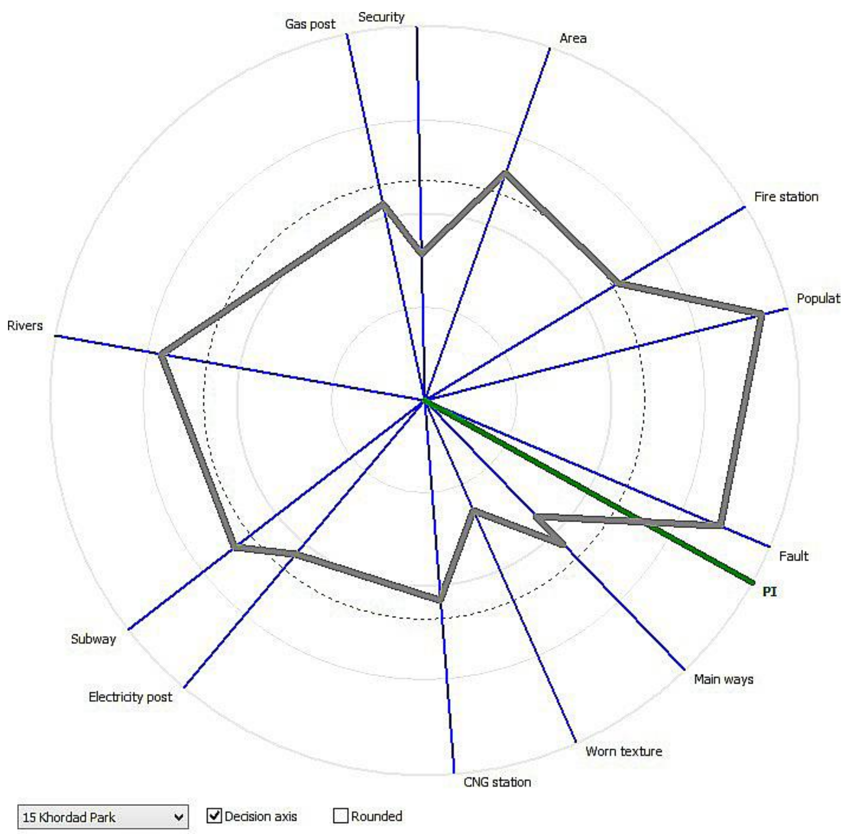

Fig. 6. GAIA web option 15Khordad Park.

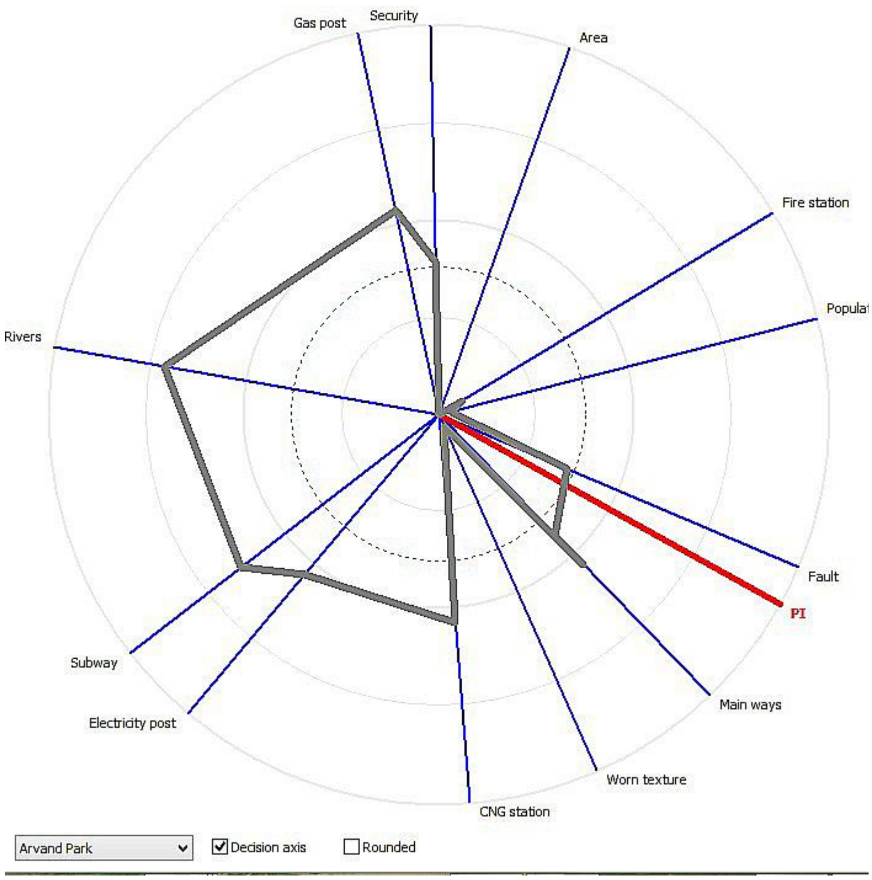

Fig. 7. GAIA web option Arvand Park.

Table 6. Optimal options evaluated by PROMETHEE V.

Actions	Net flow	Optimal	Compare
	TOTAL	0.6901	0.6901
Shams Park	-0.02	NO	NO
Arvand Park	-0.2425	NO	NO
15 Khordad Park	0.1789	YES	YES
Kargar park	-0.0166	NO	NO
Narges Park	-0.0465	NO	NO
Laleh Park	-0.0349	NO	NO
Qaem Park	0.0796	YES	YES
Orkideh Park	0.0699	YES	YES
Roudaki Park	0.0486	YES	YES
Valiasr Park	-0.0927	NO	NO
Niloufar Park	0.1491	YES	YES
Bahman Park	0.0308	YES	YES
Golestaneh Park	0.1332	YES	YES
Mina Park	-0.0615	NO	NO
Nowrooz Park	-0.1754	NO	NO

5 | Conclusion

In Iran, the location of relief centers is usually done on a trial basis and without considering the necessary standards by relief organizations. In this research, GIS has been used due to its capabilities in collecting, storing, controlling, analyzing, modeling and displaying geographical data and PROMETHEE method has been used due to its many advantages such as balancing the flow. The entropy method has also been used to weight the research criteria. After weighting the criteria, the options were prioritized by the PROMETHEE method. The optimal options were identified using PROMETHEE V. The limitations of this research include the limitation of the distance with the dangerous criteria, which according to the experts, if these distances are not observed, it will not be possible to accommodate the injured in times of crisis. There are also two limitations to choosing close-knit options, meaning that centers that are close to each other can not be selected because they compete directly with each other. Due to the existing research gap, the application of these restrictions and the prioritization of options by PROMETHEE V will see clearer and more reliable results. But does not meet some sensitive and dangerous criteria such as the distance to the gas station, and this is in conflict in terms of defining the role of relief centers in times of crisis. The results showed that half of the considered locations in the area were not optimal. Even the optimal options did not perform well in some essential criteria (in terms of weight importance) such as area (0.075), distance from lean tissue (0.074) and security (0.065). The results of the research indicate the improper performance of these places in complying with the research criteria. Considering the vital role of supply chain network, especially relief centers for housing, it is recommended to use the optimal places identified in this research as accommodation places in crises and identify the identified weaknesses. It is also suggested that these places be examined and compared in terms of cost and economic criteria. Other suggestions include comparing relief centers designated in the region with other areas in terms of efficiency and effectiveness. Also, due to the epidemic conditions, it is recommended to check the usability of these centers during the virus epidemic. The limitations of the research included the lack of access to some sensitive information layers, such as the layers related to gas and oil pipelines and some strategic layers of the region. Also, due to Corona conditions, experts and experts were used to evaluate the criteria online.

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