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Research Article

Optimal Site Selection of Hospital Using Fuzzy TOPSIS (Case Study in Malayer City)

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Abstract

Background and Objectives: Building new service centers requires many expenses, and health-care uses are one kind of this field that it`s distribution on the city and specifying the optimal place for it is so important in order to give every citizen the best performance. Malayer is one of the cities of Hamedan in Iran that doesn't have suitable health-care and the hospital distribution, and by considering the increase in population, and need to fast access to the hospital, selecting the proper position become more important. In this paper, Malayer is chosen as a case study. This research aims to study on selecting the appropriate place by considering qualitative criteria and presenting the appropriate model for Malayer.

Methods: In this research, we tried to choose the optimal place to build a hospital in Malayer by using the ordinary fuzzy decision-making method. The parameters that are taken into account are population density, distance to other hospitals, access to main roads, and distance to industrial and military centers. These parameters are combined ordinary by fuzzy TOPSIS.

Results: Results indicate that constructed hospitals in Malayer do not match with position-selecting criteria.

Conclusion: This important point shown by this research is some regions of the town have no health service. In contrast, the citizens placed in the other areas receive more suitable services and the number of hospitals needed at the moment for Malayer is six.

Keywords: Site Selection, Hospital, Multi-criteria decision-making, Fuzzy TOPSIS

Background and Objectives

Health-care services are group services that are presented by doctors and other employees, and the main goal is to provide excellent services for all people, as in new sanitation, both personal and social health are considered[1]. Some centers for health services are clinics, hospitals, infirmaries, and laboratories. In according to the definition made by the world sanitation organization, the hospital is an enterprise that accepts clients for a long or short term period, and provides health services for patients.

Location of social facilities is a sample of governmental policies, with understanding benefits resulted from saves in resources, increasing productivity, especially in crucial situations; these benefits are crucial for countries faced by sharp increase in population[2] and also one of the most important goals of urban planning is to provide useful general services.

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Because of modern world changing and the existing of different problems for cities and villages, providing the fast service is essential[3], that in this regard, proper distribution in terms of space and position for these services by considering future urban changes will increase the satisfaction level of people.

Today, the increasing population of cities induces demand for new hospitals. Selecting wrong position for hospital, will cause some experienced problems and implies that hospital must be constructed industrial, military, and crowded regions and access ways must be right that means closeness to main roads, closeness to more populated places, and finally it must be constructed in the appropriate distance to other hospitals, in order to good distribution of medical services on the city. The geographical position is the main component of accessibility of medical services that is studied by different researchers with various views and by using different methods[4]. Rapid changes in urban patterns and population growth in cities will lead to a shortage of facilities[5].

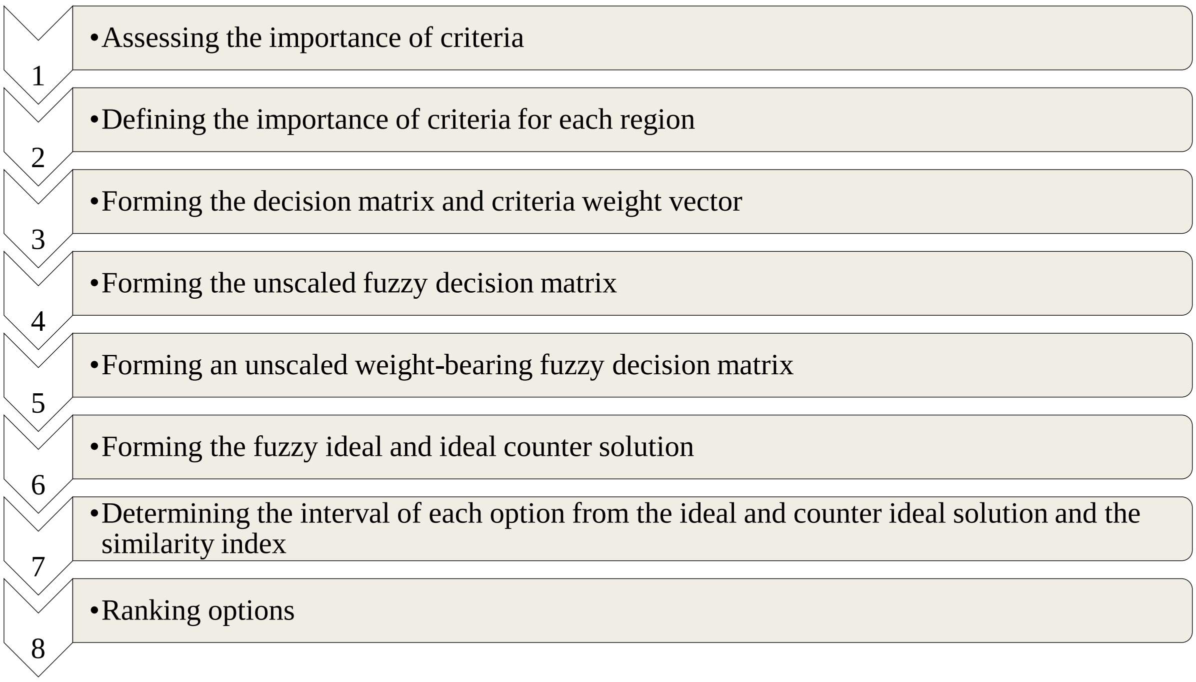
In justice-based urban planning, fair access to land and using it optimally is one of the main components of sustainable development and social justice. This problem becomes more critical, especially about the access to people to vital places. Sanitation is one of the important issues[6]. In general, the location of individual facilities is one of the common problems in the field of decision-making, which have become more favorable in recent years[7,8]. We must adopt several environmental factors to build these centers. This implies that urban planners are faced with sophisticated decision-making situations. This complexity is a result of the fact that several effective criteria must be considered, and sometimes it's hard to understand relationships between them[9]. In this regard, Vahidnia et al[10] developed a multi-criteria decision analysis process that combines Geographical Information System (GIS) analysis with the fuzzy analytical hierarchy process (FAHP) in which three methods were used to estimate the total weights and priorities of the candidate sites: fuzzy extent analysis, center-of-area defuzzification, and the α-cut method. The result was used to determine the optimum site for a new hospital in the Tehran urban area. Senvar et al.[9] proposed a multi-criteria decision-making (MCDM) process that integrates hesitant fuzzy sets to a technique for order preference by similarity to ideal solution. In this paper, the proposed process was defined under uncertainties that are perfectly defined that reflecting comprehensively hesitant thinking of decision-makers and implemented to select the optimum site for a new hospital in Istanbul. Esra Aytaç and Ayşegül[7] applied technique for order of preference by similarity to ideal solution (TOPSIS) evaluation based on the distance from average solution and combinative distance-based assessment methods which are distance-based multi-criteria decision-making methods to the hospital site selection problem. The weights of the hospital site selection criteria are derived from criteria importance through the inter-criteria correlation method, whereas the complete ranking of the hospital site alternatives is obtained using their proposed method. They showed that the most important criterion is 'market conditions' and the other criteria follow this criterion are cost, transportation, geological factors, land strategy, financial support by the government, environmental consideration, and demographic consideration, respectively. Pınar and Figen[1] suggested a framework includes a fuzzy technique for order preference by similarity to ideal solution approach and applied it for a case study of regional hospital location selection in Adana province.

One of the main problems in planning is to know enterprise abilities. Since there are several different problems and complexities in environmental factors, decision-making and selecting the proper policy to do it must be performed by considering all effective factors. In this regards, multi-criteria decision-making models are developed in the field of planning, because they give planners the best choice by using several criteria[11].

Multi-criteria decision-making is a technique with the aim to find the best option among a finite number of different solutions[12]. TOPSIS is based on defining the ideal positive solution and the negative ideal solution[13] and the logic behind this, is to choose the option that has a minimum distance to ideal solution. In this paper, for the first time, effective parameters for location are modeled and a fuzzy membership function is defined for each one of them. These parameters are combined ordinary fuzzy TOPSIS and the final plan that shows the utility level of each point for building a hospital in Malayer city is defined.

Method

Multi-criteria decision-making techniques are categorized into two groups: multi-objective decision making (MODM), and multiple attribute models. Multi-objective models are used to design, while multiple attribute models are used to choose the best option. This paper is based on multiple attribute methods. After studying papers in the field of urban planning and hospital planning and by considering fundamentals of location, an appropriate model is defined in order to reach the goal. MCDM and its combination with fuzzy sets are used widely in fuzzy and uncertain situations[5,14]. In summary, the research steps are as follows:



Fuzzy TOPSIS technique

As in the real world due to vague, qualitative and uncertain nature of the experts' comments as well as the lack of

$$\widetilde{W} = [\widetilde{W}_1, \widetilde{W}_2, \dots, \widetilde{W}_n] \quad (1)$$

information, it is not possible to measure these comments[10], in this article we use the logic, set and fuzzy numbers.

TOPSIS as a multiple attribute decision making method, is a simple but useful method. This method was proposed by Chen and Hwang according to the book of Hwang and Yun in 1981.

TOPSIS is used to evaluate elements of the decision matrix that are stated orally, and so we can solve the problem of similarity to the ideal solution method[15]. In other words, the distance between every criterion is calculated from a positive and a negative ideal solution, and this is a criterion to rank options; the best option must have maximum distance to negative ideal solution and minimum distance to a positive ideal solution. Briefly, the positive ideal solution involves the best values and the negative ideal solution includes the worst values[16].

Since MCDM problems in the real-world are mental and qualitative and state them certainly is difficult for decision-makers, so to solve this problem, triangular fuzzy numbers are used. We have used these numbers, because they can be used directly by decision-makers and make the calculation simple. In addition, it is proved that triangular fuzzy modeling is so useful for problems that have inaccurate data[17]. According to research of Guo & Zhao the steps of fuzzy TOPSIS are described in the following section[4].

TOPSIS

The steps of TOPSIS are as follows:

1- Building decision matrix: evaluate option in term of criteria

2- Determination of criteria weights matrix: in this step, define the important factor for each criterion in the following way:

If triangular fuzzy numbers are used, every element W_j (Weights of criteria) will be replaced by $\widetilde{W}_j = (W_{j1}, W_{j2}, W_{j3})$ and if fuzzy trapezoidal numbers are used, every element W_j will be replaced by $\widetilde{W}_j = (W_{j1}, W_{j2}, W_{j3}, W_{j4})$.

3- Building a non-dimensional fuzzy decision matrix: when X_{ij} is fuzzy, r_{ij} will be fuzzy also. In order to build a non-dimensional matrix, instead of sophisticated calculations in the method, linear scaling is used to transform different scales to one comparable scale.

If numbers are triangular (for positive criteria) in which (*a, b, c*) are three points of triangular fuzzy numbers.

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j}\right) \quad (2)$$

If numbers are fuzzy and triangular (for negative criteria)

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \quad (3)$$

4- Determination of weighted fuzzy decision matrix: having weights of different criteria, weighted fuzzy decision matrix is calculated by multiplying importance factors vector by non-dimensional fuzzy matrix and is obtained as follows:

$$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_j \quad (4)$$

If numbers are triangular (for positive criteria)

$$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_j = \left(\frac{a_{ij}}{c_j}, \frac{b_{ij}}{c_j}, \frac{c_{ij}}{c_j}\right).(w_{j1}, w_{j2}, w_{j3}) \quad (5)$$

If numbers are fuzzy and triangular (for negative criteria)

$$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_j = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}}, \frac{a_j^-}{c_{ij}}\right).(w_{j1}, w_{j2}, w_{j3}) \quad (6)$$

5- Finding ideal fuzzy solution A^* and anti-ideal fuzzy solution A^-: Ideal fuzzy solution and anti-ideal fuzzy solution are defined as follows.

$$A^* = \{\tilde{V}_1^*, \tilde{V}_2^*, \dots, \tilde{V}_n^*\} \quad (7)$$

$$A^- = \{\tilde{V}_1^-, \tilde{V}_2^-, \dots, \tilde{V}_n^-\} \quad (8)$$

where $\tilde{V}_i^*$ is the best value of i among all options, and $\tilde{V}_i^-$ is the worst value of criteria i among all options. Options that are in A^* and A^-, show the best and worst options, respectively.

6- Calculating the distance to ideal and ideal fuzzy solutions in which d is the distance between to fuzzy numbers that if (a_1, b_1, c_1) And (a_2, b_2, c_3) be to triangular fuzzy numbers, the distance between this two numbers is:

$$d_v(\tilde{M}_1, \tilde{M}_2) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]} \quad (9)$$

7- Calculating similarity criterion:

$$cc_1 = \frac{s_1^-}{s_1^* + s_1^-} \quad i = 1,2, \dots, m \quad (10)$$

8- Ranking the options: In this step by considering the value of similarity criterion, options are ranked in the way that options with higher similarity criterion will have higher priority. Now, by using these steps above, we can solve the location problem.

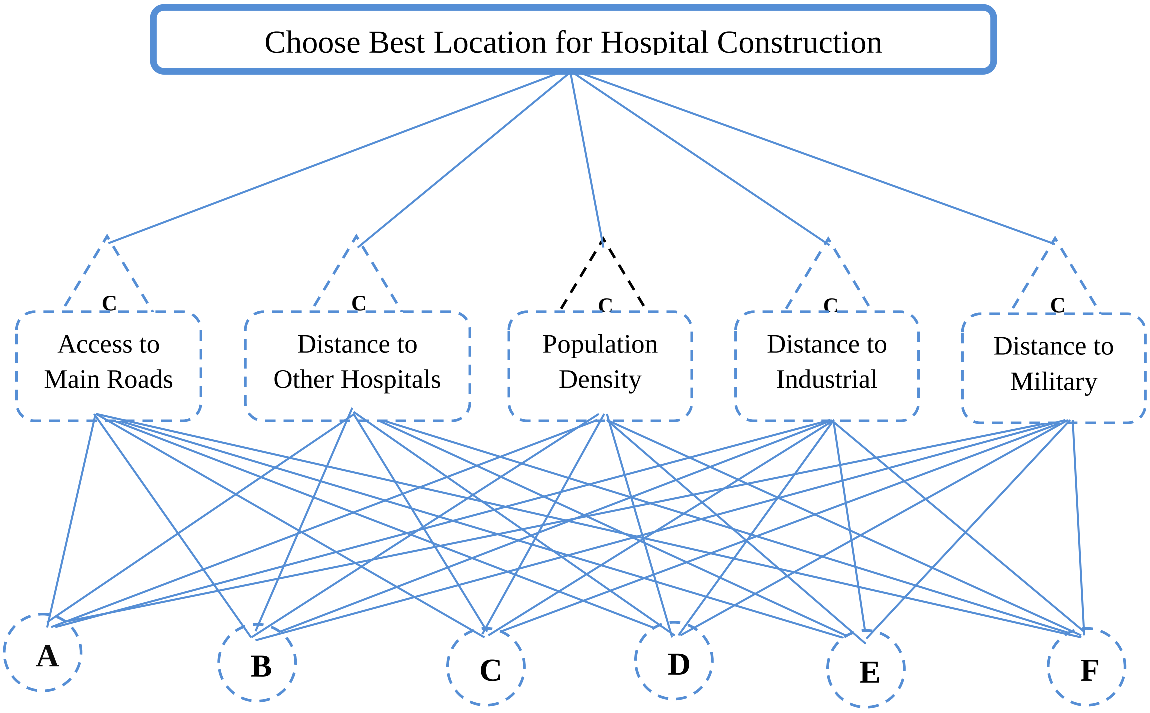


Figure 1. Hierarchy Chart

Table 1. Linguistic variables for ranking options

Code	Linguistic Variables	Corresponding Fuzzy Number
1	Very Low	(0, 0, 1)
2	Low	(0, 1, 3)
3	Mean – Low	(1, 3, 5)
4	Mean	(3, 5, 7)
5	Mean – High	(5, 7, 9)
6	High	(7, 9, 10)
7	Very High	(9, 10, 10)

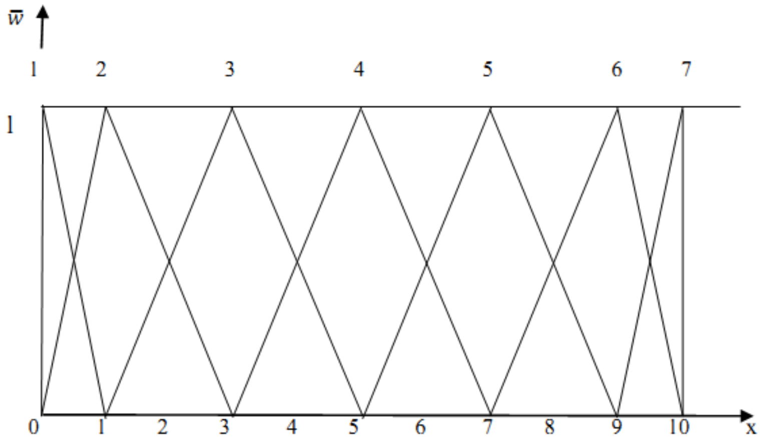


Figure 2. Linguistic variables for ranking options

Table 2. Linguistic variables for assessing the importance of criteria

Important	Fuzzy Number
with very low importance	(0, 0, 0.1)
with low importance	(0, 0.1, 0.3)
somehow with low importance	(0.1, 0.3, 0.5)
Indifferent	(0.3, 0.5, 0.7)
somehow important	(0.5, 0.7, 0.9)
Important	(0.7, 0.9, 1)
very important	(0.9, 1, 1)

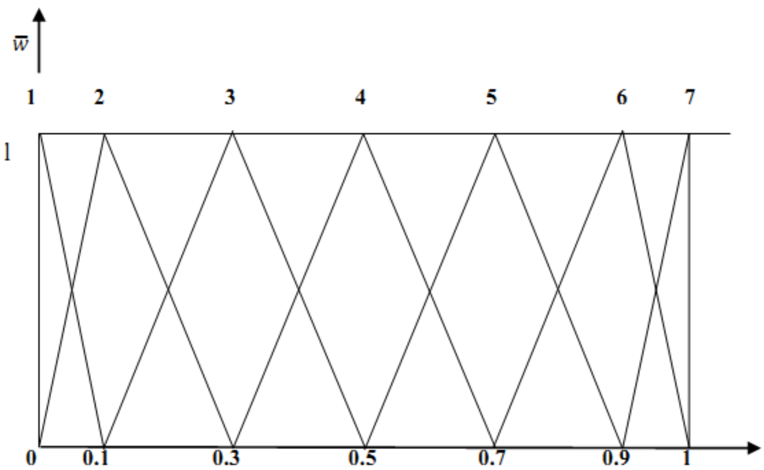


Figure 3. Linguistic variables for assessing the importance of criteria

Case Study

In this paper, Malayer is selected as a case study. This research aims to study on selecting the proper place by considering qualitative criteria and presenting the proper model for Malayer. In this research, we tried to select the optimal place to build a hospital in Malayer by using the ordinary fuzzy decision-making method.

Case Study

Malayer is one of the cities of Hamedan,in Iran. Malayer is located at:

Latitude: 34°07' to 34°13' Longitude: 48°48' to 48°52'

Figure 4. Malayer Position

Malayer population is 287982 and it covers 5210 km^2 land. Malayer involves five towns that studied town is Malayer. In this method, by using oral variables, parameters are transformed into fuzzy parameters. Five parameters are used to build a fuzzy inference engine that are access to main roads, distance to other hospitals, population density, distance to industrial centers, and distance to military centers. These criteria are similar to the criteria used by other relevant works[10,18-21] . These criteria are presented in the following. It is important to state that this model has the ability to develop and to adopt any parameter to increase accuracy.

C_1 : Access to Main Roads[18]
C_2:Distance to other Hospitals[19]
C_3:Population Density[10]
C_4: Distance to Industrial[20]
C_5:Distance to Military[21]

According to the opinions of urban planners of the studied city, the regions shown in Figure 5 are proposed to construct the hospital.

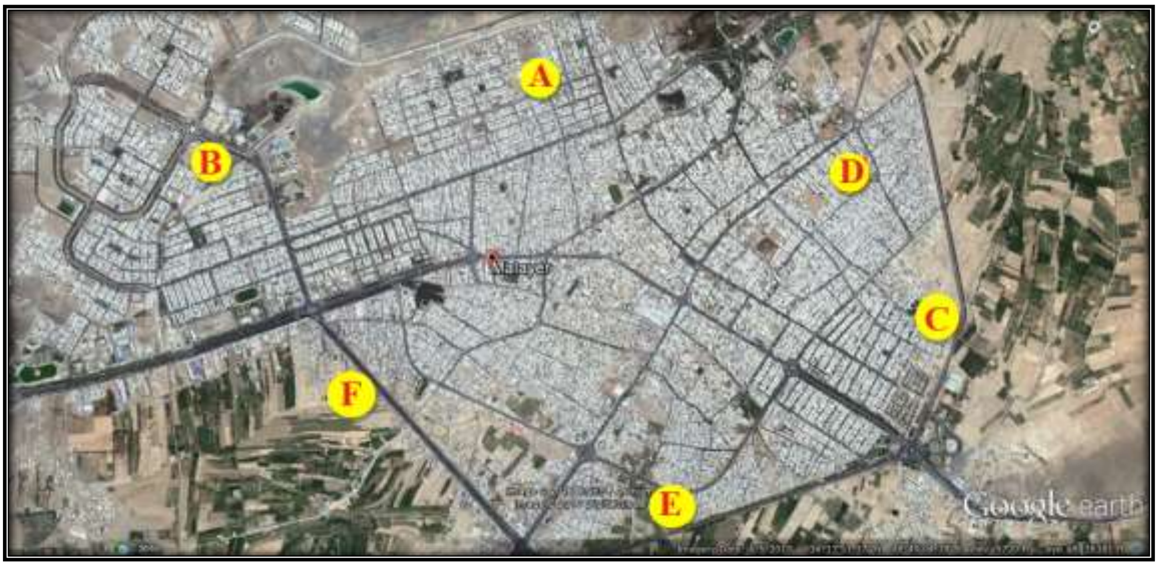


Figure 5. Alternatives position

Table 3. Geographical Coordinate

Location	Longitude (N)	Latitude (E)
A	34°18′26.03″	48°49′34.98″
B	34°19′03.43″	48°48′19.79″
C	34°16′54.87″	48°49′57.04″
D	34°17′24.66″	48°50′10.21″
E	34°17′05.89″	48°48′41.18″
F	34°18′11.97″	48°48′08.55″

Results

Step 1) Assessing the importance of criteria: experts try to define the importance of the criteria.

Table 4. Assessing the importance of criteria

Criterion	Determiner (D_1)	Determiner (D_2)	Determiner (D_3)
C1	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)
C2	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)
C3	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.7, 0.9, 1)
C4	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.3, 0.5, 0.7)
C5	(0.7, 0.9, 1)	(0.5, 0.7, 0.9)	(0.5, 0.7, 0.9)

Step 2) Criteria ranking: experts try to define the importance of criteria for each region.

Table 5. Options ranking

	C1			C2			C3			C4			5		
	D1	**D2**	**D3**	**D1**	**D2**	**D3**	**D1**	**D2**	**D3**	**D1**	**D2**	**D3**	**D1**	**D2**	D3
A	6	6	5	3	4	3	7	5	7	5	4	4	3	3	**4**
B	3	3	4	3	4	3	2	3	5	2	1	3	6	6	**5**
C	3	3	5	6	7	6	4	4	6	3	2	4	5	4	**3**
D	2	2	3	4	4	4	6	6	6	6	5	6	7	6	**7**
E	5	5	6	6	7	7	6	3	4	5	4	6	2	1	**2**
F	5	3	5	4	3	3	2	2	4	5	4	5	5	4	**1**

Table 6. Options ranking

Criterion	Location	D1	D2	D3
C1	**A**	(7, 9, 10)	(7, 9, 10)	**(5, 7, 9)**
	B	(1, 3, 5)	(1, 3, 5)	**(3, 5, 7)**
	C	(1, 3, 5)	(1, 3, 5)	**(5, 7, 9)**
	D	(0, 1, 3)	(0, 1, 3)	**(1, 3, 5)**
	E	(5, 7, 9)	(5, 7, 9)	**(7, 9, 10)**
	F	(5, 7, 9)	(1, 3, 5)	**(5, 7, 9)**
C2	**A**	(1, 3, 5)	(3, 5, 7)	**(1, 3, 5)**
	B	(1, 3, 5)	(3, 5, 7)	**(1, 3, 5)**
	C	(7, 9, 10)	(9, 10, 10)	**(7, 9, 10)**
	D	(3, 5, 7)	(3, 5, 7)	**(3, 5, 7)**
	E	(7, 9, 10)	(9, 10, 10)	**(9, 10, 10)**
	F	(3, 5, 7)	(1, 3, 5)	**(1, 3, 5)**
C3	**A**	(9, 10, 10)	(5, 7, 9)	**(9, 10, 10)**
	B	(0, 1, 3)	(1, 3, 5)	**(5, 7, 9)**

	C	(3, 5, 7)	(3, 5, 7)	**(7, 9, 10)**
	D	(7, 9, 10)	(7, 9, 10)	**(7, 9, 10)**
	E	(7, 9, 10)	(1, 3, 5)	**(3, 5, 7)**
	F	(0, 1, 3)	(0, 1, 3)	**(3, 5, 7)**
C4	A	(5, 7, 9)	(3, 5, 7)	**(3, 5, 7)**
	B	(0, 1, 3)	(0, 0, 1)	**(1, 3, 5)**
	C	(1, 3, 5)	(0, 1, 3)	**(3, 5, 7)**
	D	(7, 9, 10)	(5, 7, 9)	**(7, 9, 10)**
	E	(5, 7, 9)	(3, 5, 7)	**(7, 9, 10)**
	F	(5, 7, 9)	(3, 5, 7)	**(5, 7, 9)**
C5	A	(1, 3, 5)	(1, 3, 5)	**(3, 5, 7)**
	B	(7, 9, 10)	(7, 9, 10)	**(5, 7, 9)**
	C	(5, 7, 9)	(3, 5, 7)	**(1, 3, 5)**
	D	(9, 10, 10)	(7, 9, 10)	**(9, 10, 10)**
	E	(0, 1, 3)	(0, 0, 1)	**(0, 1, 3)**
	F	(5, 7, 9)	(3, 5, 7)	**(5, 7, 9)**

Step 3) Forming the decision matrix and criteria weight vector.

Example for Criterion 1, Location A:

$$\left(\mathrm{Min}(5,7,7), \frac{7+9+9}{3}, max(10,10,9)\right) = (5,8.33,10)$$

Table 7. Forming the decision matrix and criteria weight vector

		C1	C2	C3	C4	C5
	Weight	**(0.5, 0.766, 1)**	**(0.5, 0.76, 1)**	**(0.5, 0.83, 1)**	**(0.5, 0.766, 1)**	**(0.5,0.76, 1)**
Location	A	(5, 8.33, 10)	(1, 3.66, 7)	(5, 9, 10)	(3, 5.66, 9)	**(1, 3.66, 7)**
	B	(1, 3.66, 7)	(1, 3.66, 7)	(0, 3.66, 9)	(0, 1.33, 3)	**(5, 8.66, 10)**
	C	(1, 4.3, 5)	(7, 9.33, 10)	(3, 6.33, 10)	(0, 3, 7)	**(1, 5, 7)**
	D	(0, 1.66, 5)	(3, 5, 7)	(7, 9, 10)	(5, 8.33, 10)	**(7, 9.66, 10)**
	E	(5, 7.66, 10)	(7, 9.66, 10)	(1, 6.33, 10)	(3, 7, 10)	**(0, 0.66, 3)**
	F	(1, 5.66, 9)	(1, 3.66, 7)	(0, 2.33, 7)	(3, 6.33, 9)	**(3, 6.33, 9)**

Step 4) Forming the fuzzy decision matrix without a scale.

$$\tilde{r}_{ij} = \left[\frac{a_{ij}}{d_j}, \frac{b_{ij}}{d_j}, \frac{c_{ij}}{d_j}\right]$$

Table 8. Fuzzy decision matrix without a scale

	C1	C2	C3	C4	C5
A	(0.5, 0.86, 1)	(0.1, 0.36, 0.7)	(0.5, 0.9, 1)	(0.3, 0.56, 0.9)	**(0.1, 0.36, 0.7)**
B	(0.1, 0.36, 0.7)	(0.1, 0.36, 0.7)	(0, 0.36, 0.9)	(0, 0.13, 0.3)	**(0.5, 0.86, 1)**
C	(0.1, 0.43, 0.5)	(0.7, 0.93, 1)	(0.3, 0.63, 1)	(0, 0.3, 0.7)	**(0.1, 0.5, 0.9)**
D	(0, 0.16, 0.5)	(0.3, 0.5, 0.7)	(0.7, 0.9, 1)	(0.5, 0.83, 1)	**(0.7, 0.96, 1)**
E	(0.5, 0.76, 1)	(0.7, 0.96, 1)	(0.1, 0.63, 1)	(0.3, 0.7, 1)	**(0, 0.06, 0.3)**
F	(0.1, 0.56, 0.9)	(0.1, 0.36, 0.7)	(0, 0.23, 0.7)	(0.3, 0.63, 0.9)	**(0.3, 0.63, 0.9)**

Step 5) Forming a weight-bearing fuzzy decision matrix without a scale.

Table 9. Weight-bearing fuzzy decision matrix without a scale

	C1	C2	C3	C4	C5
A	(0.25, 0.65, 1)	(0.05, 0.27, 0.7)	(0.25, 0.74, 1)	(0.15, 0.42, 0.9)	**(0.05, 0.27, 0.7)**
B	(0.05, 0.27, 0.7)	(0.05, 0.27, 0.7)	(0, 0.29, 0.9)	(0, 0.09, 0.3)	**(0.25, 0.65, 1)**
C	(0.05, 0.32, 0.5)	(0.35, 0.7, 1)	(0.15, 0.52, 1)	(0, 0.22, 0.7)	**(0.05, 0.38, 0.9)**
D	(0, 0.12, 0.5)	(0.15, 0.38, 0.7)	(0.35, 0.74, 1)	(0.25, 0.63, 1)	**(0.35, 0.72, 1)**
E	(0.25, 0.57, 1)	(0.35, 0.72, 1)	(0.05, 0.52, 1)	(0.15, 0.53, 1)	**(0, 0.04, 0.3)**
F	(0.05, 0.42, 0.9)	(0.05, 0.27, 0.7)	(0, 0.19, 0.7)	(0.15, 0.47, 0.9)	**(0.15, 0.47, 0.9)**

Step 6) Forming the fuzzy ideal and ideal counter solution.

$$\tilde{V}_1^* = \begin{pmatrix} max(1, 0.7, 0.5, 0.5, 1, 0.9), \\ max(1, 0.7, 0.5, 0.5, 1, 0.9), \\ max(1, 0.7, 0.5, 0.5, 1, 0.9) \end{pmatrix} = (1,1,1)$$

$$\tilde{V}_1^- = \begin{pmatrix} min(0.25, 0.05, 0.05, 0, 0.25, 0.05), \\ min(0.25, 0.05, 0.05, 0, 0.25, 0.05), \\ min(0.25, 0.05, 0.05, 0, 0.25, 0.05) \end{pmatrix} = (0,0,0)$$

$$A^* = [(1,1,1), (1,1,1), (1,1,1), (1,1,1), (1,1,1)]$$

$$A^- = [(0,0,0), (0.05,0.05,0.05), (0,0,0), (0,0,0), (0,0,0)]$$

Step 7) Determining the interval of each option from the ideal and counter-ideal solution (S_1^-, S_1^*) and the similarity index.

$$C_{1,} A_{1} = \sqrt{\frac{1}{3}[(0.25-1)^2 + (0.65-1)^2 + (1-1)^2]} = 0.5$$

Table 10. Interval between each option and the ideal solution for each criterion

	C1	C2	C3	C4	C5	Interval values of an ideal solution
d(A, A*)	0.5	0.71	0.45	0.59	0.71	2.96
d(B, A*)	0.71	0.71	0.71	0.84	0.47	3.44
d(C, A*)	0.73	0.41	0.56	0.75	0.65	3.1
d(D, A*)	0.82	0.63	0.4	0.48	0.4	2.73
d(E, A*)	0.5	0.4	0.61	0.56	0.89	2.95
d(F, A*)	0.64	0.71	0.76	0.58	0.58	3.27

Table 11. Interval between each option and the counter-ideal solution for each criterion

	C1	C2	C3	C4	C5	Interval values of antis ideal solution
d(A, A-)	0.7	0.39	0.73	0.57	0.43	2.82
d(B, A-)	0.43	0.39	0.54	0.18	0.7	2.24
d(C, A-)	0.34	0.68	0.65	0.42	0.56	2.6
d(D, A-)	0.29	0.64	0.74	0.69	0.73	3.09
d(E, A-)	0.68	0.69	0.65	0.65	0.17	2.84
d(F, A-)	0.57	0.39	0.41	0.59	0.59	2.55

Table 12. Interval values between ideal solution and similarity index for each option

	A	B	C	D	E	F
Interval values of ideal solution	2.96	3.44	3.1	2.73	2.95	3.27
Interval values of antis ideal solution	2.28	2.24	2.6	3.09	2.84	2.55
similarity index	0.565	0.6	0.54	0.46	0.5	0.561

Step 8) Ranking options: the options according to the above calculations can be ranked as below.

$$B > A > F > C > E > D$$

Discussion

Findings show that, since many factors are effective for selecting the best option, so traditional location theories cannot adopt all criteria in the location process. On the other hand, as you saw in this research, the geographical information systems, having many analytical abilities in the field of space-position analysis, enables us to analyze many kinds of information and is capable of combining all parameters that are important in the location of service centers. In the location of every service center like a hospital, different factors and criteria are effective and based on the importance level of each criterion (applications and indicators), and distance to other service centers, decision must be made. Considering these factors, we can almost be sure about the decision.

Conclusion

One of the main problems in planning is to know enterprise abilities. Since there are several different problems and complexities in environmental factors, decision-making and selecting the proper policy to do it must be performed by considering all effective factors. In this regards, multi-criteria decision-making techniques provides the best choice by using several criteria. In this research, we have tried to evaluate building a hospital in the several possible locations in Malayer using scientific standard criteria and rank them in order to define proper plans for future development. In this regards, five parameters includes main roads, distance to other hospitals, population density, distance to industrial centers, and distance to military centers were used to build a fuzzy inference engine. These parameters were combined by ordinary fuzzy TOPSIS and the final plan that calculates the utility level of each point for building a hospital was defined. The results indicates that constructed hospitals in Malayer do not match with a position-selecting criteria. Also, this important point shown by this research was some regions of the town have no health service, while the citizens placed in other regions receive more suitable services. Furthermore, as shown in the results, the number of hospitals needed at the moment for Malayer is six, and city officials can use these points to eliminate shortcomings in this area, after comparing the results with real-world facts.

Abbreviations

GIS : Geographical Information System
FAHP : Fuzzy Analytical Hierarchy Process
MODM: Multi-Objective Decision-Making
MCDM: Multi Criteria Decision-Making
TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution

Competing Interests

The authors declare no competing interest.

Authors contributions

In this research, using the fuzzy analytical hierarchy process, building a hospital in the several possible locations in Malayer is evaluate by scientific standard criteria and rank them in order to define proper plans for future city development.

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