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Hospital Location in the Southern Fars Province by Using Multi Criteria Decision Making Techniques

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Abstract

The growing urban population and the priorities of the government in a better and faster service to the community, the importance of identifying the most appropriate location for the construction of new hospitals will be felt more than ever. Because of many accidents in the southern region of Fars province, there is very high demand for medical services. On the other hand, the lack of well-equipped hospitals in the region, the construction of a new hospital in the region is a priority construction projects. The present study considers Lamerd city, Mohr and Galle Dar as options to candidate for this purpose. Based on various criteria such as the concentration of population, the rate of accidents, road quality, access to the provincial capital, the region climate defines convenient location. Because of the structure and nature of the multi-criteria problem, we use Analytic Hierarchy Process method, TOPSIS method, Simple Additive Weighted method and the ELECTERE method. When conflicting decision criteria make it difficult to choose the options, Multi Attribute Decision Making techniques are used. Based on the results of all four methods, Lamerd city is determined as the most appropriate location.

Keywords: location, hospital, AHP method, TOPSIS method, ELECTERE method, Simple Additive Weighted method, Southern Fars province.

Introduction

The rapid population growth results in greater demand of therapeutic services. For this purpose, it is necessary to establish new health care centers and hospitals. The south area of Fars Province includes cities of Lamerd, Mohr, and Galleh Dar. The statistics of accidents in the last year has been 806 persons that unfortunately, some of these persons were died because of the distance of these cities from the center of province and the lack of a well-equipped hospital. For this reason, establishing a well-equipped hospital in this area is among the developmental priorities. Owing to the multi-criteria structure and nature of decisions relevant to selecting the location of hospital, decisions require purposeful plans largely influenced by individuals' opinions. Therefore, it is indispensable to decision-makers to use tools for proper decision-making.

The process of planning is an effort to establish an appropriate framework in which the planner can make attempt to reach the optimum solution. After determining the general goals, statement of purposes, planning and compiling different choices to achieve goals of planning, "evaluation" would be performed to select the desirable or optimum choice based on the relative merit of each choice. Criteria are usually used to measure the relative merit of each choice. Criteria such as distance from the center of province, greater population dense, quality of road, rate of accidents and the climate of area should be regarded so as to make decision concerning the superiority of different lands. In such conditions that criteria are not consistent (it means a city, which is better in terms of accessing the province, may be worse in terms of population dense) decisions should be made in a multi-dimensional space. In such conditions, multi-criteria evaluation methods are used due to the fact that in these methods, each criterion is a separate axis or dimension.

Various researches have been conducted in selecting the location of hospital up to now that most of them have used Multi-Criteria Decision Making (MCDM) technique. Tavfiqi et al. (2010)have investigated the factors affecting the selection of an appropriate location of hospital in operational areas by using Analytic Hierarchy Process (AHP). Yaghoobi et al. (2011)dealt with the selection of the location of hospital in Esfahan by using criteria affecting patients' preference. Vahidinia et al. (2009)used Fuzzy AHP and GIS techniques to select the optimum location of hospitals in the urban areas of Tehran depending on the area population, travelling time and cost. Wu (2007)used AHP method and the sensitivity analysis of criteria to select the location of hospital in Taiwan. This investigation provides analysts with valuable results in standardizing the process of selecting hospitals. Soltani et al. (2011) used two-phase Fuzzy MCDM and GIS in selecting the location of hospital in Shiraz. Chatterjee (2013)used AHP approach to select the location of hospital in India.

In this paper, a specified application of MCDM techniques in the urban and areal planning is investigated in order to select the appropriate location. Results show that these techniques can have desirable application in studying issues concerned with urban and areal planning and settling through flexibility, employing quantitative and qualitative criteria simultaneously and capacity of investigating compatibility in judgments. In the present paper, AHP, TOPSIS, ELECTERE and SAW (Simple Additive Weighted) were used for this purpose. Cities of Lamerd, Mohr, and Galleh Dar as the choices for establishing hospitals and factors of distance from the center of province, grater population dense, road quality, rate of accidents, climate of area and the distance of cities from each other as decision-making criteria were taken into consideration

Research Method

Study Area

Lamerd City is located at the southernmost point of Fars Province with the area of 3932 square kilometers, at longitude 52-54 and latitude 27-28. It is located precisely at 405 km and 100 km from the cities of Shiraz and Mohr, respectively and has 4.6% of the total area of the province. According to the statistics, its population and rate of annual accidents are 82169 and 336 people, respectively.

Mohr City is located between the orbits of 52 degrees and 45 minutes of north latitude and 27 degrees and 42 minutes of south latitude from the Greenwich Meridian with the area of 2354 square kilometers. It is also located in the southern extremity of Fars Province at the distance of 305 km from the center of the province. This city is located between the cities of Lamerd and Galleh Dar that its distance from Galleh Dar is 55 km. According to the statistics, its population and rate of annual accidents are 56817 and 196 people respectively.

Galleh Dar is a city in the south of Fars Province and on the border of Fars Province and Bushier Province. This city is located between the orbits of 49 degrees and 36 minutes of north latitude and 22 degrees and 35 minutes of south latitude from the Greenwich Meridian with the area of 1234 square kilometers. Its distance from the center of the province is 250km. According to the statistics, its population and rate of annual accidents are 32451 and 274 people respectively.

Effective Criteria

Various criteria and factors play role in identifying and selecting the location of establishing a new hospital that each of them has particular importance and sets some limits in the selection. The center of province, grater population dense, road quality, rate of accidents, climate of area and the distance of cities from each other can be mentioned among these criteria.

Methodology

In the present research, four techniques common from the multi-criteria decision-making have been attempted to be used in the locating issue including AHP, TOPSIS, ELECTRE and SAW in order to reach correct and logical results.According to applying different methods, some data are also considered in accordance with them to locate the establishment place of hospital which are processed in the software Expert Choice, Solver TOPSIS and MCDM-Engine and finally, the appropriate location is determined.

Analytic Hierarchy Process (AHP)

In fact, AHP is a comprehensive method to solve multi-criteria problems and this system is employed to solve strategic problems both in reality and in theory. AHP in 1980 was suggested by Saaty as the wide analysis tool in modeling issues such as political, economic, social and educational sciences and the value of a group of issues was founded on the basis of pairwise comparison. This method is from the most comprehensive designed systems for MCDM, because it formulates problems hierarchically and can consider different quantitative and qualitative criteria in the problem.

The first phase in AHP is analyzing decision-making problem hierarchically that includes the most important elements of decision-making problem. In making a hierarchy, high level is a decision-maker's ultimate goal. Then the hierarchy goes down from the whole to more details until reaches to a level of features. This is the level in which decision-making choices are evaluated as the lowest level of hierarchy opposite to it. Each level should be attached to its previous higher level. The process of AHP can be delineated and implemented in four levels as follows:

- Declination and description of hierarchy
- Pairwise comparison of hierarchical elements
- Calculation of the weights of the relative importance of criteria
- Compatibility of system

The questionnaire of pairwise comparisons is the dual combination of all criteria and choices. Thus, if the number of criteria and sub-criteria to be high, it increases the number of pairwise comparisons making the questionnaire such longer that it may confuse the respondents in comparisons or they may not fill out the comparisons carefully and therefore, the rate of compatibility may increase.

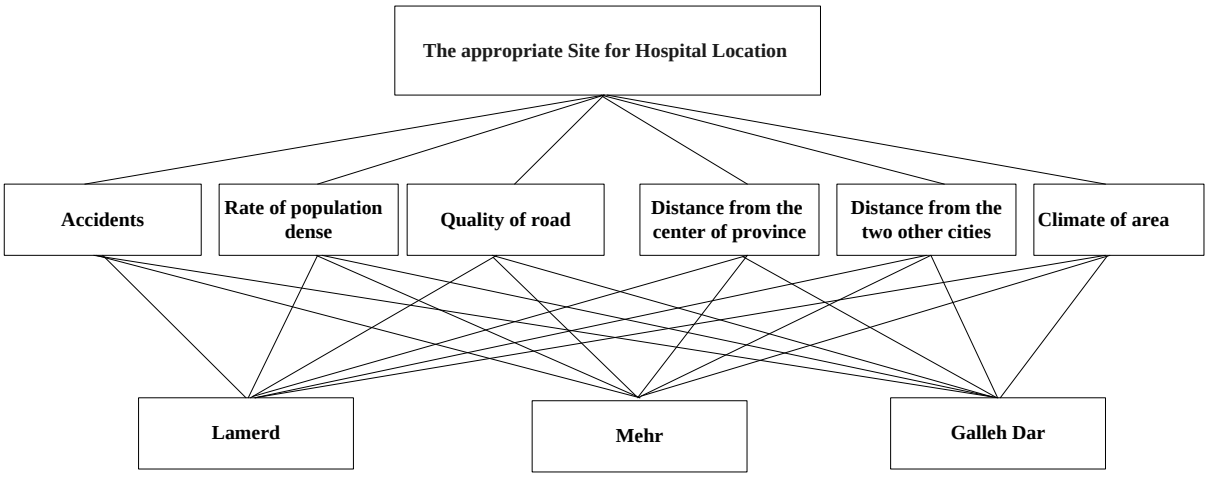


Figure 1: AHP – Establishing the hierarchy of the intended locating

Figure 1 shows the hierarchy of the criteria. In the next step, after making a hierarchy for the criteria, the questionnaire was compiled and some experts' view in this regard was considered as matrices of pairwise comparison to determine the importance of the degree of criteria in relation to each other and according to Table 1, each criterion was considered in the scale from 1 to 9.

Table 1: Important values for pairwise comparison

Score	Preferences (oral judgment)	Descriptions
1	Equally Preferred	Both will have equal effect on the goal
3	Moderately Preferred	Experience or arbitration prefers one to another
5	Strongly Preferred	Strong experience or arbitration prefers one to another
7	Very Strongly Preferred	In practice, the priority of one over another is confirmed
9	Extremely Preferred	The priority of one over another is at its maximum rate
2, 4, 6, 8	Between	-----

Comparison of decision-making elements in pairwise form

Pairwise comparison is a basic method to test AHP. This method reduces the complexity of the model significantly, because only two components are investigated at a time. This method is performed in three phases:

a. Compilation of comparison matrix in each hierarchy started from the top and continued to the bottom

b. Calculation of the weights of each element of hierarchy

c. Estimation of Compatibility Ratio (CR)

Consider:

x1= Accidents

x2= Rate of populationdense

x3=Quality of road

x4=Distance from the center of province

x5= Distance from the two other cities

x6= Climate of area

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	0.44	0.63	0.37	0.27	0.36	0.27
X_2	0.11	0.16	0.37	0.22	0.24	0.17
X_3	0.15	0.05	0.12	0.22	0.24	0.17
X_4	0.09	0.04	0.03	0.05	0.03	0.09
X_5	0.15	0.08	0.06	0.22	0.12	0.27
X_6	0.07	0.04	0.03	0.03	0.02	0.04

Figure 2: Pairwise comparison of the criteria in Expert Choice Software

The priority of the criteria in relation to each other was determined according to the questionnaire Shiraz Namazi Hospital and Traffic Office and the following results were obtained by using Expert Choice Software.

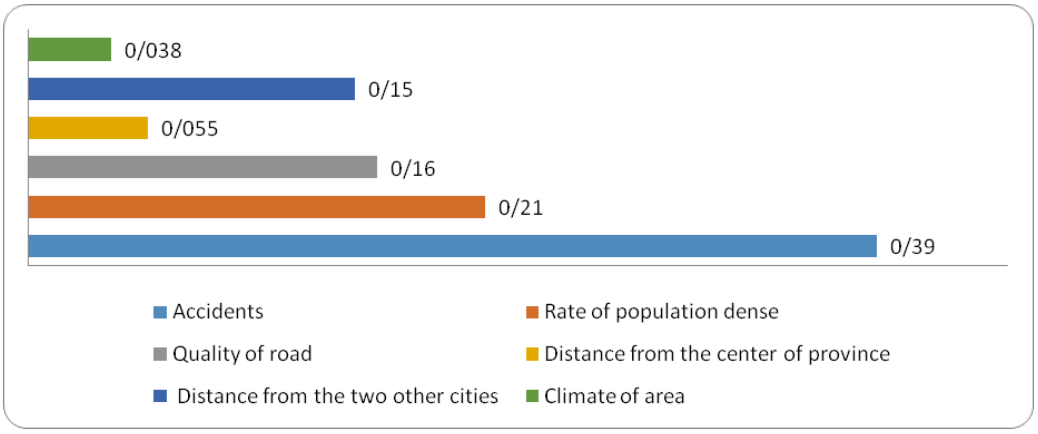
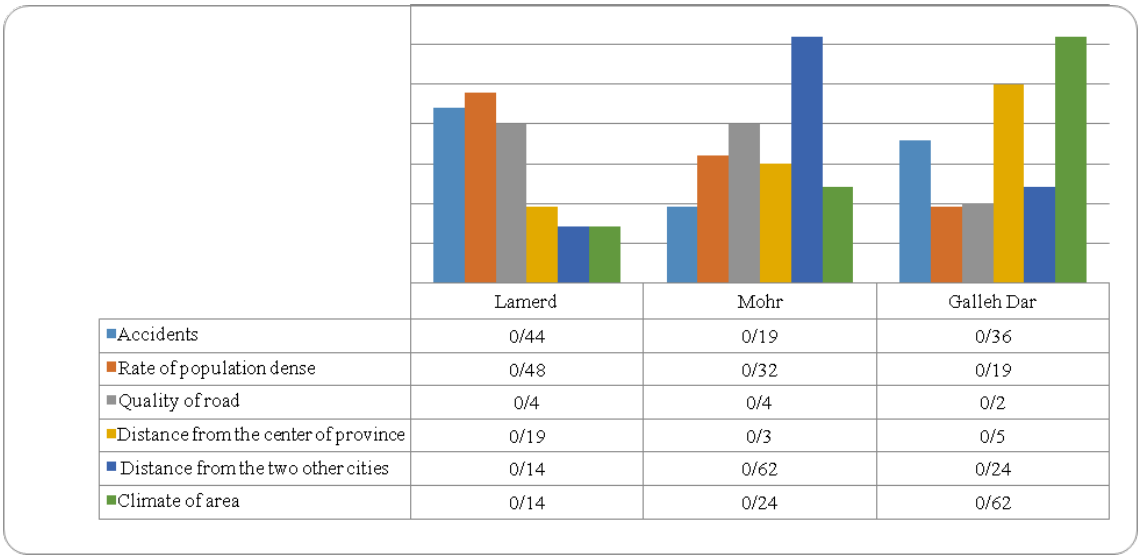


Figure 3: Calculated weight of each criterion



	Lamerd	Mohr	Galleh Dar
Accidents	0/44	0/19	0/36
Rate of population dense	0/48	0/32	0/19
Quality of road	0/4	0/4	0/2
Distance from the center of province	0/19	0/3	0/5
Distance from the two other cities	0/14	0/62	0/24
Climate of area	0/14	0/24	0/62

Figure 4: Weight of criteria in the candidate choices

In AHP model, the priority of each choice is measured according to the product sum of the priority of that choice based on the different criteria.

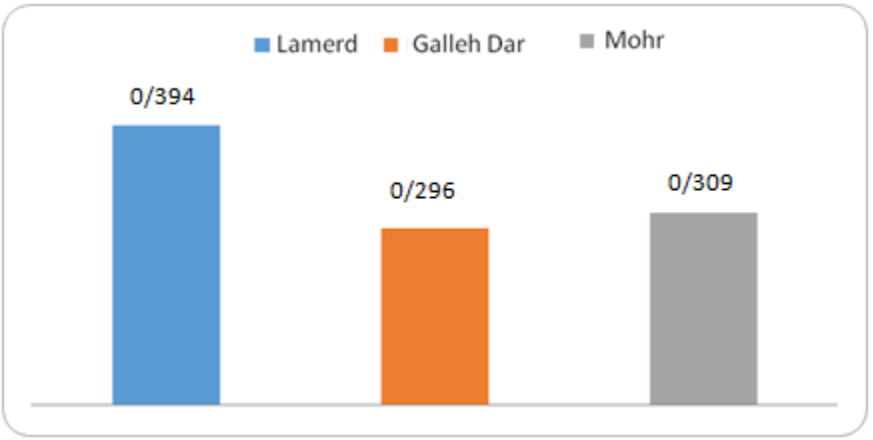


Figure 5: Final score of the suggestive location in Expert Choice

According to the software results, Lamerd city is chosen as the best location for establishing hospital in the southern area of Fars with 0.394 score

TOPSIS Method

In this method, in addition to considering the distance of a choice from the ideal point, its distance from the negative ideal point is also considered so that the chosen option should have the shortest distance from the ideal solution and at the same time has the longest distance from the negative ideal solution. The fundamental realities of this method are as follows:

A. The desirability of each index should be consistently increasing or decreasing (as "is" is higher, desirability is higher or vice versa) so that the best available value of an index indicates its ideality and the worst available value of an index would be the negative ideal for it.

B. The distance of an option from the ideal or negative ideal may be calculated in the form of Euclidean distance (from square) or in the form of the total of absolute value of linear distance (known as block distance) that this issue depends on the exchange rate among the indices.

Steps of TOPSIS Method

First step: Normalization
Second step: Multiplying w-vector by decision-making matrix
Third step: Determining positive ideal alternative (A+) and negative ideal alternative (A-)
Fourth step: Calculating separation index (distance)
Fifth step: Calculating closeness value to the ideal solution
Sixth step: Rating alternatives according to the descending order

Results of locating hospital from TOPSIS Method

According to our previous data, the results of Solver TOPSIS Software are as follows:

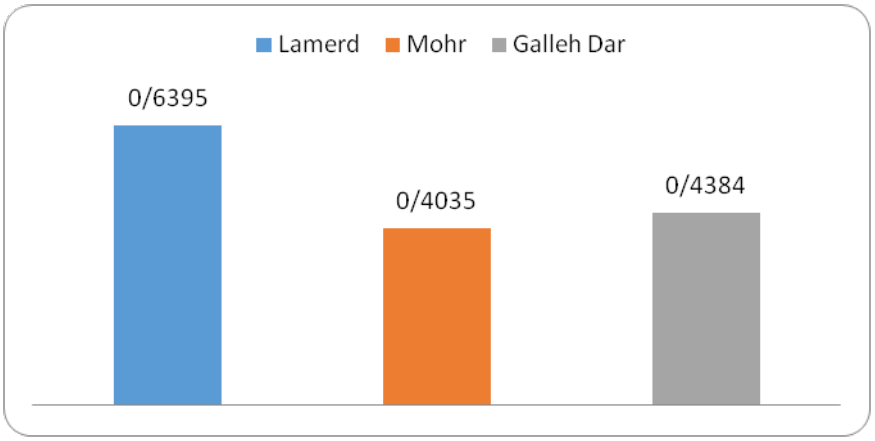


Figure 6: Comparison of choices in TOPSIS

The closeness coefficient of the cities to the ideal choice are as follows:
The closeness coefficient of Lamerd City to the ideal choice: 0.6395
The closeness coefficient of Mohr City to the ideal choice: 0.4035
The closeness coefficient of Galleh Dar City to the ideal choice: 0.4384
According to the method, Lamerd City is considered as the best location.

ELECTRE Method

In this method, a new famous concept called "non-rating" is used instead of rating options so that for example $A_k \rightarrow A_l$ indicates that although options k and 1 have no priority over each other mathematically, DM and risk analyst accept the betterment of Ak over A1. In this method, all

options are evaluated by using non-rating comparisons and ineffective option are eliminated. Pairwise comparisons are founded on the basis of congruence degree of weights and difference degree of the values of weighty evaluation (V_{ij}) and are jointly tested for evaluating options. All of these phases are founded on the basis of a coordinated set and an uncoordinated one that is known as "coordination analysis".

Steps of ELECTRE

First step: converting Decision-making (D) matrix to a descaled matrix

Second step: Forming weighty descaled matrix (V) like TOPSIS method

Third step: Specifying coordinated and uncoordinated sets for each pair of options

Fourth step: Calculating coordination matrix

Fifth step: Calculating uncoordinated matrix

Sixth step: Specifying effective coordinated matrix

Seventh step: Specifying effective uncoordinated matrix

Eighth step: Specifying effective general matrix H

Ninth step: Eliminating low-attractive options so that each column of H that minimally one element is equal to the unit that can be eliminated, because that column is dominated by a row or rows.

Results of Locating Hospital through ELECTRE Method

According to the results of MCDM-Engine Software, the general effective matrix is determined as follows:

$$H=\begin{bmatrix}0 & 1 & 1\\ 0 & 0 & 0\\ 0 & 0 & 0\end{bmatrix}$$

Lamerd City is chosen as the appropriate location based on this method.

SAW Method

SAW Model is one of the simplest methods of multi-criteria decision-making. This method can be used by calculating the weights of indices.

a. Quantifying decision-making matrix

b. Linear descaling decision-making matrix

c. Multiplying descaled matrix by the weights of indices

d. Selecting the best choice

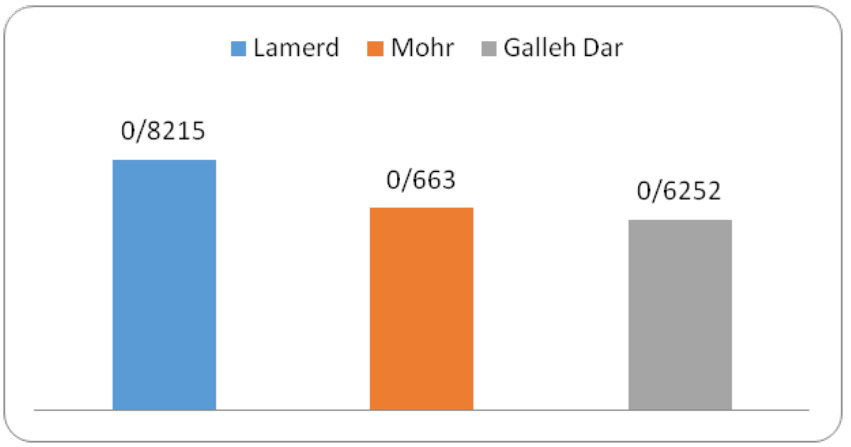


Figure 7: Comparison of choices in SAW

As the results show, Lamerd City is chosen as the best choice based on the SAW Method.

Conclusion

The present analysis has dealt with the determination of the appropriate location for establishing a new hospital in the southern area of Fars Province. Due to the statistics of accidents and remoteness from the center of the province as well as people's need to a well-equipped hospital, three choices were considered as the candidate places including Lamerd City, Mohr City and Galleh Dar City. The six criteria including the rate of accidents, population dense, quality of road, distance from the center of the province, climate of area and the distance of the cities from each other were determined as the effective factors in decision-making. To access the initial data, some questionnaires were distributed in Shiraz Namazi Hospital and Traffic Office and the initial data was determined as the basis of calculation from the results of the questionnaire depending on the experts' view. According to the results, the criteria of the rate of accidents and population rate were determined as the most important criteria. Four techniques namely AHP, TOPSIS, ELECTRE and SAW were used to determine the appropriate location. Using software analyses, all the four methods determine Lamerd City as the best location for establishing the new hospital.

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