Optimum site selection for support centers and health clinics by GIS and DEA (Case study:Tehran,District 16)

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Abstract

Human has been encountered unpredictable incidents from the first and the only way to control the harm of these events is to have a suitable planning before the occurrence of such events. Among the planning constructing support-centers in optimum places is a challenge that urban planners are facing with. The construction is costly, and hence optimum places affect economy as well as health issues. Considering governing factors can result in constructing the sites in optimum places and increase the effectiveness of the sites.
Data Envelopment Analysis (DEA) is a tool to optimize the use of resources. It's simplicity in understanding and performance in addition to its high accuracy and it's wide usage in different fields of science have been the reason for paying attention to it in recent years.
The objectives of this are to identify the governing factors of health centre locations. Due to the data limitations, this paper applies three main factors, namely; population, number of existing support centers and clinics. Data needed were prepared with ArcGIS software and the analysis has been performed in Frontier Analyst environment and ArcGIS. In order to assess the results, a scientific-comparison between the optimum locations and the existing ones has been performed. The study area of this research is in six zones of district sixteen in Tehran. The results showed that in two zones the number of facilities were enough as compared with population.

Key words: DEA, GIS, Health clinics, Site selection, Support centers

1. *Introduction*

Unexpected phenomena always occur in all over the world. In certain places of the world, these phenomena change into crises; yet in some other places, they remain neutral.The difference between these two should be looked for in the preparedness of human to confront phenomena. In fact, whenever human prepares himself to confront the phenomenon, he can stop the phenomenon.Yet, if there is no such preparedness due to any reasons whatsoever, then, crises occur. And sometimes, they defeated human. Therefore, a program for confronting unexpected phenomena is necessary for any organization and/or type of activity. Treatment centers are not excluded and considering their function type and their locations among the first places of referrals can play a vital role in damage remedy.

Treatment centers, especially hospitals are considered among the places, in which, safety is of high importance. The presence of patients in these centers increases the sensitivity of the issue and in addition to preservation of labor force, protection of life and security of the patients and their concomitants are of high importance.

1.1. DEA Model

DEA is one of the non-parametric planning methods, which has grown importance during recent years. (Pardalos, 2002) The "Multi-factor Efficiency Analysis" is used for measuring the relative efficiency of the decision-making units.(Vincova, 2005) This method can be also used for evaluating the performance of schools, hospitals, banks, factories and allocating the resources. .(Talleri, 2000) DEA evaluates the efficiency of the units towards one another without any need for a special functional relation between product factors and the rate of products. DEA concept is very simple and useful. In this method, if all factors are considered fixed, the input is a factor whose increase results in efficiency increase and whose decrease results in efficiency decrease.(Desai, 1990)

In this method, there are certain decision-making units that have some definite values of production factors and outputs.(Allen, 1997) In order to determine and compare the efficiency of decision making units there are different methods, many of which compare the efficiency of a unit with the average of the rest units, while, DEA only compares the efficiency of the under revision unit with that of the best unit.(Jacobs 2006)

In addition, it shows the non-efficiency of other units. The substantial hypothesis of DEA is that if Unit A can produce Y(A) making use of X(A), the rest of units should be efficient as well. Then, Unit A and the rest of units can be mixed together and constitute a combined producer (combination of product factors and their products), which is not embodied and called virtual producer. The objective of achieving the best possible producer is real for each unit. If the performance of the virtual unit is better than that of real unit (that is, it can produce the very amount of products with lower amount of data or produce more products with the very amount of data), it can be then said that the real unit is inefficient. While efficient unit has an efficiency of 1 other has an efficiency below 1.(Alirezaei, 1998)

In the case study conducted in the research, each area is considered a decision making unit. DEA model, which is used in the paper is output-oriented Banker,Charnes and Cooper(BCC) Model. DEA model is divided into two input-oriented and output-oriented models. The objective of the former is to provide improvement course as well as decreased input; and the objective of the latter is to design improvement course with increased outputs.(Dula, 2001) As the objective is to suit more people, the output-oriented model is selected. One of the specifications of DEA model is the relation between the structure of its output to scale. Output to scale can be fixed or variable. Constant Returns to Scale (CRS) means that increase in the rate of input leads to increase in output to the same extent. In Variable Returns to Scale (VRS), increase in output is higher or lower than the ratio of increase in input.(Ghoseiri,2007) This research considers BCC model. The BCC Model is mathematically described as below(Gavami, 2010)

Max μ

$\sum_{j=1}^{n} \lambda_j * x_{ij} \leq x_{i0}$ i=1,..,m

$y_{r0} \leq \sum_{j=1}^{n} \lambda_j * y_{rj}$ r=1,…,s

$$\sum_{j=1}^{n} \lambda_j = 1$$

$\lambda_j \geq 0$ j=1,…,n (1)

Where

J: Index of decision-making unit

I: Input Index

R: Output Index

X_{ijI}: ith input of Decision Making Unit(DMU)

Y_{rj}= rth output of DMU

λ_j: Non-negative weights for DMU

μ: Optimal output amount

This linear planning model will be calculated for n times and for each DMU. For example, DMU_o is selected as an under revision unit.
After selecting a model appropriate for the problem, it is time for selecting input and output indexes. Due to limitation of elements in this research, clinic and support units are considered as outputs.Table 1 is showing selected output and input parameters:

Table 1) Input and Output Indices for DEA Model

Output Index	Input Index	Efficiency
Population	Number of clinics and support centers	Performance Efficiency
Population	Number of clinics and support centers that are located within lower risk	Local Efficiency

	limit	

It is noteworthy that, in performance efficiency, number of clinics and support centers of each area enter as input. Yet, in local efficiency, clinics and support centers are located as described below.

2.Data and Material

In this research, the study case is District 16 of Tehran as shown in Fig. 1. Among the specifications of the district are the existence of railways and South Terminal, which are considered important centers for transportion. They play a salient role in transporting people to all over the world. This area with a population of 308410 has 43 fire stations, 42 hospitals and clinics, 14 gas stations and 6 support centers. It also includes structures with different strengths. The study case measures 1667 km^2.

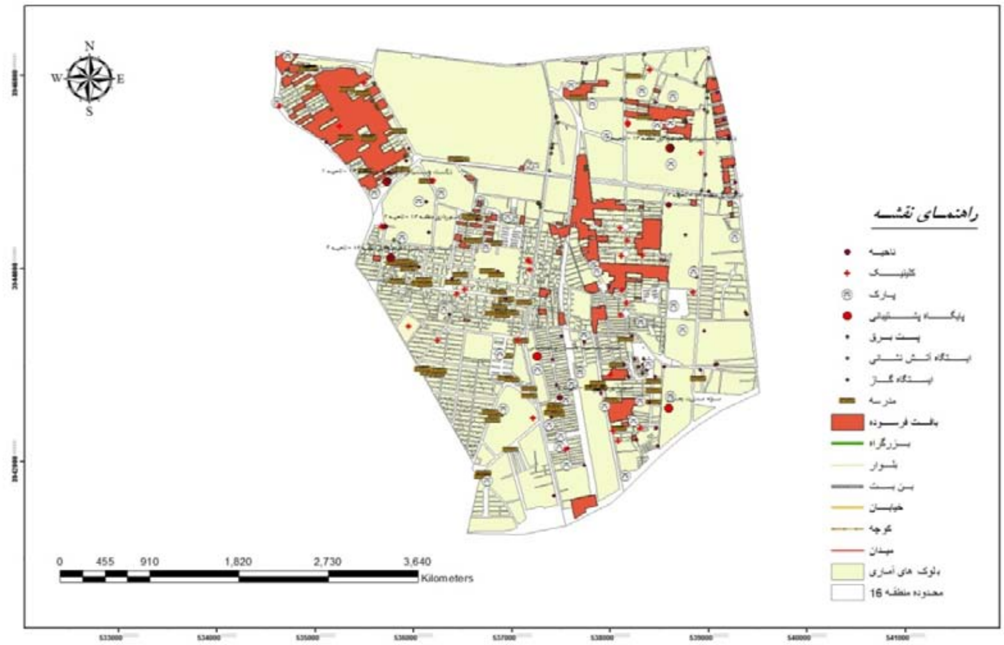

Fig. 1: Study area, District 16 of Tehran City

3.Research Methodology

In this research, the use of GIS is conducted in two stages. First, there is a local database for storing local layers and their descriptive information related to the requirement. In the second stage, the existing GIS local analysis and instruments are used for displaying preparation and provision of appropriate input and output parameters; and DEA model is used for analysis of results.

Our data is divided into two categories:

1. Data related to the orientation of clinics and support centers, electricity post, gas stations and fault position.
2. Statistical data related to the study area such as population. In order to determine the destructive range arising from earthquake, a 500-m buffer is drawn for the fault and two 300-m buffers for electricity posts and gas stations, then, GIS Analyses are used to combine the existing information, and the data resulted from these analyses can be used as input and output of DEA model for evaluating the efficiency.

4.Results and Analysis

4.1.Results of DEA Model for Performance Efficiency:

At first, BCC model is used for calculating the efficiency of 6 areas of district 16 making use of the existing data such as number of clinics and support centers. The objective is to maximize the output, that is, increased population that accesses the facilities of these places. Frontier Analyst solves the model, which is a specialized analysis software. Table 2 is showing selected output and input parameters for six areas and table 3is showing result efficiency for them:

Table 2) Input and Output parameters for six areas

District	Number of Clinics	Number of Support centers	Population
1	4	0	54085
2	8	1	49724
3	8	1	81755
4	4	1	56063
5	5	2	42734
6	4	1	24049

Table 3) The results of DEA model

District	Score
1	100
4	100
3	74.22
5	60.98
6	45.14

2	42.90

Considering the results obtained, Areas 1 and 4 are located efficiently. Area 3 has relatively good efficiency; and this is due to a better equilibrium between the number of clinics and support centers and population.

4.2. Results of Model DEA for Local Efficiency

Table 4 and 5 are showing Input and output parameters for six areas and Results arising from DEA model:

Table 4) Input and output parameters for six areas

District	Number of Clinics	Number of Support centers	Population
1	4	0	54085
2	5	1	49724
3	8	1	81755
4	2	1	56063
5	2	0	42734
6	4	1	24049

Table 5) Results arising from DEA model

District	Score
1	100
5	100
4	100
3	44.38
2	41.39
6	24.35

After analysis of the areas based on statistical patterns, now it is time for discussing local efficiency. As seen, upon local analyses made; three clinics from Area 2, two clinics from Area 4, three clinics and 2 support centers from Area 5 are deducted, and these changes are due to proximity to electricity post or gas stations or fault. Considering this topic, some changes occur in the evaluation of efficiency and therefore area 1, 2 and 4 find appropriate efficiency.

5.Conclusion

The best method for obtaining a comprehensive evaluation of the performance of areas is to compare the results of local and performance evaluation.In contrast to the results of some researches this paper showed that no clear positive or negative relation can be established between local and performance efficiency. On the other hand, an area with high local efficiency may have high or low performance efficiency. The areas with high efficiency for both local and performance view have appropriate location and provide more people with services.Table 6 is showing Local efficiency against performance efficiency:

Table 6) Local efficiency against performance efficiency

District	Local Efficiency	Performance Efficiency	Difference
1	100	100	0
2	41.39	45.14	- 3.75
3	44.38	74.22	- 29.84
4	100	100	0
5	100	60.98	39.02
6	24.35	42.90	- 18.55

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