

Proposed Locations for Optimal Medical Centers Using the Network Analysis Model (Case Study: District Six of Tehran)

Abbas Najafi¹, Saeed Karimi^{2*}, Hamidreza Jafari³, Ehsan Karimimanesh⁴

^{1,4}A graduate student of environmental planning, Faculty of Environment, Tehran University

^{2,3}Assistant professor, Faculty of Environmental Management, Planning and Education, Tehran University

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ABSTRACT

Nowadays, with population growth, the number of hospitals to consider public health is quite important. The optimal distribution of hospitals in order to observe the principle of access to justice for all segments of society, is one of the essential principles in the city. Community health needs access to medical and hospital services. Correct site selection which is one of the main goals of urban planning in the field of public health should be set in such a way that people spend a little time to access health centers. In this study, first the layers which determine the appropriate locations to build hospitals in the district six are extracted. The layers have been consulted by experts as well. After, the final weight of the layers obtained with the expert choice. Then, appropriate distances for individual layers are considered by GIS software. Afterward, layers multiply in the final weight and overlap using FUZZY-WLC. As a result, the optimal locations selected. Finally, Suggested locations for the regions which have the least possible time to achieve hospitals in an intervals of 3, 5 and 10 minutes are selected using Network Analysis. At the end, 6 new hospital centers were added to the 10 old hospital centers. These new hospital locations will provide more health facilities to the people in the region in the shortest possible time.

KEY WORDS: Health use, GIS, expert choice, Network analysis

1. INTRODUCTION

The beginning of the 21st century has been associated with great developments in human life. The developments in the context of globalization on economic, cultural and social relationships affect human life and the reflection of these effects revealed especially in the cities. Without a doubt, the most important feature of this century is opening up new perspectives in human settlements and unprecedented concentration of population in large cities and world cities (8). So population growth and rapid urbanization over the past decades have had adverse effects such as inconvenient physical development of cities, creating marginal neighborhoods, poverty and declining standards of living, lack of service centers and finally inequalities in cities opportunities. Urbanization and specific problems of urbanization, more and more represent demand for effective strategies to optimize citizen's life. Without hesitation the most important effects of rapid urbanization and uncontrolled growth of urban space are the disruption of distribution system services and service system failure [16]. Today, living in cities, due to the complex structure of spatial-physical and socio-economic activities, expanding social and economic division of labor and the growing needs for culture, leisure and social citizens, more than any other period related services [19]. Part of the services constitute health related and individual citizen's services provided by hospitals or health centers located in areas inside the city. Today, growing population in urban areas has increased the demand for new hospitals. It should be observed that the creation of new service centers is costly so determining the optimal location of these centers which all citizens benefit from is important [10]. Choose the right places for hospitals in the region required city planning. One of the main goals of urban designers is creating urban environment in such a way that all citizens have easy access to urban services because accessibility is an indicative of the quality of the urban environment [14]. Therefore, we can use urban planning to examine optimal locations for human health. In this study public health for the individual considered as a basic human rights and it should be considered seriously by governments and administrators. According to International organizations including the World Health Organization, right to health is the main purpose of a communities and the health benefits is the basic need of the sustainable development and one of the main bases of social justice [4]. Equal access to health services including hospital services is a fundamental right of all human beings. In this context, inequality in the spatial distribution of health resources will hard the access to health services [3] The

*Corresponding Author: Saeed Karimi, Assistant professor, Faculty of Environmental Management, Planning and Education, Tehran University.

most important health care centers are hospitals which directly involved in providing health of citizens and responsible for public health promotion [24] The idea of hospital site selection carried out by Leslie Burke Myhyv in yerak College London. His main work was developed and evolved of spatial model to predict the flow of patients to the hospital as a result of changes in supply and demand for non-hospital services [16]. By looking at demographic trends and urban development, we considered regional level hospitals in different areas. For example, by studying in the district six of Tehran, increase population in recent years require to increase the number of hospitals for health and welfare of people in this area. To be most effective these hospitals should be located in a place that local people spend least amount of time to get to these health centers.

1.2. Theoretical

In developing countries, because of the lack of information, skills and expertise in the field of health care programs most of the resources are allocated unevenly. In this regard, the establishment of health centers in public places can be considered as an indicator of access to health care [5]. From the perspective of urban ecology, access to health and care for all people in all neighborhoods are important criteria to a healthy society. It can be said that appropriate access to health services play an important role in promoting health, security and safety of the community. On the other hand, it is an important indicator to get social justice. Although providing health services in the cities have long history however, in the field of site selection of medical centers and services, there is no long term history. Experience of these studies goes back to the 1970s. In 1973 the UK Department of Health and Social Welfare drew its attention on developing health care centers. And Since then, studies in this area began and during the years 1980-1982. These studies were followed by Austria. The idea of hospital site selection carried out by Leslie Burke Myhyv in yerak College London. His main work was developed and evolved of spatial model to predict the flow of patients to the hospital as a result of changes in supply and demand for non-hospital services [16]. Moreover, it can be noted that the article written by tag Goetz at the University of Kansas titled as the application of GIS in emergency management operations in the Journal of Urban Planning and Development published in September 2000 or an article titled green spaces or useful places (the role of private power in Johannesburg urban parks) from Rovass Macy's [15]. Network is a collection of related linear effects through which materials, goods and people are transported or takes place along the data transfer. Therefore, the definition of Network Analysis can be said that Network models in GIS is a symbol of the components and counterparts features in the real world [17].

1.3. Research background

Although providing health services in the cities have long history. But in the field of site selection of medical centers and services, there is no long term history. Experience of these studies goes back to the 1970s. In 1973 the UK Department of Health and Social Welfare drew its attention on developing strategic health care centers. Since then, studies in this area began and during the years 1980-1982 These studies were followed by Austria [22]. Albert et al (2005) observed use of application of GIS in Research studies related to health services, the aim of which is divided into two portions:

1. Collecting and summarizing the existing literature on GIS and health services research.
2. Contribute to understanding of GIS in research of health services, including Distribution of doctors, hospitals and other medical facilities that in this regard, provide rich information about the use of GIS in health services research, researchers and practitioners.

Other surveys done by Fybz and Vlaft (1995), Cooley et al (1995), Gadland (1961), Lavy lynd kuyst (1995), Walsh et al. (1997), Perry and Gessler (2000), Luo and Wang (2003), Curtis (2004), Varnakvyda and Messina (2005), Murad (2007), Hare and Barkus (2007) have also been carried out [16].

Other research and studies are conducted about site selection urban centers as follows:

- 1- Application of GIS in the analysis, F.A Pour Master's thesis, titled network and space spatial distribution of pharmacies, Case study: district 6 of Tehran Tarbiat Modarres University, 1380.
- 2- Jafar Shali's paper titled geography research Published in the Journal of the spatial distribution centers health services in urban areas of Tehran No. 38, October 1379 [8].

2. REGION INTRODUCTION

Tehran's sixth district has certain characteristics compared to other districts of the city such as, spatial region in central Tehran metropolis. On the one hand, it become the conjuncture communication and traffic between northern, southern, western and eastern. On the other hand, the establish of numerous activities and users' administrative-services in

metropolitan, regional, national and even transnational scale, land use and spatial diversity, and finally its function in the city center in Tehran that become The most important part of the core of Tehran (and hence the capital city of Tehran). About 33 percent of ministries and its subordinate institutions, 28 percent of higher education institutions, specialized hospitals and performance 19%, national agencies and departments of the ministries 40percent, 20percent of public provincial and performance hospitals, 18percent of cinemas, 80 percent of the religious places of minorities and 5.6 percent of high school vocational technical centers in Tehran metropolitan are located in this area. This region has an area of 45.1238 hectares, included about 3.3 percent of the cities. District six in terms of geographical location is located in the central part of Tehran. From the north to the district of 3, from the East to the district of 7, from the south to the districts of 10, 11, 12 and from the West limits by district 2 [9]. According to the latest municipal division in 1384, district 6 consists of 6 sub-region. The fourth sub-region, the largest one with a surface area of 470.79 hectares and the third, the smallest one with surface area of 242.7 hectares [2].

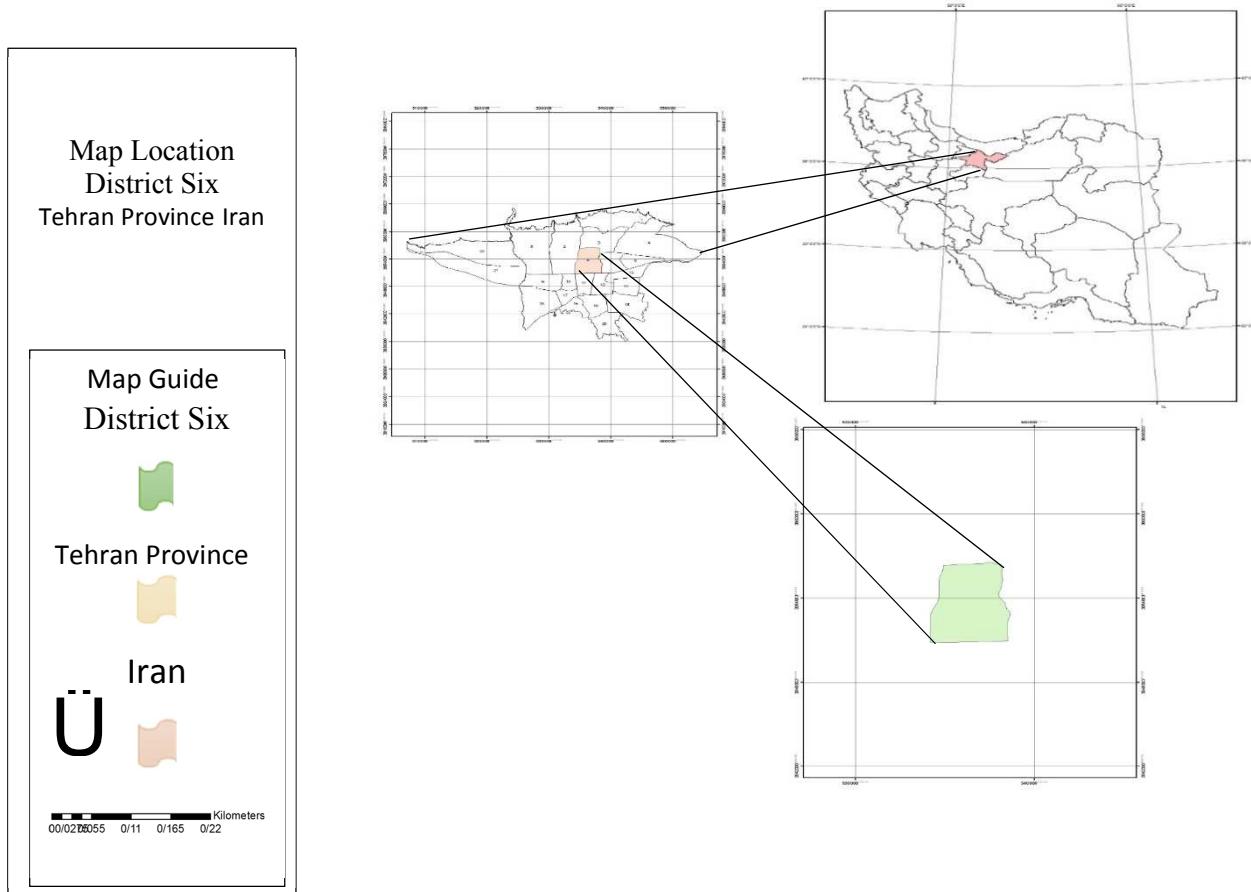


Figure 1: Study area

3. MATERIALS AND METHODS

This study in terms of objective is applied research and in term of nature is descriptive-analytic research. In order to access of community to medical care, site selection must be done with regard to criteria. Site selection is a process to determine the best location for an activity based on the conditions and resources availability. It means that in site selection the analysis of both spatial data and descriptive data done for more spatial location with descriptive characteristics of the user's [9]. GIS is a tool, used for this analysis. First, provide the layer required for the proposed locations of hospital centers in the specified area. Then, weighting the layers in the expert choice in order to use in GIS as input data. Give distance value to GIS layers then FUZZY the layers and weighting it. After then, use linear combination model (WLC) to overlap. The result is raster maps which show that the optimal locations. In the final map, Using Network Analysis to select optimal places that can be get to Hospital Center at the least amount of time.

For evaluating the criteria, there exist methods such as weight indicator, Delphi process, estimate the ratio, logistic regression, and Analytic Hierarchy Process (AHP). Among them AHP is one of the most best decision making techniques [18] that provide an efficient method for weighting, found by the Satty (1980). It will play an important role in selecting the optimal suggestions [20].

AHP based on three principles: analyzing, Decisions by Comparing and combining priorities. At each stage, the criteria considered according to their importance in the decision. It compared in pairs. After the formation of the comparison matrix, the relative weights are calculated for different elements. Relative weight derived due to the different elements at each stage. Relative weight calculated according to each adjacent element at a high level at each stage and used as normalized vector components associated with the special vector comparison matrices. Then, combining weights are determined by the total weight of the entire hierarchy. The result of this combining is special normalized vector of selected total weight [5].

Decision, the judging and selecting, is one of the most important characteristics of human. The need for powerful technique that can help people in this field is obvious. For complex decisions, mathematical models used often to simplify and summarize real-world problems. Using mathematical models have many advantages such as simplify the problems, analyze issues and determine clear target. As well as the ability to perform comfortable and comparative calculations. To do this, use decision-making procedure, called Analytical Hierarchy Process [1; 11]. So Analytical Hierarchy Process is a method of decision that the decision-maker or decision-making group will be shape desired issue and based on the resulting structure, perform comparison to determine the priority of making options decision. AHP process, requires pairwise comparisons. After then, determination and evaluation of factors is done. In this way, the option gain the highest value of weight would be the best option. Among the advantages of this method, its use in qualitative criteria decision-making. Another advantage of this method, give the structure to the problem through the formation of hierarchical decision-making. Classification criteria from top to bottom makes the complex issues examined systematically by AHP. Now the use of AHP is more in decision-making socio-economic systems such as the allocation of resources, performance evaluation, sequencing and other work items [12].

Network analysis: analysis of network-based on urban street and roads plays a vital and fundamental role in urban mobility and used for linear effects. For this reason the results of this analysis have a very high degree of confidence in compare with the spatial analysis that just determine the spatial path between two points [7].

The ideal aim of this study was justice in access of a diverse group of civil society to health services. To access this, the use of all influential factors and the use of various statistical societies are essential. The overall goal in conducting this study was to investigate the distribution of health centers and determine the most appropriate places for these centers in the district six. Using existing data, the optimal location for the establishment of health care providers were identified. Health care services similar to other public services require planning and policy makers for optimum distribution. However, due to two factors influencing health services, namely population health care providers and consumers (patients), it can be used not only to regulate the relations of efficient health care and more efficient performance but on the larger level to optimize the distribution of these facilities in the city as well.

4. RESULTS

District six of Tehran now has 10 health and treatment centers. The distribution and the accessibility, access and distance radius shown in the following figure.

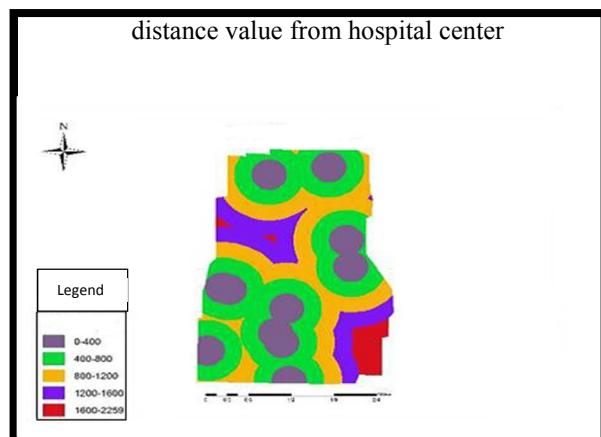


Figure 2: distance value from hospital center

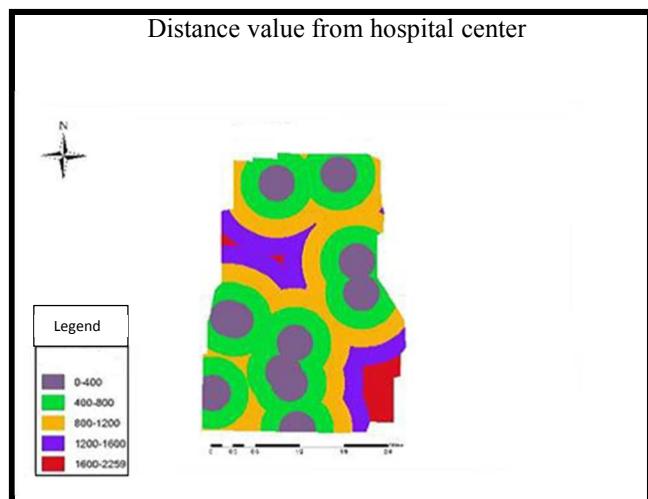
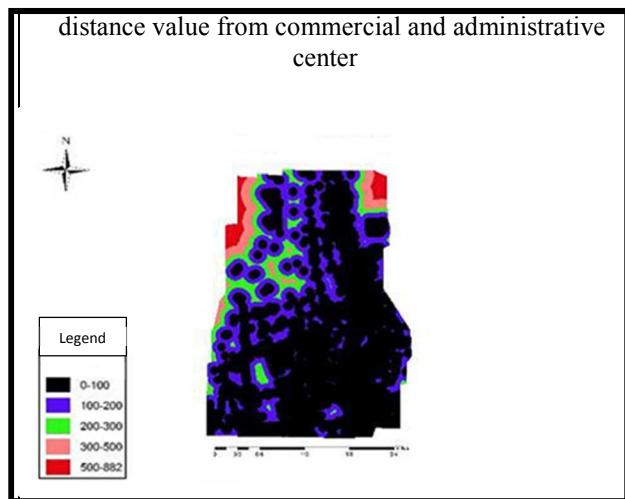
Site selection of new hospital centers

The first step to do this is to identify the parameters affecting the choice of this location. Parameters in the selection of these hospitals include:

- 1- Distance from the existing hospital
- 2- distance from fire stations
- 3- Distance from green space
- 4- Distance from industrial centers
- 5- distance from the subway
- 6- Distance from residential
- 7- Distance from city services
- 8- Distance from transportation and storage
- 9- Distance from military bases
- 10- Distance from the commercial and administrative centers

a. Evaluation of data layers

In this study, to create hospital centers model, map produced for each of the named data layers. Then, each map will convert to the five classes. In this five maps below (Distance from hospital centers, industrial facilities, transportation and storage, commercial and administrative centers, military bases) as distance increases, the valuation of layers increase and it will be affected selecting the optimum proposed locations of hospitals.



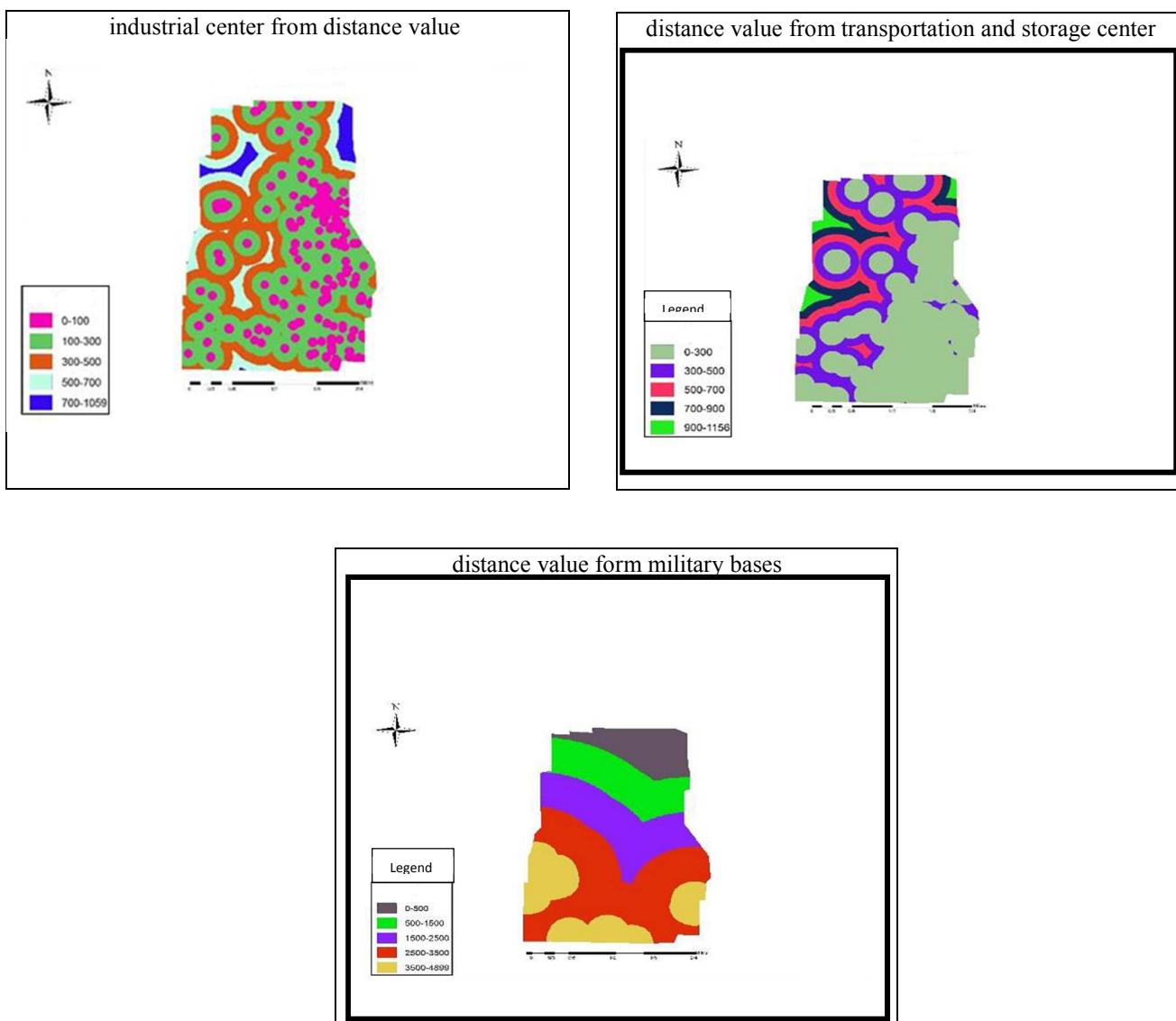
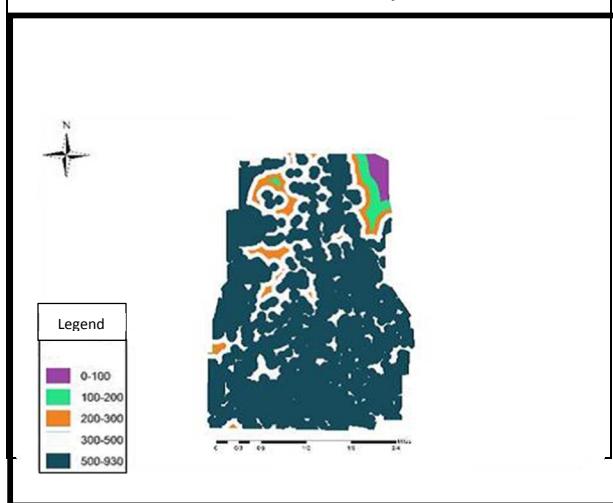


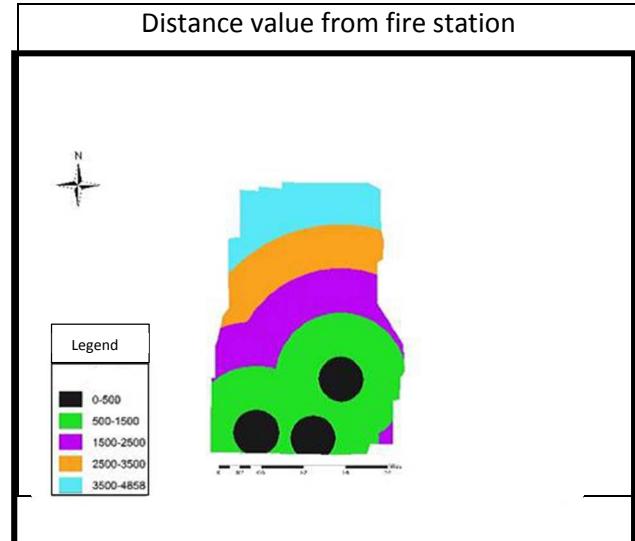
Figure 3: distance value (hospitals, transportation, commercial, industrial and military)

In this five maps below (Distance from utilities, fire, subway, green space, residential areas) with increasing distance, the value of it will be decrease in the final weight. This means that whatever the distance is less the optimum location is more.

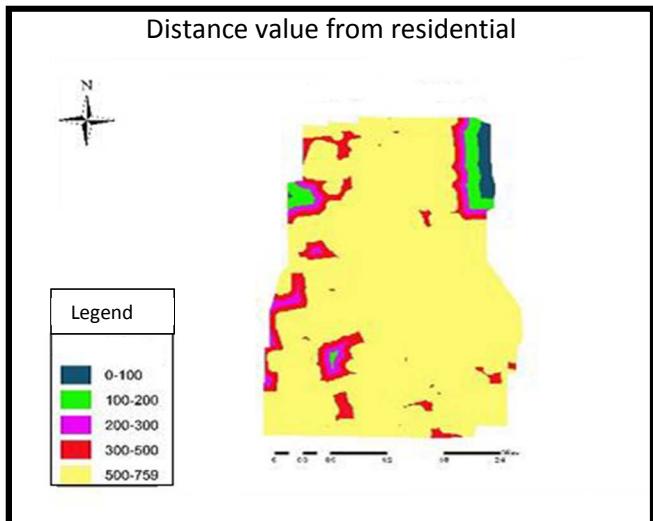
Distance value from city services



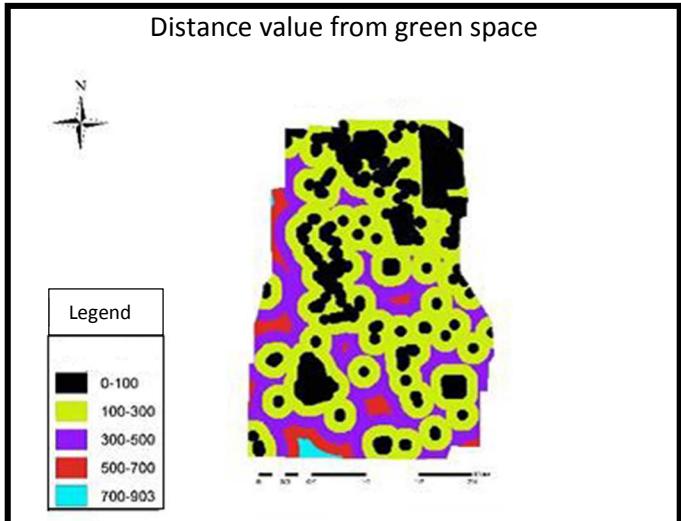
Distance value from fire station



Distance value from residential



Distance value from green space



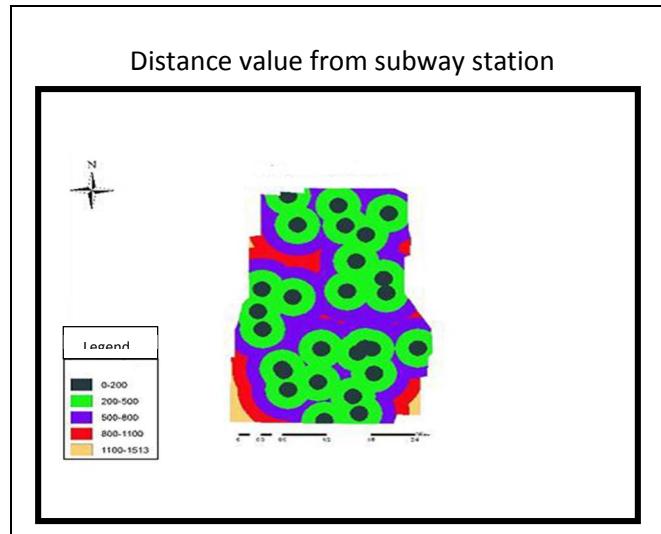


Figure 4: distance value (fire, utilities, metro, residential, green space)

b. Weighting layers of data

After selecting effective criteria in site selection to combine them together first, the layers are given weighting. The weighting is done in the expert choice with AHP model that is the Analytic Hierarchy Process. This method was invented in 1977 by the Saati. The method is based on layers pairwise comparisons relative to each other. The following table shows the process of weighting the criteria

Weight (sub-criterion)	Sub-criterion	Weight (criterion)	criterion	number
1	0-400	0.293	Distance from the existing hospital	1
2	400-800			
3	800-1200			
4	1200-1600			
5	1600-2259			
5	0-500	0.214	Distance from fire stations	2
4	500-1500			
3	1500-2500			
2	2500-3500			
1	3500-4858			
5	0-100	0.153	Distance from the green space	3
4	100-300			
3	300-500			
2	500-700			
1	700-903			
1	0-100	0.108	Distance from industrial centers	4
2	100-300			
3	300-500			
4	500-700			
5	700-1059			
5	0-200	0.076	The distance from the subway	5
4	200-500			
3	500-800			
2	800-1100			
1	1100-1513			
5	0-100	0.053	Distance from residential areas	6
4	100-200			
3	200-300			

2	300-500				
1	500-759				
5	0-100				
4	100-200				
3	200-300				
2	300-500				
1	500-930				
1	0-300				
2	300-500				
3	500-700				
4	700-900				
5	900-1156				
5	0-500				
4	500-1500				
3	1500-2500				
2	2500-3500				
1	3500-4899				
1	0-100				
2	100-200				
3	200-300				
4	300-500				
5	500-882				

Table 1: weighting the criteria in AHP for selecting optimal locations hospital centers

Green space	Commercial and administrative centers	subway	Transportation and storage	Military services	Fire stations	City services	hospitals	Industrial centers	residential	criterion	number
5	9	8	9	7	6	3	2	4	1	residential	1
2	7	5	6	4	3	0.5	0.33	1	4	Industrial centers	2
5	9	7	8	6	5	2	1	3	0.5	hospitals	3
3	8	6	7	5	4	1	0.5	2	0.33	City services	4
0.5	5	3	4	2	1	0.25	0.2	0.33	0.16	Fire stations	5
0.33	4	5	3	1	0.5	0.2	0.16	0.25	0.14	Military services	6
0.2	2	0.5	1	0.33	0.2	0.14	0.12	0.16	0.11	Transportation and storage	7
0.25	3	1	2	0.5	0.33	0.16	0.14	0.2	0.12	subway	8
0.16	1	0.33	0.5	0.25	0.2	0.12	0.11	0.14	0.11	Commercial and administrative centers	9
1	6	0.4	0.5	3	2	0.33	0.25	0.5	0.2	Green space	10

Table 2: layers final score to site selection

c. Combine layers of data

After determine the effective criteria in site selection, weighting them based on importance of criteria. These criteria should be combine with an appropriate method and this overlap occurs in the GIS.

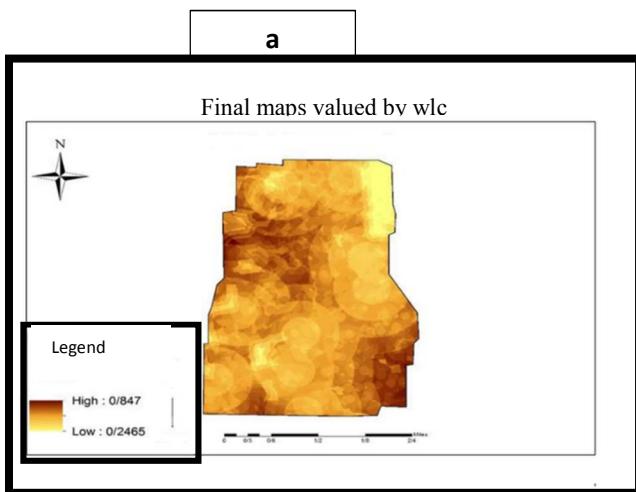


figure 5: a) final map valued by (wlc) method

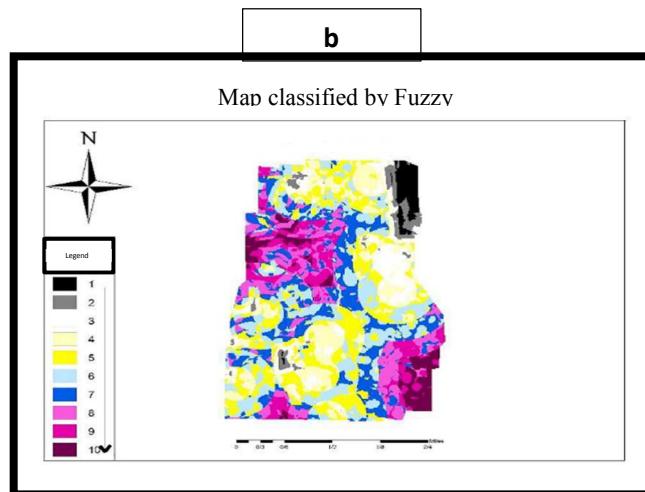


figure 6: b) final Fuzzy method

The proposed location for the hospital centers with regard to the optimal place and time

Since routing between the occurrence of accidents at the hospital centers is very important. First, hospital centers must be placed away from troublesome and annoying areas, including industrial centers, administrative centers and etc. Second, patients get to the hospitals as soon as possible. To choose how to get to the hospitals with the shortest time used GIS Network Analysis and selected three time intervals that included 3-5 and 10 minutes. Obviously, the much less time waste in a route, the patient less be in trouble and the possibility of patient recovery is more.

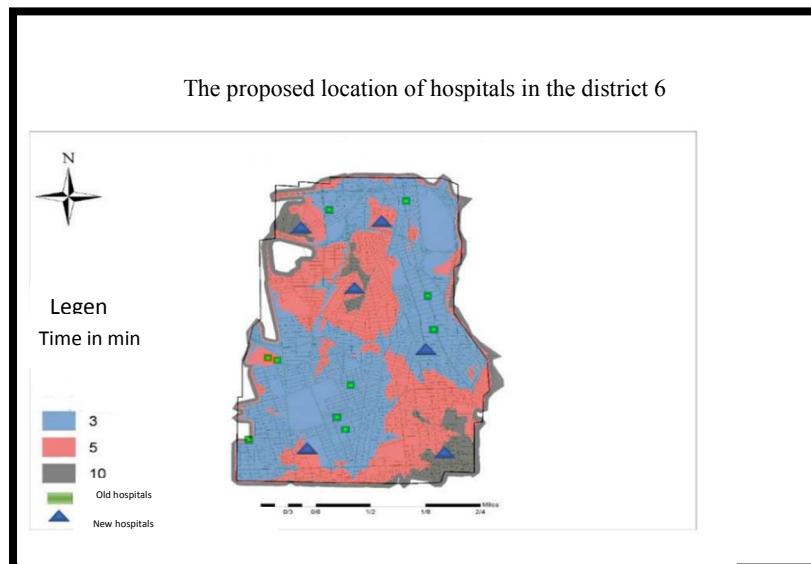


figure 6: The proposed location of hospitals in the district six

d. CONCLUSION

Nowadays, urban areas face with population growth and urbanization. These areas have a significant role in increasing pollution. Thus, increasing pollution threatens human health instead and represent the urgent need to locate a suitable hospitals in urban centers. So, located these centers in urban communities is very important. Influential factors should be considered before construction of these facilities. With a long-term planning and appropriate methods in the process of site selection we can reduce costs and prevent incorrect decisions. It also increasing the efficiency and performance in the regions and prevent the waste of money and time. Therefore, sorting hospitals is one of the main concerns in planning process. As well as number of health centers in the area must be too enough that

Patients can be transferred to the hospital in less time. In this study, using criteria in selecting a suitable location for the optimal hospital centers. First, for the desired layer, weighting all criteria using AHP model. Since for the Analytic Hierarchy Process, optimal site selection is highly effective. Then, ARCGIS has been applied for suitable hospital areas. GIS has been used 10 layers and the layers are initial distance valued. The final weights obtained by AHP. At the end, the optimal places that cope with the people problems selected with regard to all aspects. Now by selecting optimal locations for hospitals, time to reach hospitals should be reduced to the minimum possible time and minimize the effects of risk to patients. In this part the extension Network Analysis is used for the optimal times and considered time intervals of 3, 5 and 10 minutes. In this period 6 points was added over the previous 10 points hospitals. The new centers will be give most effective services for people in less time so that people feel more health and welfare.

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