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Assessment and Comparison the Location of Six Universities in Tehran City Using GIS and Multi Criteria Decision Making Methods

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Dear colleagues and friends,

It is our great pleasure to invite you to attend the EURASIAN GIS Congress 2018 held in Baku on 04-07, September 2018. EURASIAN GIS Congress 2018 is a candidate of one of the most important event in the scientific schedule and tenders a possibility for researchers and academicians who researches on GIS and related disciplines. You can find a first class programme of plenary speakers, technical sessions, exhibitions and social events in this book. You will be able to catch up with the developments in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, meet friends and experience the traditional and fascinating culture of AZERBAIJAN. As a international congress in the field of geo-spatial information and remote sensing, EURASIAN GIS Congress 2018 is devoted to promote the advancement of knowledge, research, development, education and training in Geographical Information Sciences, Information Technology, Environmental Management and Resources, Sustainable Agriculture, Surveying, Photogrammetry and Remote Sensing, their integration and applications, as to contribute to the well-being of humanity and the sustainability of the environment. The EURASIAN GIS Congress 2018 will provide us an opportunity to examine the challenges facing us, discuss how to support Future Earth with global geo-information, and formulate the future research agenda.

150 scientists from 13 countries attended to the congress. 7 plenary speakers, 120 oral presentations and 8 poster presentations, all together with 135 in total, are presented during the congress. 135 presentations take place in 21 sessions in three days. **Mohammadi & Hosseinali (2019)** presented in the organization was selected for publication in **IJEGEO 6(1) as Short Communication.**

The Congress is carried out with the support of the organizations as the Konya Technical University, Selcuk University, Azerbaijan National Academy of Sciences Institute of Geography, Baku State University, Ministry of Agriculture of Azerbaijan Republic, General Directorate of Land Registry and Cadastre, General Directorate of Agricultural Reform of Turkey, International Federation of Surveyors (FIG), International Society for Photogrammetry and Remote Sensing (ISPRS) and Igdir University. In addition, the congress is also supported by the commercial organizations of INTEGRIS LLC, KUTLUBEY Engineering Co, RUBIKON Geosystems LLC, NETCAD, HARMIAD Surveying Engineers Businessmen Association, GEOGIS Engineering Co, MESCIOGLU Engineering Co, EMI Group Information Technology Co, PaksoyTeknik, and 4B Ölçüm.

Finally, we cheer on all of you to participate in this congress of EURASIAN GIS , and special thanks to all sponsorships and government partners for the congress. Enjoy your time and share your experiences with your friends.

Baku/Azerbaijan, September, 2018

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Short Communication

Assessment and Comparison the Location of Six Universities in Tehran City Using GIS and Multi Criteria Decision Making Methods

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Abstract

Universities are the engine of science in any country. Thus improvement of a university led the country to development. Location of the university is one of the factors which are effective on the quality of research and educational activities at the university. Crowded or polluted areas are not proper places for the universities. There are also the other criteria such as quality of transportation system which may affect the satisfaction of the people who deal with the university. GIS has powerful tools to spatially analyze the location and produce the outputs to be considered as the indexes of properness of a location for a specific activity.

In Iran most of the major universities have been constructed in the capital: Tehran. Tehran is a crowded, polluted and large metropolis which contains various neighbourhoods with various conditions. This research aims to assess and compare the spatial conditions of six important universities in Tehran. To extract the effective factors more than 500 students were interviewed. The extracted factors were categorized into two main categories of spatial and environmental and then were divided into five subcategories, namely: greenness, air pollution, noise pollution, accessibility and compatibility of surrounded land-uses. Using GIS analyzes the quantitative values extracted from the maps, satellite images and statistical data. Then Multi-Criteria Decision Making (MCDM) methods were used to combine the factors. The results revealed that Amirkabir University of Technology achieves the highest score while Allameh Tabataba'i University is ranked below among the considered six universities.

Keywords: Location, Compatibility, Access, Environment, Tehran

Introduction

Educational period is an important part of the life of any educated people. Thus, spending nice time in the educational places can help people to improve learning. One of the factors that may affect the quality of educational places is their locations. Students usually like the places with some properties such as good access to facilities and transportation network as well as silent and clean places. This study aims to analyze and compare the desirability of the location of six universities in Tehran, Iran.

GIS is a professional system to deal with the spatial data. Therefore, in this research GIS is used to analyse the maps and extract the indexes of desirability. On the other hand combination of various indexes of desirability is done through Multi Criteria Decision Making (MCDM) methods.

One can find several records of site selection of educational places in the scientific literatures. However if the case is a university, the records are very limited. In this research we do not aim to find the best places to construct a university. Instead we extract the corresponding criteria and then we assess and compare the location of existing universities. It is obvious that the extracted criteria for assessing the location of universities may valuably be used for site selection of new universities. However, it depends to the demands. In the following some related researches are briefly reviewed.

Moller (1998) analyzed the process of site selection of educational places in Copenhagen, Denmark. He then produces a pattern for site selection of educational places (Moller-Jensen, 1998). Pizzolato et al. (2004) aimed to find the best sites for schools. They considered various criteria such as geology, slope, faults, population and urban areas. Using Analytical Hierarchy Process (AHP) the criteria were weighted and then combined. Finally the best sites for constructing schools were selected (Pizzolato et al., 2004). Taleai et al. (2007) aimed to develop a model for assessing land-use compatibility in densely built-up urban areas. In this process, a new model was developed through the combination of a suite of existing methods and tools include: GIS, Delphi methods and spatial decision support tools: namely multi-criteria evaluation analysis, analytical hierarchy process and ordered weighted average method (Taleai et al., 2007). Okan (2012), in his research, studied the role of GIS in education. The main purpose of the research was to use Web GIS technology to analyse the geographical location of Tbilisi schools. The data used in the research include: the capacity of each school, the number of students, the spatial distribution of schools,

the physical conditions of schools, the location of schools in relation to other land-uses, and so on (Okan, 2012; Aslan & Akyürek, 2018; Vaghela, et al., 2018). In the study of Shahraki et al. (2016) the first aim was to analyze the distribution pattern of existing educational sites across a case study city and to examine an optimal model to redistribute the schools. The ultimate goal was to give a new map on the spatial distribution of educational sites in tune with new urban needs and development. Their research used an integrated spatial equity evaluation method, which is analytic and descriptive. They used the Moran's I index to classify and analyse the collected data. (Shahraki et al., 2016).

The study area

Six universities in Tehran, capital of Iran has been chosen for this research. There are various reasons for the authors to select these universities among several universities in Tehran. They are almost known for the authors, their locations are distributed in the city and each of them is a top university of Iran in some areas of science. The location of six selected universities is illustrated in Fig. 1.

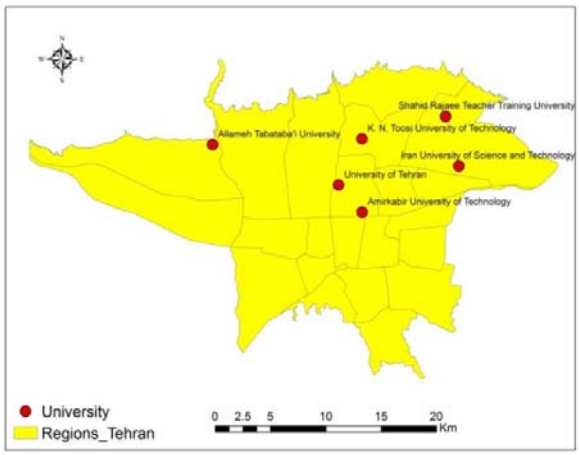

Figure 1: The location of six selected universities in Tehran

Methodology

The first step of this study is to identify the criteria of desirability for the location of a university. To do this task more than 500 students of the selected universities were interviewed. The ideas of students indicated that the criteria can be categorized into two groups of spatial (or physical) and environmental factors. Next the factors were divided into subcategories. Environmental factors include greenness, air pollution, and noise pollution (Günay et al., 2018; Kaya et al., 2017). Spatial factors involve accessibility and compatibility of surrounded land-uses.

The next step is to define indexes to determine the values of criteria (factors) and then combine them to rank the desirability of the location of six universities.

In environmental category, greenness can be achieved by using satellite images. NDVI is a usually used index in this field. NDVI is defined by (Tucker, 1979):

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{R}}{\mathrm{NIR} + \mathrm{R}} \tag{1}$$

where, NIR is the value of near infrared band and R is the value of red band in the satellite image. The value of NDVI index is in the range of -1 and +1 where intense green coverage equals to +1 and less values indicates the less greenery.

In Tehran metropolis air pollution and noise pollution (especially the former) are unsolved problems. A suitable location for an educational land-use (such as university) should have the minimum possible air and noise pollution. For this task the maps of noise pollution and air pollution for the whole city must be prepared. In this study air pollution map is produced using land-use regression method (Rawlings et al., 2001). The reference for detecting the amount of air pollution is the fixed air pollution sensors which are mainly managed by the municipality of Tehran. On the other hand, the data of noise pollution sensors are the reference for preparing noise pollution map. Kriging method is applied to produce noise pollution map (Abbaspour et al., 2015).

To produce accessibility map, first it must be defined that which places are important to access. Interviews with the students of the universities revealed that possibility of walking to eight places is important which are: bus stops, subway stations, mosques, sport fields, clinics and hospitals, cultural shops and centers, green spaces (such as parks) and educational places (such as educational institutes). The possibility of walking means that the distance between the origin and the destination must be almost short. In this research the maximum distance of walking on the network considered as 3000 meters on the network of streets. It is obvious that except point destinations (bus stops and subway stations) for the other destinations the capacity is important. The capacity of destinations is approximated by their area. Thus the accessibility is evaluated by the following relation (Tsou et al., 2005):

$$A_i = \sum_{J=1}^{n} W_j * D_{ij} * P_j^l \tag{2}$$

Where, A_i is the accessibility index of the origin i to the destination j, W_j is the weight of destination j, D_{ij} is the standardized distance between the origin i and destination j. D_{ij} is calculated by the followings (Tsou et al., 2005):

$$D_{ij} = \begin{cases} 1 & \text{if} \quad d_{ij} < d_0^l \\ 1 - \frac{d_{ij} - d_0^l}{d_d^l - d_0^l} & \text{if} \quad d_0^l \le d_{ij} \le d_d^l \\ 0 & \text{if} \quad d_{ij} \ge d_d^l \end{cases} \tag{3}$$

where, d_{ij} is the distance between the origin i and destination j on the network, d_0^l is the optimum distance

between the origin and the destination and d_d^l is the final possible effective distance to the destination. P_j in relation (2) is the index of attractiveness of the destination and is calculated by:

$$P_j^l = \frac{S_j^l}{\bar{S}^l} \tag{4}$$

where, S_j^l is the area of destination land-use and $\bar{S}^l$ is the average area of all similar land-uses in the effective distance.

Compatibility of surrounded land-uses is calculated using compatibility matrix. In fact, for any land-use the compatibility with other land-uses can be estimated. Thus the compatibility of university land-use can be compared with other surrounded ones using pair-wise comparison. Finally the weights of compatibility of land-uses with the considered land-use (university in this research) are calculated (Taleai et al., 2007). In addition to the weights of compatibility the area of land-use is another effective factor which should be taken into account.

Implementation and analysis

Each of considered factors is extracted from a corresponding map and this is the point that highlights the role of GIS. For environmental factors three maps was produced and then combined. Greenness map in this study is a map showing the NDVI index which covers Tehran. To produce this map, image of LANDSAT 7 satellite, ETM+ sensor, band 3 and 4 was used as the input of relation (1). Fig. (2) shows the produced NDVI map. ENVI software was used for this process and NDVI obtained within a thousand meters radius of each university. For the other map processes in this study ArcGIS 10.3 software was used. Fig (3-4) show the noise pollution and air pollution maps respectively. Afterward, three factor maps were combined using Index overlay method with the equal weights and environmental index map was created Fig. (5). It is worth noting that time of gathering data for each factor map is different. It depends on the accessible data and suitable time for the particular factor under the consideration.

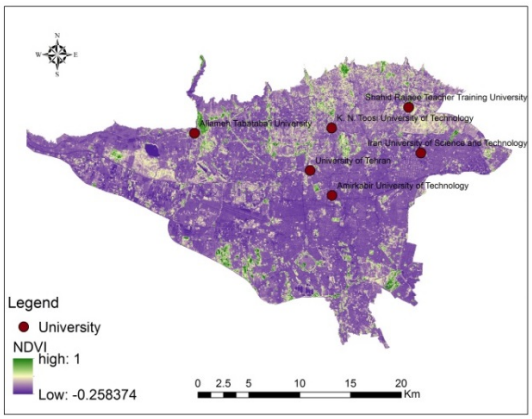

Figure 2: NDVI map(2013/6/22)

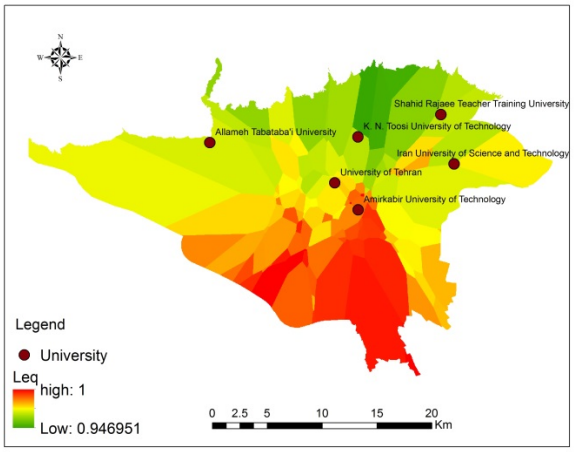

Figure 3: Noise pollution map (2017/10/23)

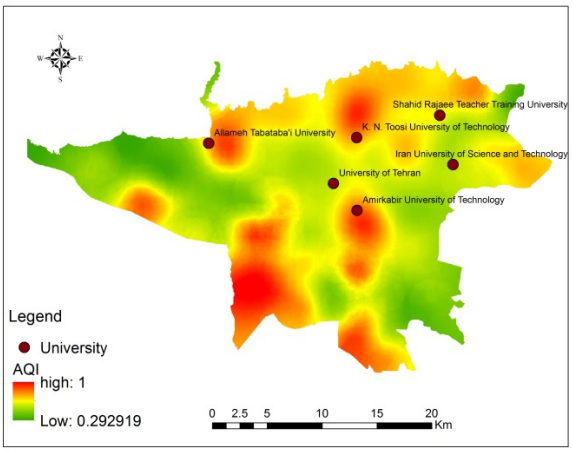

Figure 4: Air pollution map (2012/12/21)

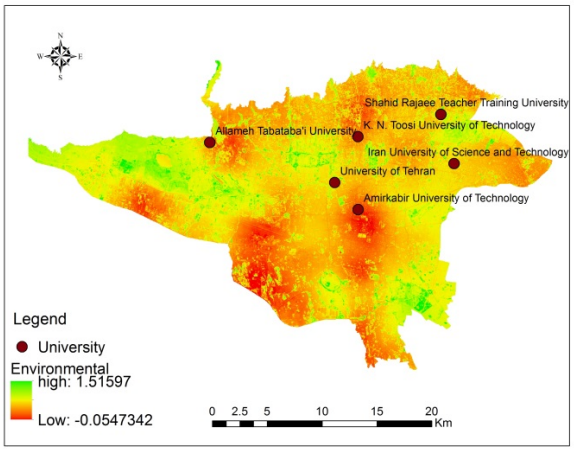

Figure 5: Environmental map

Air pollution is at the highest in winter. Noise pollution is significantly higher on days in the mornings. Real greenness is observable in summer when all the trees have leaves. Different time of gathering will not affect the results because the relative conditions of the target universities are fairly constant during the interval of collecting data. The obtained values for environmental factor are listed in Table 1.

Table 1: The values of environmental indexes

University	NDVI	AQI	Leq	Environmental
Iran University of Science and Technology	0.140	0.554	0.968	0.617
Shahid Rajaee Teacher Training University	0.229	0.636	0.965	0.627
Allameh Tabataba'i University	0.240	0.735	0.969	0.536
Amirkabir University of Technology	0.121	0.834	0.987	0.3
University of Tehran	0.170	0.568	0.974	0.626
K. N. Toosi University of Technology	0.165	0.764	0.962	0.439

To produce physical index map, accessibility and compatibility of surrounded land-uses must be determined. Accessibility was extracted on a 1:2000 map of Tehran using OD-cost matrix in ArcGIS. Table 2 shows the related distances and weights used for calculating accessibility index.

Table 2: The distances used for calculating accessibility and their corresponding weights (Hoseini et al., 2016)

Land use	$d_0^l - d_d^l$	W_j
Educational	1000-2500	0.073
Health & Therapy	650-1500	0.048
Cultural	800-2000	0.170
Religious	1000-2000	0.024
Sports	1500-3000	0.121
green space	650-2000	0.146
Subway	1200-2500	0.219
bus stop	1200-2500	0.195

To generate compatibility various land-uses around the target universities were determined and their compatibility with university land-use was compared pair-wisely. The compatibility expressed in five levels. Levels of compatibility have then been assigned different weight based on previous works (Taleai et al., 2007). Calculated accessibility and compatibility are illustrated in Fig (6-7respectively.

Once the values of factors obtained, they can be combined to get the final index. However, the weights of each criterion must be assigned. Like the previous works these weights are calculated using AHP as multi criteria decision making method. The weights of accessibility and compatibility of surrounded land-uses were calculated equal to 0.75 and 0.25 respectively. On the higher level of AHP hierarchy the weights of physical criterion calculated as 0.6 while the weight of environmental factor is equal to 0.4. All of the weights in this research were evaluated based on the idea of interviewed students.

At last, the final index for desirability of the location of target universities achieved by combining sub-criteria. The achieved values are demonstrated in Fig (8).

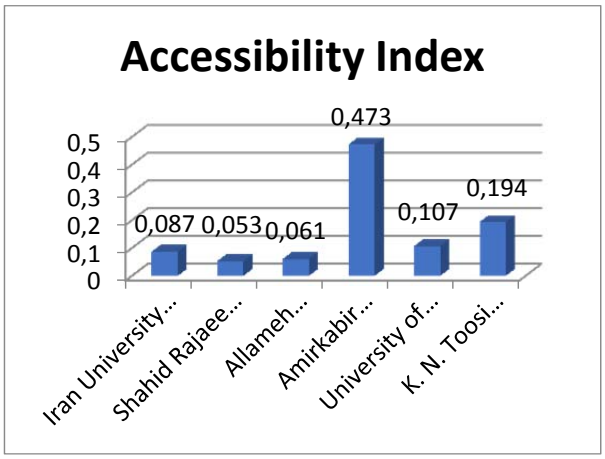

Figure 6: Calculated accessibility of universities

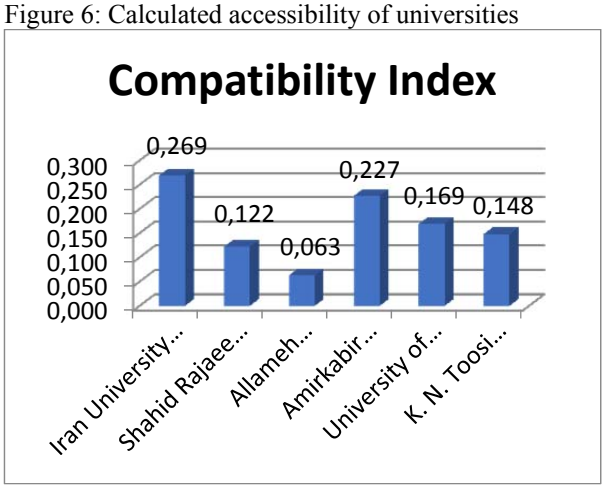

Figure 7: Calculated compatibility of universities

As can be seen in the Fig. (8) Amirkabir University of Technology was ranked first while the lowest score assigned to Allameh Tabataba'i University. The main factor of this result is accessibility. The other factors were not at a level to be able to compensate the large amount of difference between the accessibility factors of highest score and lowest score universities. These results reveal that despite of high values of air pollution and noise pollution at the central districts of Tehran, steel these districts are the best locations for the universities. To make the suburban area of Tehran the better places for the universities the accessibility of the selected locations as well as the compatibility of surrounded land-uses should be considered precisely.

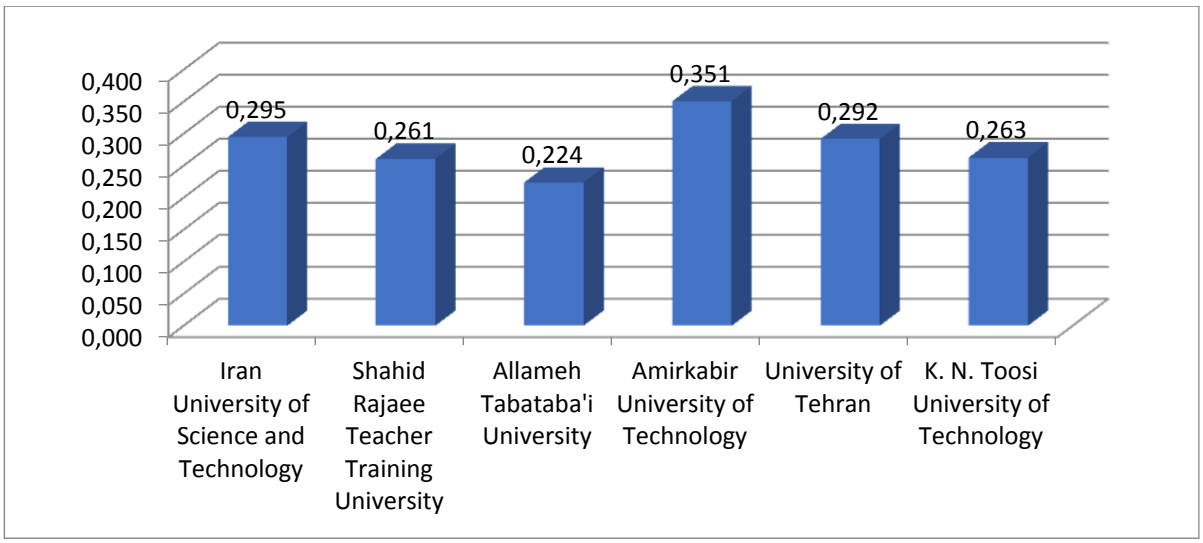

Figure 8: The comprehensive calculated index of desirability of the location of six selected universities in Tehran

Conclusions and Recommendations

This research analyzed and assessed the location of six universities in Tehran using GIS and multi criteria decision making methods. In this research more than 500 students from six universities were interviewed to find out the effective factors on the desirability of the location of the university as well as the relative importance of effective factors. The extracted factors were categorized into two main categories of physical (spatial) and environmental and then were divided into five subcategories, namely: greenness, air pollution, noise pollution, accessibility and compatibility of surrounded land-uses.

It may be obvious that crowded or polluted areas are not proper places for the universities. However, the results of this study revealed that in the students' point of view it is very important that the facilities such as transportation network or parks etc. be accessible on foot from the university. The results showed that location of Amir Kabir University of Technology achieves the high score among the six assessed locations of universities. It is recommended to address the effects of the location of universities on the quality of education.

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