Assessment of industrial site selection with emphasis on mcdm models (case study: tabriz province)

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ABSTRACT

Industry” is related to economic activities so the term “Industry” is used in affairs such as fishing, electronics, and retails. The goal of land use planning in terms of industry on the whole country scale, is logically locating different fields of industry in space, balanced, harmonic and proportionate development of different provinces of the country in different industrial fields and branches by using natural and human resources to get the maximum efficiency. Therefore, the goal of the present paper is zoning suitable locations of the industrial town. The main indicators that were used in this study are: Social - economic indicators (education and employment, costs and access to markets), Environmental indicators (Climate, Pollution and Topography), and Infrastructure indicators (water and energy). Prioritizing the criteria was done based on hierarchical analysis model and by using the experts’ ideas who are specialists in theoretical and practical location and by the means of multi-criteria evaluating in the form of network analysis. The results reveal that environmental and infrastructural criteria have the highest grade in suitable zoning of industrial town in Tabriz. Preliminary results indicate that Environmental and infrastructure indicators, with a values of 0.447 and 0.348, are respectively impact on the industrial town in Tabriz. Also, studies show that, the northern, eastern and southern zones are appropriate for industrial site selection, but considering that the northern and southern zones are in the vicinity of Einali Mt and Sahand Mt, Therefore, these zones are inappropriate to industrial site selection.

Key words: Industrial Location, Zoning, Fuzzy, MCDM
Introduction

Determining location for industrial projects and industrial production locations is one of the most important investment issues. However, in economic geography, the situation of all economic activities is not investigated (Watts, 1987:2). The search of new industrial emplacements is a key aspect in regional planning since their development has a social, economic and environmental influence (Ruiz, et al, 2012). Industrial states are usually located outside the main residential areas and provided with convenient transportation access. This idea of setting land aside through this type of zoning is based on several concepts. First, to concentrate dedicated infrastructure in a delimited area to reduce the per-business expense of that infrastructure. Such infrastructure includes roadways, railroad sidings, ports, high-power electric supplies (often including three-phase power), high end communications cables, large-volume water supplies and high-volume gas lines. Second, to attract new businesses by providing an integrated infrastructure in one location. Third, to reduce the environmental and social impact of the industrial areas by setting aside their residential usage and fourth, to create competency for industrial state members for more benefits and finally, provide localized environmental controls for the specific needs of an industrial area(Vahidi, et al, 2013). According to globalization and joining Iran to WTO, economists have paid more attention to industrial towns as they can increase the competing skills of units in the series because they have access to marketing and informing and can fulfill the financial needs. On the one hand, cooperation between the units in industrial town identifies them and increases their bargaining skills. On the other hand, inflexibility of the units in confronting the market changes and competing pressure of globalization will increase. In the view of environmental biology, they can use the waste material and secondary productions of each other as their raw materials in their production, by developing industrial towns and appearing industrial coexistence and proximity of units in town. This will lead to a decrease in using resources for decreasing the expenses, decreasing trash and waste and increasing energy. (Roberts, 2004) Industrial site selection is critical point in the process of starting, expanding or changing the location of industrial systems of all kinds. One of the main objectives in industrial site selection is finding the most appropriate site with desired conditions defined by the selection criteria (Rikalovic, 2014: 1054-1055). Industrial town location is also considered based on the features of urban constant development (Gibbs and Deutz, 2007).

Industrial towns are considered a vital part of urban strategies especially in developing countries. As this research focuses on investigating industrial town location, in the following we will study the internal and external researches done on this field.

Ruiz (2007) introduces the criteria for the best location for industrial towns in the north GIS of social, economic and infrastructural and also determines the industrial town locations by Spain. Fernands (2009) mentions the social, economic, programming, infrastructural and environmental factors as influential factors in industrial town location and uses a model to show that environmental and economic factors are the most important factors in locating AHP industrial towns in the region of Cantabria in the north of Spain. Ruiz, et al (2012) investigated the suitable areas for industrial towns in the north of Spain. Therefore, they did location in two processes. The results of the research reveals that among the economic, social, physical, infrastructural and urban development factors the land price, unemployment rate, transportation and land zoning are the most important factors in industrial town location.

Therefore, according to the above mentioned analysis, as fulfilling the goals of the mentioned groups will not be possible without considering the industrial town location, the present paper has been prepared to determine the efficient criteria for industrial town location according to constant development indexes and answers the question “what are the most important criteria in industrial town location according to constant development indexes?” and then prioritizes them.
**Study Area**

Tabriz, the capital city of Iranian province of East Azerbaijan with a population around 1,500,000 lies at 46.13 east and 38.8 north with an altitude of 1363 meters above sea level. The temperature varies between +38°C and –15°C (Census of Population and Housing 2011). Tabriz is the fourth largest city and one of the historical capitals of Iran and the capital of East Azerbaijan Province. Tabriz is the fourth most populous city in Iran after Tehran, Mashhad, and Esfahan, and is also a major Iranian heavy industrial and manufacturing center. Some of these industries include automobile, machine tools, oil and petrochemical and cement production (Ahmadi, 2011)(Fig 1).

Tabriz is located on the intercontinental highway in vicinity to the Republics of Azerbaijan, Turkey and Armenia. Tabriz for a long time lay on a major trade route between the West and Asia and for many centuries it was a flourishing center of commercial trade (Master Plan, 2006).

Modern industries in Tabriz include the manufacturing of machinery, vehicles, chemicals and petrochemical materials, refinery, cement, electrical and electronic equipment, home appliances, textiles and leather, nutrition and dairy factories and woodcraft. There are hundreds of industrial complexes in Tabriz industrial area. Iran Tractor Manufacturing Co (ITMCO) is one of the biggest industrial complexes in the region. This complex has the highest foundry and forging capacity in Middle East, the biggest manufacturer of tractor in Iran, which has some domestic & abroad branches too. Although initially the complex was established with the aim of producing tractor and agricultural machines as a starting point for modernization of traditional Iranian agricultural system, nowadays its products include a large variety from auto parts to machine tools and some domestic van and trucks. Behind ITMCO there are several other industrial complexes including Machine Sazi Tabriz Co, Iran Diesel Engine Manufacturing Co (IDEM), and Pump Iran, Tabriz Petrochemical Complex, Tabriz Oil Refinery and couple of industrial regions which are including hundreds of small industries (Statistic of Tabriz Municipality, 2014).

**Table 1- General information on Tabriz**

<table>
<thead>
<tr>
<th>Number of Cities</th>
<th>Number of District</th>
<th>Area(km²)</th>
<th>Population</th>
<th>The growth rate 2006-2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>6</td>
<td>2167.19</td>
<td>1579312</td>
<td>1695094</td>
</tr>
</tbody>
</table>

Source: Detailed Plan 2011

![Figure 1: Location of Iran and Tabriz](image-url)
MATERIALS AND METHODS

In order to conduct a research, the boundary of the studied region has been shown on topographic maps in the scale of 1/25000 by folding the boundary on the determined satellite images. Slope map, slope direction, and height from the sea level, faults, and the maps of distances from main roads, power transmission lines and surface water have been all prepared by topographic maps and have used fuzzy model and hierarchical process analysis for weighting criteria. Also, the statistics of statistics organization and industrial towns’ corporation of the east Azerbaijan province have been used in this research.

![Flowchart](image)

**Figure 2: Research process**

After studying the related literature and evaluating the experts’ ideas, effective factors in industrial town location are divided to the following four groups according to constant development indexes:

Social factors: These factors reveal the effects of social factors on industrial town’s location and include two sub-criteria of educational structure and employment.

Economic factors: these factors reveal the effects of economic factors on industrial town’s location and include two sub-criteria of expenses and market access.

Environmental factors: these factors can include environment management, pollution, climate and topography.

Infrastructural factors: these factors include the criteria of proximity with transportation, access to energy and water.

After distinguishing the effective factors in industrial towns location according to constant development indexes, in this level the hierarchical structure is planned by four criteria and nine sub-criteria and its goal is to offer a general and understandable division. The next level is prioritizing criteria and sub-criteria that is mentioned as follows:

![Diagram](image)

**Figure 3: Criteria and sub-criteria for industrial site selection**
AHP Method

The AHP and its use of pairwise comparisons has inspired the creation of many other decision-making methods. Besides its wide acceptance, it also created some considerable criticism; both for theoretical and for practical reasons (Saaty, 1980) (Lin, 2007) (Boroushaki, 2008), (Saaty, 1980). The AHP method worked out by Thomas Saaty (1994) is presented in many papers as an effective tool to support the multi-attribute decision-making process. Interestingly, decision making in AHP involves the judge on the basis of the expert’s knowledge; however, it cannot reflect the exact thoughts due to the different opinions and decision making mode concepts (Kahraman, et al, 2003). One of the most significant problems with traditional AHP is that the decision makers use exact values or numbers to point out their opinions (Wang, et al, 2007). Therefore, AHP has always been criticized due to several factors including being far from reality, covering the all ranges of human thinking’s templates and the uncertainty and the lack of human knowledge (Deng, 1999). Developing the fuzzy sets theory (Bellman, et al, 1977) proposes more flexible methods and covers the above-mentioned traditional AHP difficulties (Klir, et al, 1995). In fuzzy theory, a crisp set is extended which puts forth a more accurate real decision modeling and allows a comparative membership as there are just two states in crisp sets, namely non-membership and full membership (Ertuğdrul, et al, 2007). Zadeh (1965) introduced the Fuzzy Set Theory (FST) to deal with the uncertainty and vagueness. A major contribution of FST is the capability of representing uncertain data. FST also allows mathematical operators and programming to be performed to the fuzzy domain. A Fuzzy Set (FS) is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership function, which assigns to each object a grade of membership ranging "between" zero and one (Shu, et al, 2006) (Kahraman, et al, 2002). A tilde "~" will be placed above a symbol if the symbol shows a FST. A Triangular Fuzzy Number (TFN) M is shown in Fig. 1. A TFN is denoted simply as (a, b, c). The parameters a, b and c (a ≤ b ≤ c), respectively, denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. The combination of AHP and Fuzzy theory, so-called FAHP, was developed initially by Mikhailov and Tsvetinov (Mikhailov and Tsvetinov, 2004). Addressing the uncertainty, lack of knowledge and existence of non-statistical information, FAHP modeling is widely used in many management modeling projects. Van Laarhoven and Pedrycz (Van Laarhoven and Pedrycz, 1983) used FAHP for the first time to compare fuzzy ratios described by the triangular fuzzy numbers. Fuzzy sets were used with multicriteria decision-making methods, especially AHP, for optimizing and modeling various environmental issues such as metropolitan solid waste management (Hokkanen and Salminen, 1997) (Hokkanen, 1995) (Chang and Wang, 1997) site selection and ocean disposal sites (Leschine, et al, 1992).

In this paper, after reviewing the present information about the study area, influencing factors in determining the appropriate location for Industrial Estates was reviewed. Accordingly any member of the Expert Group including university professors, experts and scholars, questionnaires were distributed and were ordered according to experience, knowledge and scientific knowledge, present their suggestions. Each of indicators was classified and according to the scale of measurements indicators Different and sometimes have in conflict with each other and due to the effect of each indicator range, ranking of indicators was conducted by Fuzzy AHP Model. Finally indicators with overlay functions in Arc GIS (10.2) were prepared a suitable area for locating industrial estate.

RESULTS AND DISCUSSION

Firstly, the weight of criteria is determined. These weights are determined according to the importance of criteria against each other. Firstly, the main criteria that are in the following table are shown according to the importance of criteria of the horizontal row compared with the vertical row. Each number is determined based on table 1 and clock criteria.
Table 2- comparing criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Social</th>
<th>Economic</th>
<th>Environment</th>
<th>Infrastructure</th>
<th>Weigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>1</td>
<td>5</td>
<td>0.2</td>
<td>0.14</td>
<td>0.128</td>
</tr>
<tr>
<td>Economic</td>
<td>1</td>
<td>0.5</td>
<td>0.2</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>1</td>
<td>3</td>
<td></td>
<td>0.447</td>
<td></td>
</tr>
<tr>
<td>Infrastructure</td>
<td></td>
<td>1</td>
<td></td>
<td>0.348</td>
<td></td>
</tr>
</tbody>
</table>

Inconsistency: 0.042

Figure 4: Weight standards for industrial town location

According to the Figure 4, it is seen that environmental factors with the weight of 0.447 have the most effect in industrial town location. After comparing the criteria of the main layer, it will be the sub-criteria turn. In this level, for each criteria its sub-criteria is investigated. The sub-criteria of each layer are investigated separately. As a result, economic, infrastructure and environmental criteria each are compared with their sub-criteria. Here, only one reason of plurality of sub-criteria is mentioned.

Table 3- comparison of sub-criteria, social- economy criteria

<table>
<thead>
<tr>
<th>Sub Criteria</th>
<th>Education</th>
<th>Employment</th>
<th>Cost</th>
<th>Market Access</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>1</td>
<td>1.25</td>
<td>2</td>
<td>1.4</td>
<td>0.33</td>
</tr>
<tr>
<td>Employment</td>
<td>1</td>
<td>1.5</td>
<td>0.6</td>
<td></td>
<td>0.232</td>
</tr>
<tr>
<td>Cost</td>
<td></td>
<td>1</td>
<td>1.2</td>
<td></td>
<td>0.197</td>
</tr>
<tr>
<td>Market Access</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td>0.241</td>
</tr>
</tbody>
</table>

Table 4- comparison of sub-criteria, Environmental criteria

<table>
<thead>
<tr>
<th>Sub Criteria</th>
<th>Pollution</th>
<th>Climate</th>
<th>Topography</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution</td>
<td>1</td>
<td>0.6</td>
<td>1.25</td>
<td>0.313</td>
</tr>
<tr>
<td>Climate</td>
<td></td>
<td></td>
<td>0.7</td>
<td>0.349</td>
</tr>
<tr>
<td>Topography</td>
<td></td>
<td></td>
<td>1</td>
<td>0.337</td>
</tr>
</tbody>
</table>

Table 5- comparison of sub-criteria, Infrastructure criteria

<table>
<thead>
<tr>
<th>Sub Criteria</th>
<th>Energy</th>
<th>Transportation</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>1</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>Transportation</td>
<td>1</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

Site Selection Factors in Industrial Estate, according to the data collected in Arc GIS with given the importance and worth of each criteria was analyzed and evaluated. At the end by achieving applied weights on the desired layers, the best locations to industrial site selection were identified.
Conclusion

Industrial site selection is spatial problem. Spatial decision problem typically involve a large set of feasible alternatives. Selecting the location for an industrial site is a complex process that involves physical, economic, social, environmental and political requirements that may have conflicting objectives. Such complexity necessitated the simultaneous use of several decision support tools such as, GIS, FAHP and etc. In this paper problem of a large number of possible sites (alternatives) was resolved in screening phase, such as the choice came only sites that meet the basic criteria for industrial site selection (industrial parks, with the necessary infrastructure). In this way, we reduced time required for decision making, increased efficiency and quality in the decision making process by optimizing number of potential sites.

At the present, considering environmental, infrastructural and social-economic factors that are effective in industrial town’s location, we can say that the industrial towns in Tabriz are located in the zones of west and northwest of this city. According to the researches and the weights that were exposed from the model of FAHP, we got the result that in addition to the present zones, east zones of the province are also suitable zones for locating industrial towns. Moreover, according to the maps as a result of giving weight to the north and south zones of the cities that are near the mountains and high areas are not suitable for industrial town’s location.
The main indicators that were used in this study are social and economic factors (education and employment, costs and access to markets), environmental factors (Climate, Pollution and Topography), infrastructural factors (water and energy) are effective factors in industrial towns location that are in companion with constant development indexes. The criteria are categorized in a hierarchical structure. Prioritizing criteria and sub-criteria has been done by AHP and fuzzy model.

The results reveal that environmental and infrastructural criteria have the highest grade in suitable zoning of industrial town in Tabriz. Preliminary results indicate that Environmental and infrastructure, Social and Economic indicators, with a values of 0.447, 0.348, 0.12 and 0.77 are respectively impact on the industrial town in Tabriz. Also, studies show that, the northern, eastern and southern zones are appropriate for industrial site selection, but considering that the northern and southern zones are in the vicinity of Einali Mt and Sahand Mt, Therefore, these zones are inappropriate to industrial site selection (Fig. 6).

Future research will be focused on environmental issues, Studies land use planning in Industry issues, Also, future studies need to be done about multi-criteria decision methods for industrial site selection. Finally In order to decision makers and experts Able to make better and effective decisions in locating industrial estates necessity of the update data and database is required.

Figure 6: Zoning locating industrial town based on fuzzy- AHP model

References