

## Ecological capability evaluation for Urban physical development by using Multi-criteria decision-making analysis methods in GIS

(Case study: Mashhad City in Iran)

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### Abstract:

Assessing the ecological and land use planning for regulating the relationship between man, land and human activities in order to improve the material and intellectual conditions of community at the present time will prevent waste of natural resources and the environment as well as human poverty via introduction of the best natural land use based on the quality and quantity of the land and available socio economic needs. Therefore, this descriptive - analytical study has attempted to investigate the ecological capability evaluation of Mashhad for future development of the city with an emphasis on practical dimension by use of GIS and AHP methods. In this way for assessing ecological data several layers were generated such as: "distance from agriculture lands, gradient layer, the layer altitude, distance from the river, distance from green spaces and recreational space layer and layer fault". Finally, in order to model each criterion based on its value and importance for the physical development of the city is dedicated the appropriate weight to each of data layers based on the defined matrix in "Expert Choice" software. According to the results of the weighted combination of layers based on the importance of each layer in urban development, lands in the study area prioritized with emphasis on the natural factors then compared with land-use map. It founds that high ecological capability lands have been located far from faults, rivers and in the proper height and slope. Therefore are offered for the future physical development of the city.

**Key words:** Ecological capability, urban physical development, Multi-criteria decision-making analysis methods, Mashhad city

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## Introduction

Cities have always been shaped and developed influenced by various factors and forces. Basically the city is a social - economic phenomenon. Man to live and work and communication, gather on a limited area of more or less dense and gradually create cities. Cities transformed with social evolution, demographic shifts, economic changes and technological innovations (Richard, 2002: 280-290).

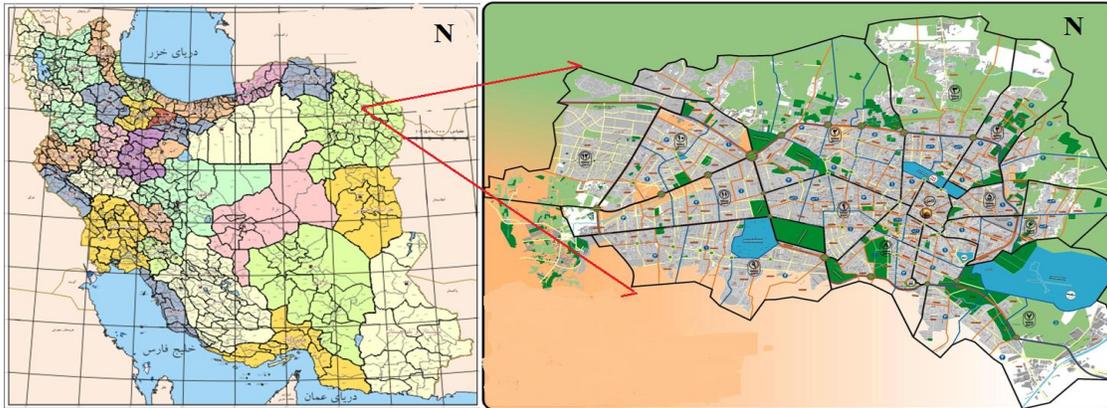
With the increase of population and development of investment and activities the structural organization of cities are experiencing fundamental changes (Saeed nia, 1999: 19). So cities will always be bigger physically and more complex structurally as living organisms. Following this physical development of the city, economic, social, cultural and above all ecological and environmental conditions are also gradually changed (Listokin, 2002: 16). This type of urbanization may be seen more in Iran so that one of the important processes of urbanization is rapid physical expansion of cities. Uncontrolled growth of cities and their uneven growth due to irregular migration and population growth is one of the major problems of urban networks in Iran. Now spread of creeping tentacles on the periphery of urban areas as a result of the urbanization is one of the problems in all cities and has consequences such as marginalization, poor services, environmental problems and ...

Harmonious relationship between man, nature and types of land uses may first need to understand the ecological capability of the nature and evaluating them to determine the appropriate land uses and consider the best (Gharkhlou, 2009: 52-54). In general it can be said, the Assessing potential ecological is the valuation of every points of land for different land use types. So the quality grade of land in each region will specify for each type of development (Sayah nia, 2002). This will reduce and minimize the negative impact of development on the environment.

In this regard, one of the places where is facing with this situation is metropolitan Mashhad. Mashhad, like most cities in their physical development has had problems and challenges. The city has been a growing trend of rapid and uneven influenced by various factors, including rural and urban migration, early 50s economic growth, rising incomes and urban developments after the revolution. Now the physical development of the city has resulted in numerous problems, including ecological effects. So assessment the potential ecological of Mashhad is necessary because inattention to its role in development of the city will be the source of many problems. The main objective of this study is to identify and assess the ecological potential for physical development of the Metropolis of Mashhad. The results of the study could be useful for help planners and managers to identify the proper physical development of the city.

## The study area

Mashhad is the country's second large city and is located in the northeastern province of Khorasan Razavi. The city is located in 36 degrees and 17 minutes of north latitude and 59 degrees and 36 minutes of east longitude than the Greenwich. Mashhad consists of twelve regions and has a population of approximately 2,815,541 people according to the 2011 census. This city as one of the metropolitan is faced with the growing population and in this regard the city is developing increasingly in horizontal direction. Due to this issue it is necessary to consider appropriate direction of development. Considering these factors suggests the ecological assessment of the physical development of cities and examined in the present study.



**Case study: Mashhad city**

## Discussion

With new developments, cities quickly adopt changes and transformations. These changes such as physical growth of cities and rapid population growth has been unbalanced and uncoordinated (Hosseyni, 2012: 2). Physical chaotic and uncontrolled urban development is one of the problems of the urbanization and modern cities. This affair in recent decades in addition to change the structures of towns, has been a great influence on the role acceptance of cities and has made uncertain adaptability of the future physical development of the cities. It can be said that physical development is a dynamic and persistent process in which its physical boundaries and the physical space increase in vertical and horizontal directions in terms of quality and quantity (Delir, 2006: 213-216).

Sustainable development of urban physical indicating the importance of this matter in promoting the cultural, social and physical aspects of the city as a basic necessity in urban development plans. According to the above analysis of the genesis and physical planning, for urban development and providing economic and social needs, the following criteria are considered (shade, 2004: 16-30). So we can say that one of the basic parameters in the development of the city is attention to natural and ecological conditions of the city and its environs (Buzbee, 2004:

50-56). Many factors are involved in physical development of the city. Natural factor is the most important that can have a positive or negative influence over direction and type of development as well as inappropriate and no schedule development can threat and destroy the city (Bullard, 2003: 22). Attention to this factor propounds evaluation of ecological on the physical development of cities. Physical environment study is an important task of urban planners and must be done before any other studies because the further planning is done on the basis of this study (ElmiZadeh, 2003: 22). In this regard, two approaches have been considered in urban development (Dawkins and Nelson, 2002: 1-5)

Despite the issues raised in this regard; uncontrolled expansion of cities is a global problem and is predicted more than 65 percent of world population will live in cities till 2025 (Kaya, 2006: 19). However, the rapid increase of urban distribution leaves adverse effects on the environment (Jaeger et al, 2010: 397). One of the important consequences of this type of development is facing urban sprawl with natural and human limitations in the surrounding of towns and pokes their ecology (MC person et al, 1994: 12-17). Despite scientific findings have demonstrated that the pattern of urban widespread development to around is not possible for their development but is prevailing pattern of urban development (Batisane and Yarnal, 2008: 2). In this regard, we can say that, in principle, the establishment and development of a city more than anything else are dependent on the condition or geographical location because the natural phenomena have a strong effect on the location, extent, spheres of influence, physical development and urban morphology. Natural phenomena are sometimes as positive factors and sometimes as negative and deterrent factors (Negaresh, 2003: 133-147). Physical development of the city can have negative effects on the natural environment and the ecological capability of the city (Srivastava and Gupta, 2003: 70-80). Before creating cities or large projects that require more capital and safety conditions addition to socio economic studies should be particular attention to ecological research in the natural and physical environment of cities, if we accept that the main goal of urban planners is urban welfare by creating a better environment, healthier and more favorable (Malczewski, 2004: 46-65). Because to achieve sustainable development and effective and efficient use of resources depends on comprehensive and accurate understanding of the possibilities and limitations that we face in achieving the desired status.

### Research Methodology

The research method is descriptive – analytical. To assess the ecological capability in (GIS,) effective factors, criteria and restrictions as map layers should be processed and analyzed. In this study aimed to assess the potential ecological is used data layers include (apart from agricultural land, the gradient layer, the layer altitude, distance from river, distance from green spaces and recreational layers, layer fault) (Makhdoom, 1999: 208). Given that the decision-making process of a multi-trait can be done using raster model, Should consider the fact that the selected software in addition to the vector model also supported raster model also have ability to use multi-criteria decision-making rules (Ahmadi, 2011: 8).

The AHP method has the following main steps:

- a) Comparison binary matrix production: a major scale with values from 1 to 9 is used to determine the relative priorities of two criteria. (Table: 1).

**Table (1):Comparison binary Scale**

Importance rate	Definition
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very strong to extremely strong importance
9	Extremely strong importance

**Source: (Qodsi pour, 1384)**

- b) Calculate weights of criterion: this step includes: 1. Sum of the values in each column comparison binary matrix. 2. Each matrix component divided into the sum of matrix column (new matrix, is called the comparison binary matrix of normalized). 3. Average estimated components of each row of the normalized matrix.
- c) Estimates the consensus proportion: this step involves the following operations: 1. Determine the vector sum of the weighted by multiplying the weight of the first criterion in the first column of the original comparison binary matrix then multiply the second criterion in the second column, the third criterion in the third column of the original matrix, Finally, sum up the values in rows. 2. Determinates the consensus vector by dividing the weight vector into criteria weights which has already been determined (Malczewski, 1999).

Simple additive weighting model is most common techniques in spatial multi-criterion decision making. This technique is also known as the weighted linear combination or Scoring Method. This method is based on the concept of weighted average. The decision maker or analyst gives weights to the criteria, directly based on the relative importance of each criterion then by multiplying the relative weight of attribute value, a final value for each option (for example, in the analysis of the spatial picture element) is obtained. After that the final value of each option was determined, options, that have the maximum amount, would be the most appropriate option for the target (Shahabi, 2008). Target can be determine the suitability of earth for a particular application or evaluate the potential for a special event. In this way the decision rule, the value of each alternative  $A_i$  is calculated by the following equation.

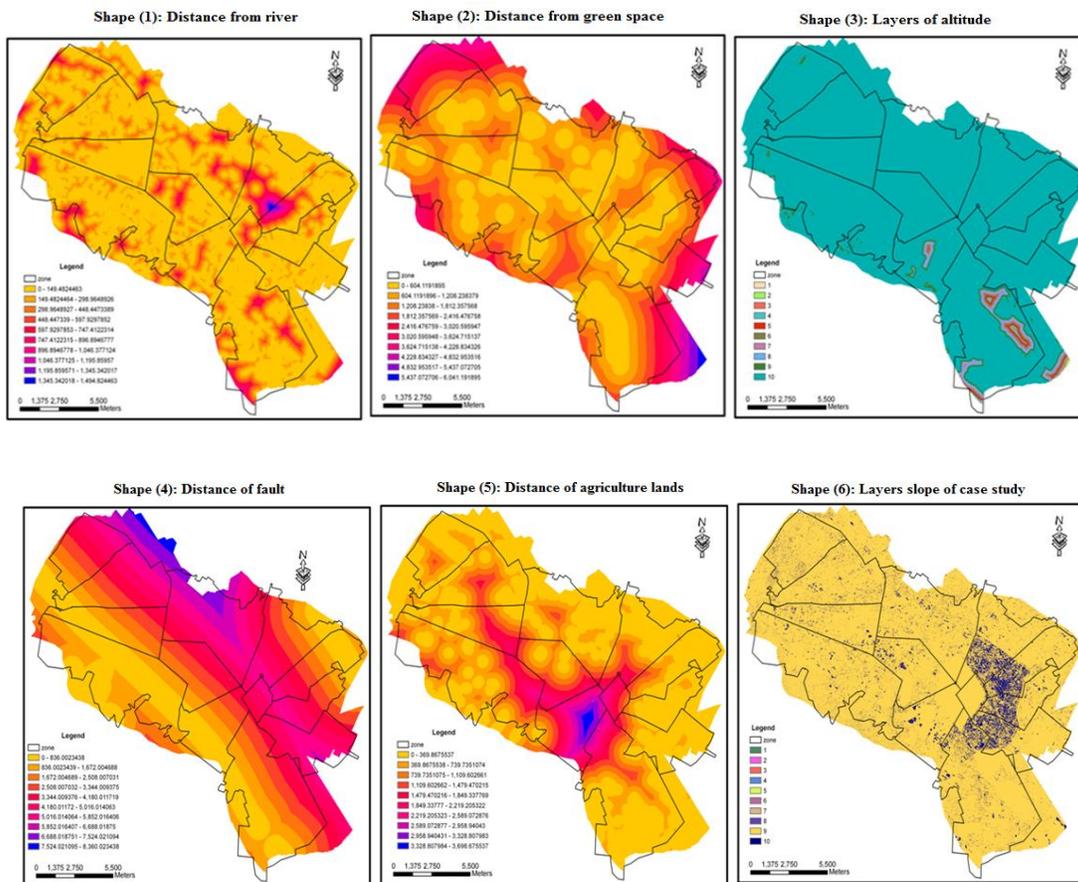
Equation: 
$$\sum w_j = 1$$
 
$$A_i = \sum w_j \times x_{ij}$$

In this formula  $W_j$  is index weight of  $j$ 'th,  $X_{ij}$  is the value that  $i$ 'th position has accepted, in other words, this value can indicate the appropriate level of  $i$ 'th position in associated with the  $j$ 'th index.  $n$  is the total number of indicators and the value of  $A_i$  belongs to the  $i$ 'th position finally.

Simple additive weighting method can be implemented by GIS overlay capabilities. By the overlay techniques in GIS we can produce a composite map layer (Map output) via combined and integrated of input layers (Map input). Using this method is practical in both of raster and vector formats of GIS (Valizadeh & Shahabi:2009).

### Preparation of required layers (criteria) to assess the ecological capability of the study area

This is a process that includes obtaining data format changes, the reference pitch, setting up, and documentation of data (Farajzadeh, 2005: 8). Geographic Information System data are including city digital maps, digital maps of existing land use, surface water network. New layers produced by using existing layers such as: distance from agriculture lands, gradient layer, the layer altitude, distance from the river, distance from green spaces and recreational space layer and layer fault.



**Layers standardization for analysis and evaluation of ecological capability**

To do this, we first compared the individual values and are dedicated the relative importance of each pair, according to the scoring table (2) and it will arrive in a matrix. Then the weights and harmony ratio (CR) is calculated, if this ratio is less than 0.1, the comparison is acceptable and the calculated weights are derived. If the harmony ratio is more than 0.1 then, set it to an acceptable level by applying changes in the comparison binary matrix. Given the weakness in the ArcGIS, Calculates the weights and harmony ratio is done by the Expert Choice. If the ratio (CR) was less than 0.1 it is acceptable and the result will be announced, (Shahabi, 2009). The ratio (CR) for our data was less than 0.1 which indicate an acceptable result.

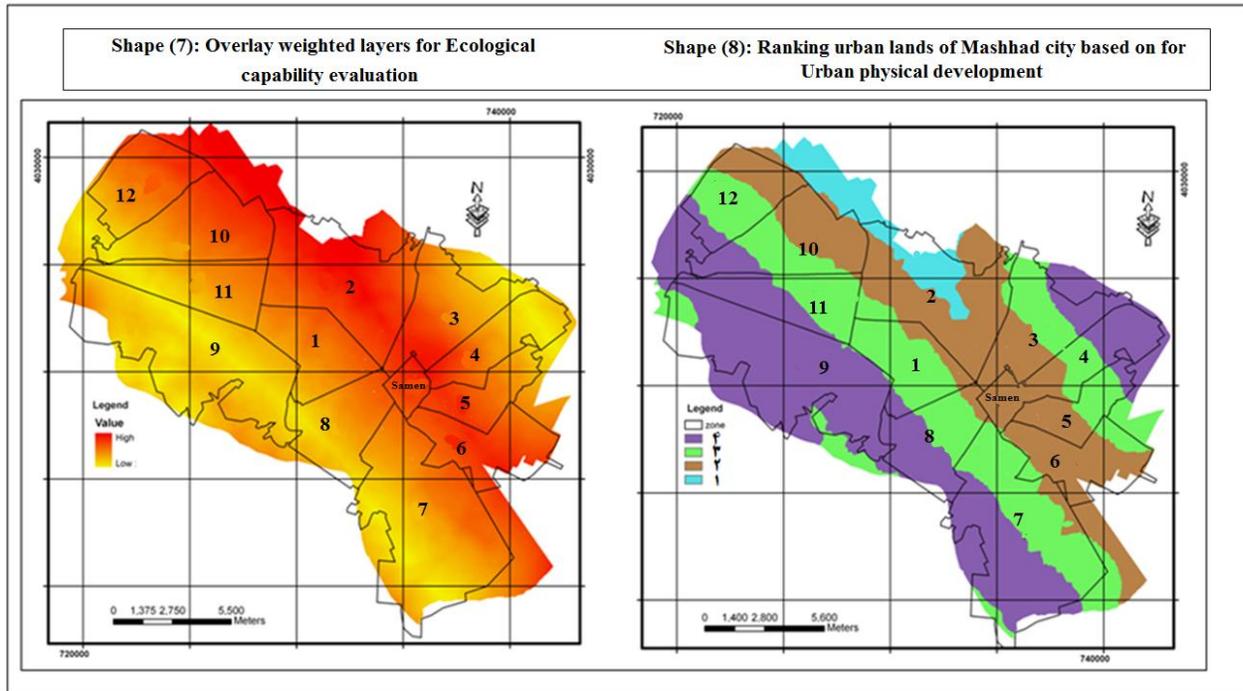
**Table (2):Comparison paired Layer in expert choice**

A	B	C	D	E	F	Criteria
4	6	3	7	2		A
3	2	5	2			B
2	3	7				C
1	5					D
1						E
						F

**Chart (1) :Weighted Chart in Expert choice**



Finally, priority areas in Mashhad were identified for future development by multiplying the weights obtained in effective layers for locating in Weighted Overlay and integration weighted layers in Raster Calculator (Figure (7 and 8)).



Map above shows the best ecological area for physical development in Mashhad. The map shows that the physical development of Mashhad is towards the lands that are ecologically in the next ranks. In recent years Mashhad has developed physically and as a result region 12 were added to Mashhad regions. But ecological evaluation of Mashhad physical development showed that this region is located on the second and third priority. Therefore, it is necessary to develop a comprehensive ecological study in order that Mashhad can have an optimal physical development.

## Results

Basically, we can say that in principle, the establishment and development of a city more than anything else are dependent on the condition or geographical location because the natural phenomena have a strong effect on the location, extent, spheres of influence, physical development and urban morphology. Natural phenomena are sometimes as positive factors and sometimes as negative and deterrent factors (Negaresh, 2003: 133-147). Physical development of the city can have negative effects on the natural environment and the ecological capability of the city (Srivastava and Gupta, 2003: 70-80). Although the rapid expansion and the atonal composition of Mashhad are due to a set of historical, economic - social, political factors but also have been the source of many problems and environmental crises. Given the resulting environmental crisis, goal of this study is ecological evaluation suburb of Mashhad to determine the direction of future development of the city.

Physical environment study is an important task of urban planners and must be done before any other studies because the further planning is done on the basis of this study (ElmiZadeh, 2003: 22). In this regard, Mashhad was examined to identify the direction of future physical development with emphasis on the natural factors. Evaluation results are provided for three classes of high ecological capability, relatively high and low ecological capability. By comparing the resulting maps with land use map of the city, it was found that these lands are located more at a Proper height and slope also away from the fault zone and farmland.

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