The Land capability Assessment For The purpose of Urban and Rural Expansion By a Compilation Of Fuzzy Classification, Fuzzy AHP, And Boolean Logic techniques (case study: Shemiranat County)

Achieving the sustainable development and efficient use of resources depends on comprehensive and accurate understanding of the capabilities and limitations that are faced in achieving the desired status (kiani, 1389). To achieve this goal, different methods of the ecological capability assessment are used. The ecological capability assessment, measures the potential of the land with the certain standards and criteria. This category is a tool for decision-making and land use planning to achieve the sustainable development (Noori, 1381).

The ecological capability assessment in Iran has an outstanding role in its sustainable development andprotection of biodiversity. But unfortunately, in recent decades, a large part of its renewable resources such as pastures, forests, soil and water resources have been destroyed, due to expansion of residential areas and the related activities (tofigh, 1384). So it is necessary to do any national and regional development planning with a vision to the land talents and capabilities (Mirkatuli, 1390).

In this regard, a combination of multi criteria decision making and GIS techniques, to achieve a spatial multi criteria decision making model can help us (Malkzewski,1999). In this article, we began with a review on these spatial models. Knowing their strengths and weaknesses, we assimilate these methods to achieve an optimum model. Ultimately on the basis of this model, we assess the land capability of Shemiranat area for establishing urban and rural land use.

For this study, digital layers of height, slope percentage and aspect has been prepared by means of DEM[1] layer. The annual rainfall average and annual temperature average layers was created using topographical lines of rainfall and temperature.

Shaping the structure of this research, we introduced the Non-Compensatory models first. These models are generally based on Boolean logic _ which is the simplest method for the combination of criteria. Nowadays this method has the most usage in the regional land use planning. The main advantage of the Non-Compensatory models is that they do not accept any risk. It means that in this model, the lands which are recognized as appropriate for an special usage, are definitely the best for

[1] Digital Elevation Model

that regard and also in reality are appropriate for the establishment of that usage. But this Boolean-based model also has some weakness points:

1- This method is one of the Non-Compensatory ones; So non satisfaction of one of the specific criteria would lead to not choosing of that biological unit for the specific usage. But based on reality, different criteria for specifying the Land Capability would cover each other, the using models for this purpose should have enough flexibility in this regard.

2- The sharp boundary of classes will part us from making models according to the reality. This will show the necessity of soft borders determination for the classification of layers, so that in the area between quite appropriate and completely inappropriate, the score of that criterion would tends from 1 to zero with a specific slope.

3- In the mentioned models, the relative importance of all layers is the same. Indeed, according to these models, all of the criteria have an equal weight. But generally and also in specific condition of each region, some of the evaluating criteria are more important.

From here, we are supposed to introduce the Compensatory Models. In these methods the layers are have not been integrated based on Boolean logic, but based on summing the weighted scores of different criteria, so that a composite indicator which shows the combination of total criteria will be attained. So the first problem of non-compensatory methods will be solved.

To remove the second weakness that is the sharpness of boundaries, which distract the model from its natural and real form, we can use the Fuzzy Layers. In spite of the black and white classic logic, In Fuzzy Logic everything is gray, and one phenomenon can be partly black and partly white in an specified time.

Also to remove the problem of equality of the criteria's weights, we will weigh the digital layers using Fuzzy Analytical Hierarchical Process. In this method, comparing the criterions two by two according to the expert ideas, will determine the criteria's coefficients which their sum is one. In Fuzzy AHP technique, Fuzzy numbers are used for paired comparisons. Fuzzy numbers are the generalization of regular numbers, which being used in ambiguity and approximation situations. For this purpose the Extent Analysis Method which was developed in 1996 by Yong Chang will be employed. Although in the real world the weakness of one geographical area in one of the criterions could be covered to some extent by others, but this principal could not be apply absolutely. So to make an optimal model, we will use a combination of

the compensatory methods and non-compensatory ones. For this purpose, we will choose a limit for each criterion in which if one area score in one of criterions goes beyond that limitations, that area will be introduce as a completely inappropriate area, without considering other criteria's scores. We will call them the limitations of criterions.

Eventually we will combine these limitation layers with weighted layers of last stage according to this function:

$$f(x) = (\sum w_i * \mu_i(x)\,) * \prod C_i$$

In above function, C_i is the layer that shows the "limitation" of criterion i and includes 0 and 1 values only. W_i is the weight of criterion i , and $\mu_i(x)$ is the digital layer which represents this criterion score in each pixel.

In this way, combining various methods of Multi Criteria Assessment, we made a model that, despite the simplicity, contains the advantages of each method and is devoid of their weaknesses.

In this article, 8 criterions have been used to assess the land capability for establishment of urban and rural use.

The criterions of temperature, rainfall, slope percentage, land aspect (by degree), and distance from faults as continuously variables, and criterions of the vegetation and geology as discrete variables have been chosen. After making digital layers for each criterion, we made them as Fuzzy layers. We did that by means of continuous desirability functions for the continuously variables, and discrete multi-level desirability functions for the discrete variables.

In the next stage, 4 limitation criteria have been defined as:

The height over 3000 meters; the slope percentage over 30%; the distance from major faults less than 200 meters; and the vegetation type of plantation forests, farming and orchards, or water reservoirs. These 4 limitation layers have been made by a binary form. To determine the weight of each layer by FAHP technique, expert ideas converted to the triangular fuzzy numbers, and then, the weights have been calculated using EA method. By multiplying each criterion's weight by its related layer, and accumulating these weighted layers, and finally multiplying this output layer by mentioned limitation layers, we reach the final map of ecological capability for urban and rural development.

Surveying the output map shows us that about 46 percent of this area has at least one of the 4 limitation factors, so is "completely inappropriate" for urban and rural use. 18 percent of the area is covered by the points which their score is from zero to 0.33 and classified as "approximately inappropriate". Similarly, 24 percents of area's surface is allocated to the "semi appropriate" class with the score between 0.33 and 0.66. Only 12 percent of this area has gained a score above 0.66 and recognized as "appropriate" for urban and rural land use. The limitation of appropriate land for urban expansion is due to limitation factors such as being a mountainous region and existence of major faults like Masha-Fasham and Northeast of Tehran faults in this region. A notable point in this regard is that all the three urban points in this area _ means Tajrish, Lavasan, and Fasham_ are located in the 200 meter buffer of major faults.