Implementation of Agricultural Ecological Capability Model Using Integrated Approach of PROMETHEE II and Fuzzy-AHP in GIS Environment (Case Study: Marvdasht county)

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Introduction

Unsuitable exploitation of land is the most important problem of land resources utilization in the country. Unsuitable pattern of land use together with severe land use changes cause different environmental crisis including: environmental pollution and deterioration, expanding desertification, soil erosion, natural resources depletion, reduction of biological diversity and reduction in potential of land capability. These problems significantly influence the production of resources needed for recent and future generation and prevent sustainable development of the country. In other words, it can be concluded that the reduction of excess resources, is the result of unreasonable using of land by human.

Land use planning is a science that determines the type of land use through studying the ecological character of the land as well as its socio-economic structure. Assessment of ecological capability, as the core of environmental studies provides an appropriate context for environmental planning. To this purpose, the agricultural and rangeland ecological capability assessment was performed using the PROMETHEE II and Fuzzy-AHP (Fuzzy Analytic Hierarchy Processes) methods in combination with GIS. The Fuzzy-AHP method was used to quantify the subjective judgments of the evaluators as the weights of the criteria whereas the PROMETHEE method was employed to prioritize the alternatives based on the weights obtained from the Fuzzy-AHP. The proposed PROMETHEE method can be useful for environmentalists in ecological capability assessment and other site selection issues.

Materials and methods

Study area

The Marvdasht County (29° 15' to 30° 59' N and 51° 44' to 53° 30' E) is located in the north part of Fars province of Iran (Figure 1). The mean elevation of the area is 1620 meters above mean sea level.

An overview of the PROMETHEE II method

The PROMETHEE II is used to provide a complete ranking on a finite set of feasible alternatives from the best to the worst. The basic principle of the technique is based on a pair-wise comparison of alternatives along their recognized criterion. This model is developed to solve multi-criteria problems and its major merit is that the information it requires is easily understandable to analysts and decision-makers. According to Barns (1986), the information needed to implement PROMETHEE II can be classified into two categories:

Weights or information between the criteria

The information between the criteria in fact shows weights representing the relative importance of each criterion. In PROMETHEE II, it is assumed that the decision-maker is able to weight the criteria appropriately.

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Weights are non-negative numbers independent of the measurement units of the criteria. Weighting is a difficult task and is highly affected by the knowledge and skillfulness of the decision-maker. In the present study, the FAHP method was used to weight the eight selected criteria.

Preference function or information within the criteria

A preference function translates the difference between two alternatives for a specific criterion into a preference degree between zero and one. For each criterion, only one preference function should be selected. Several preference functions can be defined; however, the six preference functions - linear, usual, Gaussian, U-shape, V-shape and level criterion - are the most commonly used ones.

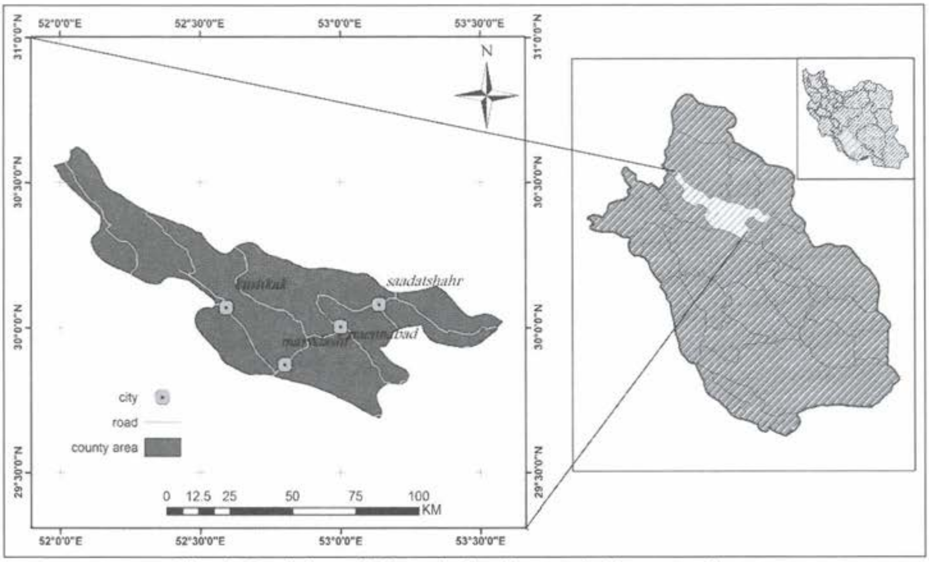

Fig. 1: Position of Marvdasht County in Fars province

Determining necessary parameters for PROMETHEE II

In the present study some criteria (i.e., texture of soil, climate, and vegetation density) have maximal effects whereas some others (i.e., slope, elevation and erosion) have minimal effects. On preference function type, Gaussian function was deployed for practical purposes especially for the continuing data. Hence, this function was selected for criteria containing continuity. For discrete data, the V-shape preference function was used. The Fuzzy-AHP method was followed in order to weigh the criteria. The necessary information to run PROMETHEE II and the weights of the criterion presented in table 1.

Table 1: Necessary parameters to run PROMETHEE II

Weight of Criteria	s	Preference function	Max/Min	Unit	Criteria
0.2558	35.29	Gaussian	Min	percent	Slope
0.1829	-	V-shape	Max	-	Texture of soil
0.1226	-	V-shape	Max	-	Drainage of soil
0.1064	1827.85	Gaussian	Min	meter	Elevation
0.0777	-	V-shape	Min	-	Erosion
0.1311	-	V-shape	Max	-	Climate
0.1105	53.25	Gaussian	Max	percent	Vegetation Density
0.0777	-	V-shape	Max	-	Vegetation Type

Discussion

Agricultural and rangeland ecological capability using integrated approach of PROMETHEE II

The overall process of the agricultural and rangeland ecological capability has been schematically presented in figure 2. The collected data related to 8 parameters was analyzed in the present work. Having collected the information layers according to the flowchart, the eight information layers were converted into the raster format in the GIS environment in order to implement PROMETHEE II, and the preliminary spatial analyses were performed on them.

Following this, the pixel values of the raster datasets related to the agricultural and rangeland ecological capability criteria were extracted and stored in eight separate fields in a database.

In addition to implement PROMETHEE II method some software (e.g., Decision Lab, D-sight) can be utilized. In the present research due to the large volume of the database the programming was done using MATLAB. After the database was imported into MATLAB, and necessary information to run PROMETHEE II and the weights of the criterion (presented in table 1) were determined. The values of the net out ranking flow were calculated for each alternative (each pixel of the raster dataset) using MATLAB programming. Finally, the values of the net out ranking flow were converted to a raster dataset which was in fact the land suitability map. The land suitability map was classified in seven equally scored classes from the least suitable to the most suitable areas. The results of the study show that the agricultural areas with capability 1 to 3 are located on slopes of 0-5 percent, soils with high fertility (Clay and sandy loam) and low erosion.

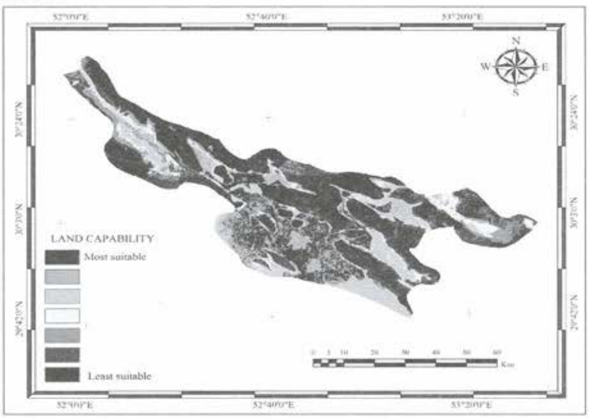

Fig. 2: final land capability map

Conclusion

The natural environment remains for humans if they use limited ecological capacity. In some environments, nature is prepared for developing with minimal damage while in some others the least development leads to environmental degradation. This implies that to develop environment ecological capacity assessment in the form of a coherent and methodical planning should be done. The results of the study indicate the efficiency of the MCDA in ecological capability and effectiveness of PROMETHEE II in the rapid assessment of large areas. The present work proposes an innovative method for ecological capability and can help policy and decision-makers to approach environmental management. The proposed technique can be as a main step in using PROMETHEE II in other raster-based site selection projects in the GIS environment.

Key Words

Land use Planning, Ecological Capability Assessment, PROMETHEE II, Fuzzy- AHP, Marvdasht