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Modelling Ecotourism Zoning Using FAHP—Case Study: Masal Area

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Abstract: This study aimed to identify and select areas suitable for ecotourism. In this research, to assess the potential of ecotourism of Masal district, Fuzzy Analytical Hierarchy Process (FAHP) and GIS were used. For this purpose, appropriate evaluation criteria and sub-criteria were identified for determining recreational potential. Then, using AHP fuzzy, criteria and sub-criteria to determine the importance of assessing the potential recreational area prepared questionnaires and, were distributed among clinicians. Weighted criteria and sub-criteria in each questionnaire were calculated and by averaging the weights, final weight was calculated using the model. The required maps for evaluating of the recreational potential were generated by using GIS software and then these data layers were standardized using pertained function in IDRISI. Finally, the final map of recreational potential was prepared. The results of the final map of ecotourism potential showed that 89.97, 8.61 and 1.42 percent of the total area have very high, low and no potential for ecotourism activities, respectively. Areas with a high density of vegetation and water resources with suitable climatic conditions have the greatest potential for ecotourism activities in the study area. Area with low and poor ecotourism potential are central and eastern parts of the region, and there are low density of ecotourism activities and facilities in this area.

Key words: Zoning ecotourism, FAHP, GIS, Masal.

Introduction

At the end of the last century, tourism became the world's fastest growing industry with the important role in the global economy (Loperz, 2002). Tourism is an ancient phenomenon that has always existed in human societies (Davenport and Julia, 2006). But the new tourism has emerged along with the industrial revolution in England and the increase in private vehicles in the mid-nineteenth century and later expanded so that from 1945, tourism grew rapidly and now has the highest growth among other economic sectors and now is among the world's three major industries (Kurttila and Pesonen, 2000). Ecotourism is a form of tourism that has its roots in nature and open environments. Ecotourism is responsible travel to nature, to preserve the environment and to increase local people's welfare (Bunruamkaew and Murayama, 2012).

The increasing pressure of human population on natural resources, limitations in natural and undisturbed areas for recreation, and lack of planning for ecotourism are the main obstacles that make tourists unable to travel to nature and enjoy natural attractions.

Also high population density in nature could be the main reason for degradation in some areas. So planning in such natural areas not only could promote social and

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economic status of people but also a comprehensive management planning could provide continuous monitoring and protection plans (Laurance et al., 2005). For ecotourism sites planning, it is necessary that the ecological potential of an area for recreation be determined based on its ecological features (Gulinck et al., 2000). Today, GIS is a powerful tool in land evaluation and as a spatial decision support system. GIS can increase the accuracy and speed of work and reduce the cost of evaluation (Li et al., 2007). Fuzzy model is suitable for preparation of maps used. This model requires less parameters and accuracy is also high (Rajesh and Slobodan,2010). The most important reasons for using the fuzzy or combination of fuzzy and fuzzy hierarchical analysis process (FAHP) relative to the hierarchical classical process of analysis is that, in the classical method of the hierarchical analysis process, the validity of the two-to-two comparisons was expressed by definite numbers (Saaty, 1987). Now that depending on the circumstances, experts cannot always define in precise form that this uncertainty can be indicated with fuzzy logic (Jiang and Eastman, 2000).The results of the comparisons in the method of AHP, especially in terms of time and place that is Space Studies, has always been a bias error. More precisely, in the present study, if the AHP method was used instead of the FAHP method, the importance of comparing the two indicators among all the existing indicators was the same. However, an indicator may be less or more important than other indicators, depending on the temporal and spatial circumstances. If this is not always an indicator depending on the circumstances of time and place, it can be more or less important than other indicators. In fact, what fuzzy logic does is to transform human knowledge within the framework of mathematical relations.

In this study, fuzzy model, fuzzy analytic hierarchy process (FAHP) and geographic information system (GIS) were used to identify potential areas for ecotourism activities. In relation to the evaluation of recreational potential and ecotourism, based on multi-criteria methods with the combination of FAHP and GIS can be Bukenya's (2000) studies at Uganda National Parks. Gul et al. (2006) in the nature park of Turkey's Chukchi, evaluated the potential of the region for recreation. In another study, Kumar et al. (2010) by using Analytical Hierarchy Process examined ecotourism potentials of Sikkim state in India.

In Iran, few studies were carried on in relation to ecotourism using conventional methods (Makhdom, 2010). For example, Farajzadeh and Karami (2004) in the Khorramabad area, investigated the potential of the area for ecotourism. Shirvani (2009) conducted a study to evaluate recreational capability using three different methods, including the hierarchical analysis process in Neka area. Few other studies have been done in Varjin, Isfahan for assessing the potential of areas for ecotourism by using AHP (Jozi et al., 2010; Hajehforooshnia et al., 2011).

This study attempts to assess the feasibility and potential of ecotourism in Masal district.

Study Area

The study was conducted at Masal area, located in the north of Iran (Figure 1). The study area is about 617.4 square kilometres, at an elevation of 84 metres above sea level. The region is one of the major tourist destinations due to its special geographical, climatic and beauty paradigm with numerous ecotourism attractions.

Materials and Methods

Relevant data and maps were gathered from related departments, literatures and field works. In this study to assess the extent of the potential of ecotourism, the most important criteria including natural, topography, socio-economic and environmental with a brief description and references from authors of similar studies have been used. These criteria were used to form the basic structure of conceptual framework of research. To locate the potential areas for ecotourism, fuzzy hierarchical analysis model was used. As is customary in the fuzzy hierarchical analysis method, this conceptual framework for the series has been developed hierarchically.

To collect information for the FAHP model, a nine-language linguistic variables questionnaire was used. Thirty-nine experts in the field of ecotourism and tourism, often from the staff of the Cultural Heritage, Environment and students, and specialists in ecotourism filled the questionnaire. Research flow diagram is presented in Figure 2.

Method of Calculation

In this research, Chang's development analysis method was used to determine the importance of factors and prioritize them (Chang, 2008). In order to implement this method, first we have to integrate the views of different experts using the nine-language linguistic variables based on the fuzzy method of the questionnaire, through the geometric meanings (Table 1). But since an

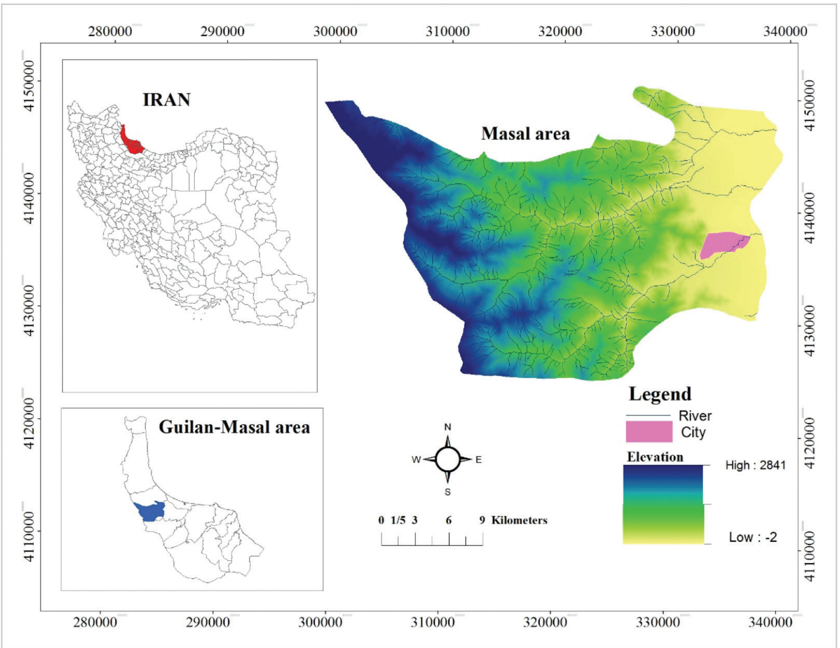

Figure 1: The geographical position of the study area.

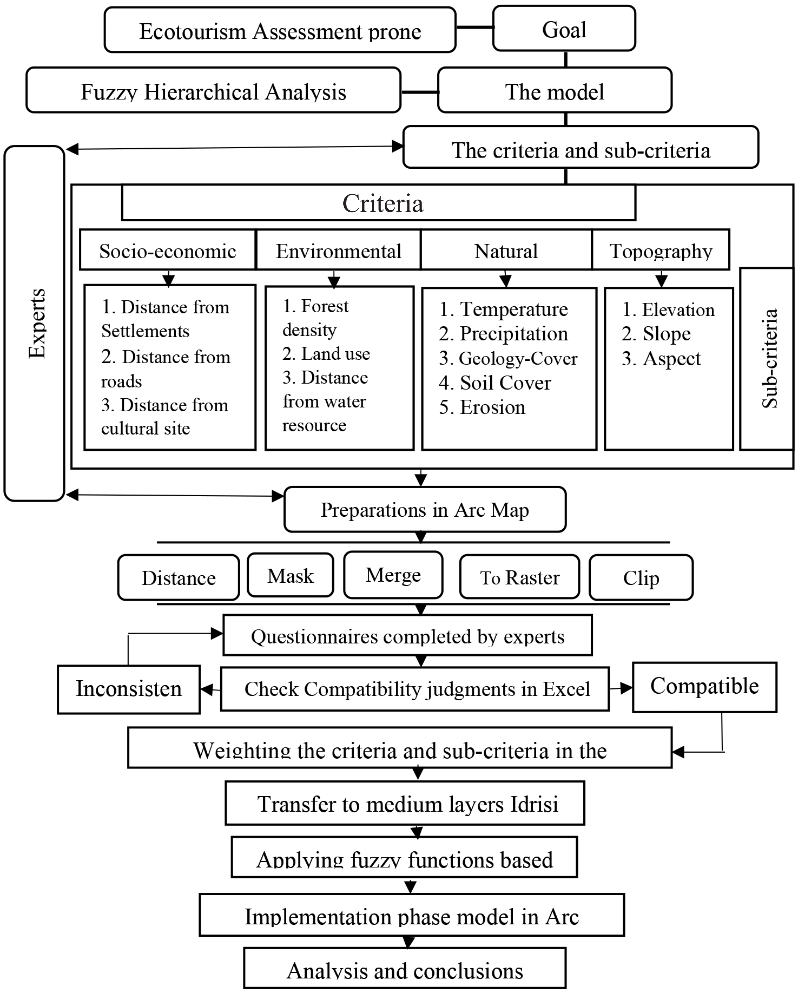

Figure 2: The research flow diagram.

incompatible matrix can lead to confusion in results, control over compatibility is necessary.

After combining the matrices of the paired fuzzy comparisons of different experts, the compatibility of each matrix must be determined.

Computation of Compatibility of Fuzzy Couple Comparison Matrices

Almost all calculations of the hierarchical analysis process are based on the decision maker's initial judgement that appears in the form of a paired comparison matrix and any errors and incompatibilities in comparison and determining the importance between the index and the criteria distort the final result of the calculation.

Experience has shown that if the inconsistency rate is less than 0.1, compatibility of the comparisons is acceptable and otherwise the comparisons should be reviewed (Saaty, 1994). In order to verify compatibility, it is necessary to first compile the data of the comparison of the paired-matrix $\tilde{A}$ in the form of triangular fuzzy numbers (Triangular fuzzy numbers are obtained from the values of each expert's preferences):

$$\overline{\text{A}}\ (a,b,c) \tag{1}$$

To find compatibility rates, the fuzzy weight vector $\tilde{W}_i$ of each matrix (with the fuzzy arithmetic mean method) should be calculated. Because matrices contain fuzzy numbers (triangular), the matrix data should be normalized. To normalize the fuzzy numbers, a definitive method is used:

$$\tilde{N}_i = \left(\frac{C_i}{\sum_{i=1}^{n} a_i}, \frac{b_i}{\sum_{i=1}^{n} b_i}, \frac{a_i}{\sum_{i=1}^{n} c_i} \right) \tag{2}$$

N is matrix dimension. The maximum specific values ($\tilde{\lambda}_{\max}$) for each matrix is calculated by the following relationship:

$$\tilde{\lambda}_{\max(i)} \tilde{w}_i = \tilde{w}_i \times \tilde{A} \tag{3}$$

$$\tilde{\lambda}_{\max(i)} = \frac{\tilde{\lambda}_{\max} n}{\tilde{w}_i} \tag{4}$$

Fuzzy incompatibility index $(\widetilde{I.I.})$ is calculated using the following equation (n is matrix dimension):

$$(\widetilde{I.I.}) = \frac{\tilde{\lambda}_{\max}\ n}{n-1} \tag{5}$$

The incompatibility of fuzzy matrix $\tilde{A}\,(\widetilde{I.R.})$ is obtained using the following formula:

$$(\widetilde{I.R.}) = \frac{\widetilde{I.I.}}{I.I.R} \tag{6}$$

In this equation, I.I.R is incompatibility index of random matrix. This index is calculated for matrices which numbers have been picked completely randomly, their values for the n-dimensional matrices are in accordance with Table 2. In other words, in each matrix, the result of dividing the incompatibility index on the random matrix of the same dimension, is a suitable measure for judging the matrix incompatibility

Table 1: Nine-linguistic variables based on fuzzy

		Fuzzy number			*Number reverse phase*		
Value	*Verbal expressions*	1	*m*	*u*	1	*m*	*u*
1	Prefer to	1	1	1	1	1	1
2	Prefer low to moderate	1	2	3	0.333	0.5	1
3	Preferred medium	2	3	4	0.5	0.333	0.25
4	Preferred medium to high	3	4	5	0.333	0.25	0.2
5	Most preferred	4	5	6	0.25	0.2	0.166
6	Rather high to very high	5	6	7	0.2	0.166	0.142
7	Rather too much	6	7	8	0.166	0.142	0.125
8	Too much prefer to be quite high	7	8	9	0.142	0.125	0.111
9	Preference is quite high	9	9	9	0.111	0.111	0.111

Table 2: Incompatibility of values of random matrices with different dimensions

n	1	2	3	4	5	6	7	8	9	10
I.I.R	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.45

which is called incompatibility rate. If this number is less than or equal to 0.1, the matrix has approximate matrix compatibility; otherwise, judgements should be revised. In this study, the standard Chang fuzzy numbers are used, which govern between the lower limit, the mean value, and the upper limit of each number, and so. Therefore, with the incompatibility of each of the matrices, the total matrix preference must be revised (Cheng et al., 2007). After obtaining the degree of incompatibility of the paired comparison tables, they should be compared to 0.1 to realize compatibility or incompatibility of these tables.

Baldwin method is used to compare the incompatibility of the table with 0.1. But because the Baldwin method is used to compare fuzzy numbers, we can find the fuzzy incompatibility values approximated by triangular fuzzy numbers, the 0.1 could be written as (0.1, 0.1, 0.1) and then compare the incompatibility of the paired comparison tables with this number. With this description, it can be estimated that a fuzzy paired comparison table is consistent or incompatible.

Calculation of Fuzzy Weights Using FAHP Process

In the Chang's fuzzy AHP (EA), each of the Matrix coefficients are calculated to determine the importance of the factors of each level. Thus, for each rows of the matrix of pairwise comparison, the S_K value which is a triangular fuzzy number, is calculated using equation (7) and to calculate each component of this relationship, equations (8), (9) and (10) are used:

$$S_k = \Sigma_{i=1}^{m} M_{ki}^{j} \otimes \left[\Sigma_{i=1}^{n} \Sigma_{j=1}^{m} M_{ki}^{J} \right] \quad (7)$$

To calculate each of the sections above, the following are used:

$$\Sigma_{j=1}^{m} M_{gi}^{j} = \left(\Sigma_{j=1}^{m} l_j, \Sigma_{j=1}^{m} u_j, \Sigma_{j=1}^{m} m_j \right) \quad (8)$$

$$i = 1, 2 \ldots n$$

$$\left[\Sigma_{i=1}^{n} \Sigma_{j=1}^{m} M_{ki}^{J} \right] = \left[\frac{1}{\Sigma_{i=1}^{n} u_i}, \frac{1}{\Sigma_{i=1}^{n} m_i}, \frac{1}{\Sigma_{i=1}^{n} l_i} \right] \quad (9)$$

After calculating all S_k, in this step, the magnitude of each element of the level should be calculated separately using the following equation:

$$V(S_2 \geq S_1) = \begin{Bmatrix} 1 & \text{if} & m_2 \geq m_1 \\ 0 & \text{if} & l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} & \end{Bmatrix} \quad (10)$$

In the next step, the magnitude of each element over other entire elements should be calculated. For example, we calculate the magnitude of S_2 over other elements as follows:

$$V(S_2 \geq S_1, S_2, S_3, \ldots \ldots S_k)$$
$$= \min V(S_2 \geq S_i) \; i = 1,2, \ldots k \quad (11)$$

Therefore, abnormal weight of each row is obtained.

$$w = \min V\,(S_1 \geq S_2),) \min (V(S_2 \geq S_i), \ldots,$$
$$\min V\,(S_k \geq S_i)) \; i = 1, 2, \ldots, k \quad (12)$$

Then, using the normal methods of Saaty abnormal weight matrix by dividing each element of the sum of the matrix elements can obtain the appropriate level of each of elements. Using Saaty methods (Saaty, 1990), by dividing each element of an abnormal weighted matrix by the sum of the elements of the same matrix, the weight of each element of the corresponding level could be obtained.

Standardization of Criteria Maps for the Composition of Fuzzy Layers with the Weights Derived from the FAHP Model

In fuzzy logic, each point takes membership value according to the amount that the criterion meets and the amount of membership is indicative of the desirability of that area. This means that each area, with higher membership, is more desirable. In fuzzy logic, there is no certainty as it is in the Boolean logic, and each layer is ranked on a scale between zero and one. On these scales, larger numbers will be more desirable, that is, the number of one has the highest desirability and the zero has no desirability, and a range of values will be between these two numbers. In addition to selecting the scale for fuzzy maps, it is also essential to examine the type of fuzzy function and select the appropriate function for the desired criterion. The membership function specifies the fuzzy value of a fuzzy set. In fuzzy standardization method, to re-format values, functions such as S-shaped, J-shaped and linear are used. One of the points that should be considered in the standardization of fuzzy mapping is the thresholds, which are also referred to as control points.

Findings and Analysis

Determine the Criteria of Assessing the Ecological Ecotourism

In this study, according to experts opinions and studies to evaluate the potential of ecotourism in such area, 14 sub-criteria or layers including slope, aspect, elevation, vegetation, temperature, precipitation, soil type, erosion, geology, land use, distance from water sources, distance from roads, distance from settlements, distance from cultural heritage sites in the form of four criteria including topography, natural, socio-economic and environment were considered. Table 3 shows criteria, sub-criteria and classification of layers in the process of evaluating the ecotourism potential of the study area.

Collect and Prepare Data

In the process of site selection, the first step of the research project is extracting required data of study area such as soil, geology, land use, etc. These data should be presented as shape file. Each shape file data was in scale 1/50000 and collected from relevant departments and sources. The Landsat 8 image was used to prepare layers of the earth's surface temperature and vegetation index (NDVI). After providing the layers of information,

Table 3: Criteria, sub-criteria and method of classification layers, threshold values and fuzzy function

Criteria	*Fuzzy and shape membership function*	*Control points/ Value points*	*Final utility*
Elevation	Linear monotonically increasing	a = 50 m b = 500 m	0–50 m equal 0, 50–500 m between 0 and 1, more than 500 m equal to 1
Slope	Linear monotonically decreasing	c = 2% d = 65%	0–2% equal 1, 2–65% between 1 and 0, more than 65% equal to 0
Aspect	Sigmoidal symmetric	a = 22.5° b = 157.5° c = 202.5° d = 337.5°	337.5–22.5° equal 0, 22.5–157.5° between 0 and 1, 157.5–202.5° equal 1, 202.5–337.5° between 1 and 0
Temperature	Sigmoidal symmetric	a = 17°C b = 19.8°C c = 20.2°C d = 22°C	Less than 17 °C and more than 19.8 °C equal 0, 17–19.8 °C between 0 and 1, 19.8–20.2 equal 1, 20.2–22 °C between 1 and 0
Precipitation	Sigmoidal symmetric	a = 600 mm b = 750 mm c = 800 mm d = 950 mm	Less than 600 mm and more than 750 mm equal 0, 750–800 mm between 0 and 1, 800–950 mm equal 1
Geology cover	Discrete categorical data	Granite, gneiss, quartz equal 1, limestone equal 0.8, conglomerate equal 0.6, alluvium, clay equal 0.4, gypsum, gravel equal 0.2, sandstone equal 0.1	
Soil cover	Discrete categorical data	Rendzina equal 1, loam, clay, equal 0.8, clay-loam sandy-loam equal 0.6, brown soil, vertisol equal 0.4, sandy, alluvial equal 0.2, silt-loam equal 0	
Erosion	Discrete categorical data	Very low equal 1, the low equal 0.8, an average equal 0.6, high-value equal 0.4, high equal 0.1.	
Land use	Discrete categorical data	Forests equal 1, meadows equal 0.8, vineyards equal 0.6, agricultural equal 0.2, urban and industrial equal 0.	
Forest density	Linear monotonically increasing	a = 10% b = 70%	0–300 m equal 0, 300–10000 m between 0 and 1, more than 10000 m equal to 1
Distance from settlements	Linear monotonically increasing	a = 100 m b = 3000 m	0–100 m equal 0, 100–3000 m between 0 and 1, more than 3000 m equal to 1
Distance from roads	Linear monotonically decreasing	c = 100 m d = 3000 m	0–100 m equal 1, 100–3000 m between 1 and 0, more than 3000 m equal to 0
Distance from cultural site	Linear monotonically decreasing	c = 300 m d = 8000 m	0–300 m equal 1, 300–8000 m between 1 and 0, more than 8000 m equal to 0
Distance from water resource	Linear monotonically decreasing	c = 100 m d = 3000 m	0–100 m equal 1, 100–3000 m between 1 and 0, more than 3000 m equal to 0

a = membership rises above 0; b = membership becomes 1; c = membership falls below 1; d = membership becomes 0.

all layers of the earth should be dereferenced and entered in GIS database for the next steps. Among the criteria mentioned above, four criteria of distance from water resources, distance from the road, distance from residential areas, and distance from cultural sites, their distance from the centre and the districts, should be produced in the raster format and also four criteria geology, soil, erosion intensification and land use should be transformed into the Raster format that could be performed using the commands and functions in ArcGIS 10.1 software.

Determining Factor in the Assessment of the Importance of Ecotourism Index Using FAHP

In the first stage, after determining the criteria and sub-criteria, in order to apply a fuzzy hierarchy process, questionnaires were developed for the formation of pairwise matrices for implementation of the model. After combining the matrix of paired fuzzy comparisons of different experts, the compatibility of each matrix should be determined. Satie and Baldwin (1980) method was used for this work; according to the results of the comparisons, all the comparison tables have approximate compatibility. Through survey, based on experts view, it was found that these criteria have different impact in assessing the potential of ecotourism. Therefore, based on their impact and importance, they should be given different weights. For this purpose, weights of criteria and sub criteria were obtained from the method of fuzzy hierarchy process analysis (FAHP) using MATLAB R2014a software (Tables 4 and 5).

Fuzzy-building Measures

For fuzzification, the layers should be in the form of a raster, so the point and line layers (distance from residential areas, distance from the river and springs, distance from the road and cultural sites) using distance analysis and for the polygon layers (geology, soil, erosion intensity, land use, vegetation) have been coded according to the theory of their suitability for ecotourism users, by giving the code 1 and up; the Feature to Raster analysis turns into raster layers. The slope, aspects, height, temperature, precipitation, which were raster, were directly standardized. After changing the layer format to raster layers, using the IDRISI functions fuzzification was done. Among the most popular default functions in IDRISI software there are some others such as sigmoidal, linear and user define. Table 3 shows the threshold values and the type of fuzzy function for standardization of criteria maps in fuzzy logic.

Final Layer Overlaid

In this study, using 14 selected criteria (slope, aspect, elevation, temperature, precipitation, land use, vegetation, land geology, soil, erosion, distance from water sources, distance from the road, distance from cultural site and distance from settlements), layers of interest in Arc Map of preparing and applying weights of processes weighting in MATLAB FAHP were provided by a model and then these layers in IDRISI software were standardized (Figure 3). Then, using the Raster Calculator in Arc GIS software layer multiplied by the weight of each layer in the map have the same phase (Figure 4).

Conclusion and Summary

In order to evaluate the potential of ecotourism in Masal area, FAHP technique combined with GIS was used. In assessing the potential of tourism in this study, fourteen sub layers including slope, aspect, elevation, geology, soil, erosion, land use, forest density, distance from water sources, distance from roads, distance from settlements, distance from cultural sites, temperature, and precipitation in the form of four criteria including topography, natural, environmental, socio-economic were used.

In assessing tourist potential in the conventional approach, slope is the most important factor. So if the slope of planning unit is inappropriate for recreation, the evaluation of other parameters is discarded and the evaluation process is stopped (Makhdom, 2010). But in studies including Farajzadeh and Karami (2004), Shirvani (2009), Arenberger (2006), Kumari et al. (2010) and Hajehforooshnia et al. (2011), although the slope is mentioned as an important factor in the assessment of recreational potential, it showed that the importance of criteria and factors depends on the conditions of the region. In assessing the ecotourism potential northern and eastern aspects usually are used for recreation in summer and South and West are perfect for winter (Makhdom, 2010). In the study area, all four main aspects have roughly equal area, indicating that the area is suitable for both summer and winter recreation. Since the season to visit natural and forest parks due to the availability of favourable holidays and climates is more spring and summer (Babaie-Kafaky et al., 2009), more score was given to eastern and northern aspects. Regarding the elevation of the area, although the region is very diverse, most area of the area is below 1120 metres above sea level, which shows that the area of the region has a desirable recreational elevation (Farajzadeh

Table 4. Pairwise comparison matrices including measures to target

The average matrix of criteria					
Topography		*Natural*	*Environmental*	*Socio-economic*	
Topography	(1, 1, 1)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	
Natural	(0.33, 0.5, 1)	(1, 1, 1)	(1, 2, 3)	(1, 1, 1)	
Environmental	(0.33, 0.5, 1)	(0.33, 0.5, 1)	(1 ,1 ,1)	(1, 1, 1)	
Socio-economic	(0.33, 0.5, 1)	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)	
Matrix of pairwise comparison criteria "Natural"					
Temperature		*Precipitation*	*Geology cover*	*Soil cover*	*Erosion*
Temperature	(1, 1, 1)	(0.25, 0.33, 0.5)	(1, 1, 1)	(0.25, 0.33, 0.5)	(0.25, 0.33, 0.5)
Precipitation	(2, 3, 4)	(1, 1, 1)	(0.33, 0.5, 1)	(0.33, 0.5, 1)	(0.33, 0.5, 1)
Geology Cover	(1, 1, 1)	(1, 2, 3)	(1, 1, 1)	(0.33, 0.5, 1)	(0.33, 0.5, 1)
Soil Cover	(2, 3, 4)	(1, 2, 3)	(1, 2, 3)	(1, 1, 1)	(0.33, 0.5, 1)
Erosion	(2, 3, 4)	(1, 2, 3)	(1, 2, 3)	(1, 2, 3)	(1, 1, 1)
Matrix of pairwise comparison criteria "Environmental"					
Vegetation		*Land use*	*Distance from water resource*		
Forest density	(1, 1, 1)	(0.33, 0.5, 1)	(0.33, 0.5, 1)		
Land use	(1, 2, 3)	(1, 1, 1)	(0.33, 0.5, 1)		
Distance from water resource	(1, 2, 3)	(1, 2, 3)	(1, 1, 1)		
Matrix of pairwise comparison criteria "Topography"					
Elevation		*Slope*	*Aspect*		
Elevation	(1, 1, 1)	(0.33, 0.5, 1)	(1, 1, 1)		
Slope	(1, 2, 3)	(1, 1, 1)	(1, 1, 1)		
Aspect	(1, 1, 1)	(1, 1, 1)	(1, 1, 1)		
Matrix of pairwise comparison criteria "Socio-economic"					
Distance from settlements		*Distance from roads*	*Distance from cultural*		
Distance from settlements	(1, 1, 1)	(0.33, 0.5, 1)	(0.5, 0.33, 0.25)		
Distance from roads	(1, 2, 3)	(1, 1, 1)	(1, 1, 1)		
Distance from cultural	(1, 2, 3)	(1, 1, 1)	(1, 1, 1)		

and Karami, 2004; Gul et al., 2006; Shirvani, 2009; Kumari et al., 2010). In this study, vegetation coverage was another criteria in assessing recreational capability of the region.

The results of analysis of vegetation density showed that most of the area has a dense vegetation density. In this study, the lands with the average density has granted the highest scores, and the lowest points were given to areas with massive and uncoated areas.

Water resources are very effective in shaping the flow of tourism in one place and adds great value to the tourist attraction of the area. Springs are also the source of drinking water, recreation and landscape values are for all age groups (Shirvani, 2009). Therefore, in this study, the distance from water resources was used as an important factor in the recreational capacity of the area.

Table 5: Fuzzy numbers with non-fuzzy and fuzzy weights extracted from the software MATLAB R2014a

Matrix 1 – Extracted weight non-fuzzy and fuzzy "main criteria" software MATLAB R2014a

Criteria	S_K		*Weights* Non-fuzzy weight	*Fuzzy weight*	*Priority*
Topography	$S_T = (0.16, 0.42, 0.80)$	$V(S_T \geq S_i) = 0.8$	0.8	0.15	4
Natural	$S_N = (0.13, 0.27, 0.48)$	$V(S_N \geq S_i) = 0.5$	0.5	0.24	3
Environmental	$S_E = (0.11, 0.18, 0.32)$	$V(S_E \geq S_i) = 1$	1	0.30	1
Socio-economic	$S_S = (0.13, 0.21, 0.32)$	$V(S_S \geq S_i) = 0.933$	0.933	0.28	2
				Total = 1	

Matrix 2 – Extracted weight non-fuzzy and fuzzy "Topography criteria" software MATLAB R2014a

Topography	S_K		*Weights* Non-fuzzy weight	*Fuzzy weight*	*Priority*
Elevation	$S_{T1} = (0.21, 0.28, 0.36)$	$V(S_T \geq S_i) = 0.5$	0.566	0.27	2
Slope	$S_{T2} = (0.27, 0.44, 0.60)$	$V(S_{T2} \geq S_i) = 1$	1	0.49	1
Aspect	$S_{T3} = (0.27, 0.33, 0.36)$	$V(S_{T3} \geq S_i) = 1$	0.461	0.22	3
				Total = 1	

Matrix 3 – Extracted weight non-fuzzy and fuzzy "Natural criteria" software MATLAB R2014a

Natural	S_K		*Weights* Non-fuzzy weight	*Fuzzy weight*	*Priority*
Temperature	$S_{N1} = (0.28, 0.27, 0.22)$	$V(S_{N1} \geq S_i) = 0.46$	0.46	0.18	3
Precipitation	$S_{N2} = (0.28, 0.27, 0.22)$	$V(S_{N2} \geq S_i) = 0.3$	0.3	0.12	4
Geology cover	$S_{N3} = (0.14, 0.17, 0.16)$	$V(S_{N3} \geq S_i) = 0.002$	0.002	0.0008	5
Soil cover	$S_{N4} = (0.17, 0.17, 0.14)$	$V(S_{N4} \geq S_i) = 0.7$	0.7	0.284	2
Erosion	$S_{N5} = (0.09, 0.08, 0.08)$	$V(S_{N5} \geq S_i) = 1$	1	0.406	1
				Total = 1	

Matrix 4 – Extracted weight non-fuzzy and fuzzy "Environmental criteria" software MATLAB R2014a

Environmental	S_K		*Weights* Non-fuzzy weight	*Fuzzy weight*	*Priority*
Forest density	$S_{E1} = (0.28, 0.45, 0.66)$	$V(S_{E1} \geq S_i) = 0.6$	0.6	0.23	2
Land use	$S_{E2} = (0.28, 0.45, 0.66)$	$V(S_{E2} \geq S_i) = 1$	1	0.38	1
Distancefrom water resource	$S_{E3} = (0.11, 0.15, 0.22)$	$V(S_{E3} \geq S_i) = 1$	1	0.38	1
				Total = 1	

Matrix 5 – Extracted weight non-fuzzy and fuzzy "Socio-economic criteria" software MATLAB R2014a

Socio-economic	S_K		*Weights* Non-fuzzy weight	*Fuzzy weight*	*Priority*
Distance from settlements	$S_{S1} = (0.28, 0.45, 0.66)$	$V(S_{S1} \geq S_i) = 0.3$	0.37	0.42	1
Distance from roads	$S_{S2} = (0.28, 0.45, 0.66)$	$V(S_{S2} \geq S_i) = 1$	1	0.42	1
Distance from cultural	$S_{S3} = (0.11, 0.15, 0.22)$	$V(S_{S3} \geq S_i) = 1$	1	0.42	1
				Total = 1	

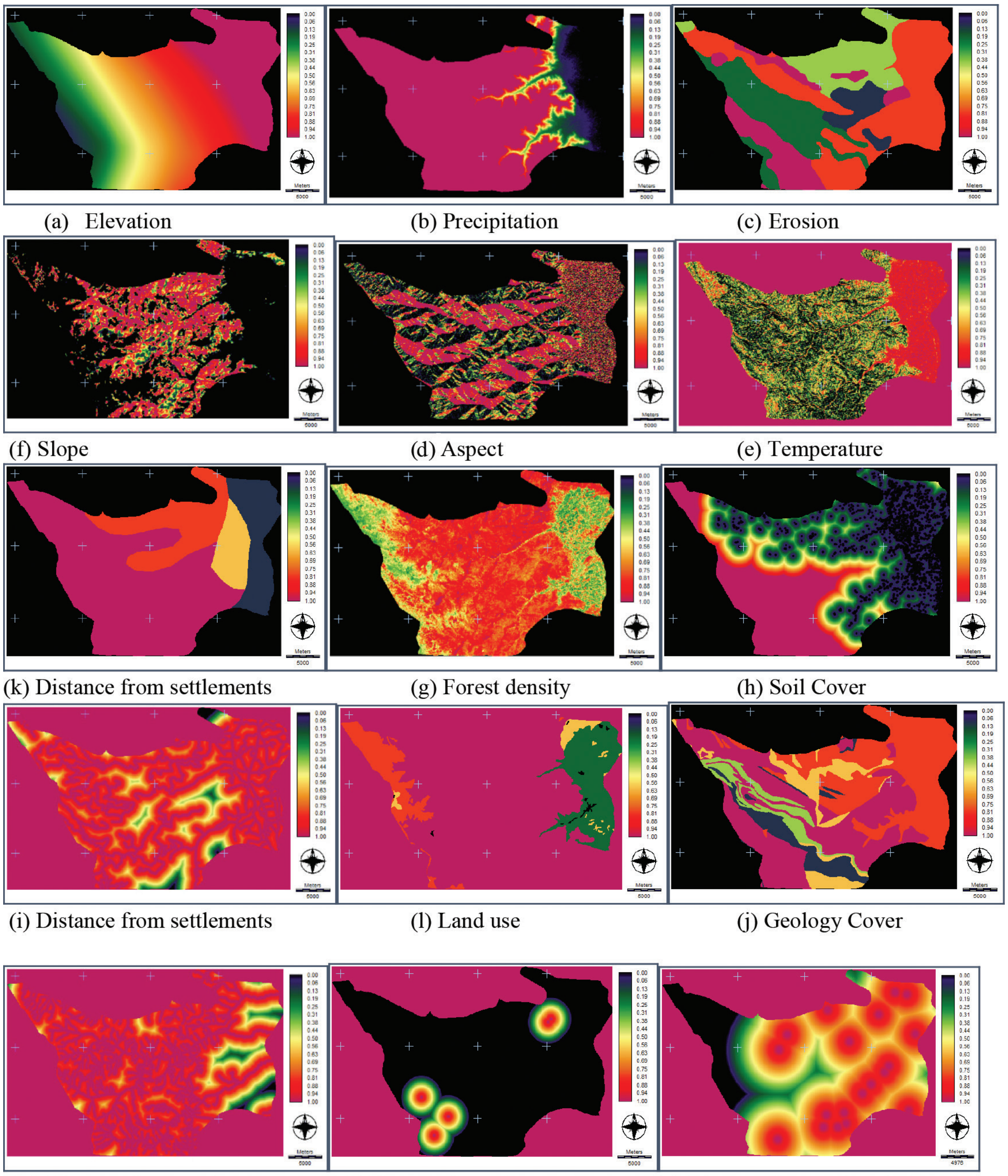

Figure 3: Maps of standardized criteria of the study area.

The results of this study indicate that the water resources layer has the greatest importance in recreational capability in this area, which is consistent with studies (Shirvani, 2009; Gul et al., 2006; Babaie-Kafaky et al., 2009). Also, the results showed that more than 60 percent of the basin area has recreational capabilities, or, in other words, the region's capacity for recreation is excellent. In general, the northern parts of the region has a better recreational capability than the southern parts, due to the almost identical distribution

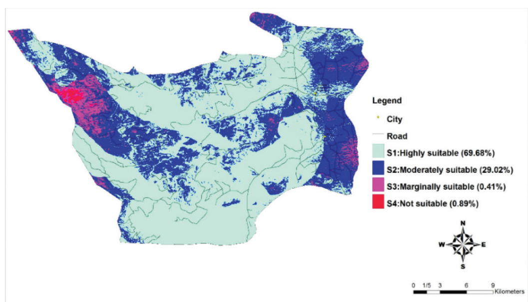

Figure 4: Suitability map for ecotourism in Masal Province, Iran.

of water resources in the basin. The main reason for this imbalance in recreational capabilities can be higher slopes and much higher elevation in the southern regions of the area, less roads and access routes.

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