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[Research]

A fuzzy multi-criteria decision method for locating ecotourism development

A. Mahdavi[1]*, M. Niknejad[1], O. Karami[2]

1. *Forest Science Department, Faculty of Agriculture and Natural Resources, Ilam University, Ilam, Iran*
2. *Forestry Department, Faculty of Natural Resources, University of Agriculture and Natural Resources of Sari, Sari, Iran.*

* *Corresponding author's E-mail: a_amoli646@yahoo.com*

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ABSTRACT

The County of Khorram-Abad enjoys a high potential for ecotourism because of its mountains, forests, natural mineral springs, natural waterfalls and diversity in folks and cultures. But, un-planned and uncontrolled ecotourism can have negative effects on environment, economy, culture and even the security of eco-tourists. The main purpose of this study is to present a fuzzy multi-criteria decision making (FMCDM) method for ecotourism development location selection. In this study we created 5 main criteria and 14 sub-criteria for locating the suitable areas for ecotourism development based on literature reviews and experts' opinions. Delphi method was used to obtain the significant criteria and sub-criteria for ecotourism development by interviewing the foregoing experts and related managers. Then, the methods of fuzzy set theory, linguistic value, hierarchical structure analysis, and fuzzy analytic hierarchy process (FAHP) were applied to find the relative weights or importance degree of each criterion and rank the overall criteria as the measurable indices for ecotourism development. Different layers were prepared and were combined using weighted linear combination (WLC) method in GIS environment. The results showed that 6.57 and 38.65 percentages of the area have an excellent and good potential for the ecotourism development. In addition, the study confirms that FAHP and GIS could be a powerful combination to apply for different land use planning.

Key words: Ecotourism, Fuzzy AHP, GIS, Delphi, Iran

INTRODUCTION

Nature-based tourism in general is one of the fastest growing sectors within the global tourism industry (Buckley, 2000; Ryan *et al.*, 2000). Reasons for this growth include demographic changes in source countries (such as older populations and, in turn, the growing number of more experienced travelers) and increasing environmental awareness on the part of the general public (Ayala, 1996).

Ecotourism is viewed as a means of protecting natural areas through the generation of revenues, environmental education and the involvement of local people in both decisions regarding appropriate developments and associated benefits (Ross & Wall, 1999). Therefore, sustainable ecotourism is a type of tourism that produces economic advantages, in addition to maintaining environmental diversity and quality thus 'combining conservation with economic development' (Wild, 1994). Unsustainable ecotourism is the result of inappropriate developments taking place in sensitive locations. The environmental effects caused by overcrowding, overdevelopment, unregulated recreation, pollution, wildlife disturbances and vehicle uses are more serious for ecotourism than mass tourism (McNeely, 1989). Without appropriate regulations and planning, problems of overexploitation, and in particular ecological degradation, may be intensified with the development of ecotourism (Mieczkowski, 1995; Kamauro, 1996; Issacs, 2000). Thus in reality there is a need for suitable planning strategies to be formulated and implemented to ensure that the future expansion of ecotourism takes place in accordance with the principles of sustainable development (Wearing & Neil, 2009). Undoubtedly, only some areas suitable for ecotourism should be developed to maximize the positive impacts and minimize negative impacts on all aspects of ecotourism. In this respect, site suitability evaluation for ecotourism should be regarded as an important tool and a prerequisite for sustainable development of ecotourism. Site suitability evaluation can be judged with the help of criteria and indicators approach, which is basically a concept of sustainable ecotourism management developed in a set of principles, criteria and indicators (Bunruamkaew & Murayama, 2011). Ecotourism should satisfy several criteria such as conservation of biological and cultural diversities through ecosystem protection and promotion of sustainable use of biodiversity with minimal impact on the environment being a primary concern (Bunruamkaew & Murayama, 2011). Anderson (1987) surveyed different methods for land capability/suitability analysis such as pass/fail screening, graduated screening, weighted factors, composite rating, and weighted composite rating and so on. A complex site selection process involves a measure of trade-offs among the criterion factors (Banai-kashani, 1989). The weighted factor method provides a procedure where each suitability factor is assigned a score, which is multiplied by the weight of that factor. The results of the multiplications are added, and thus a site composite score is determined. The composite score is compared with a predetermined standard, which is used to select or reject a site. This approach to site assessment is operational when standards are known. But for which no standards have been established or intangible criteria are used to assess alternatives the weighted-factors method is of limited use (Banai-kashani, 1989).

A common feature of different the suitability methods (for more information referred to Anderson, 1987) is their reliance upon expert judgment. But, various sources of uncertainty, such as the planning environment, value judgments, and the decisions of other participants, contribute to errors in decision making and forecasting by experts (uncertainties of the economic, demographic, and political environment) (Hall, 1980). Analytical Hierarchy Process (AHP) is an alternative to the methods used in suitability studies which can help the expert when facing uncertainty in decision-making (Saaty & Vargas, 1987). However, AHP has been shown to be effective in evaluation problems involving multiple and diverse criteria and flexibility in dealing with both the qualitative (intangible) and quantitative (tangible) factors but has some shortcomings in the performance. In the conventional AHP, the pair wise comparisons for each level with respect to the goal of the best alternative selection are conducted using a nine-point scale. AHP is criticized for using lopsided judgmental scales and its inability to properly consider the inherent uncertainty and carelessness of pair comparisons (Shaverdi *et al.,* 2013).

In order to overcome this kind of uncertainty in human preference, fuzzy sets theory could be incorporated with the pair-wise comparison as an extension of AHP. A variant of AHP, called Fuzzy AHP, comes into implementation in order to overcome the compensatory approach and the inability of the AHP in handling linguistic variables. The fuzzy AHP approach allows a more accurate description of the decision making process (Vahidnia *et al.,* 2009). There are enormous challenges toward proper management of ecotourism in Khorram-Abad province. The challenges reveal the importance of taking appropriate strategies to manage ecotourism in a sustainable manner in this region. We believe that sustainable ecotourism development efforts can be improved if priority areas for ecotourism and sustainable land uses are modified based on a comprehensive land suitability evaluation. In this regard, the study will use the integration of GIS technology and fuzzy AHP method in locating the suitable sites for ecotourism development in the county of Khorram-Abad.

MATERIAL AND METHODS

Study area

The county of Khorram-Abad as the capital for Khorram-Abad Province is located in west of Iran. Its area is about 500000 hectares and is located between east longitude from 48°, 2´, 56" to 49°, 0´, 4" and north latitude from 33°, 53´, 42" to 33°, 53´, 27" (Fig. 1). There are some important characteristics that make the area suitable for a successful ecotourism development program. For example, the county has an attractive mountainous forest landscapes, covered with a rich vegetation cover and considerable wildlife, traditional indigenous people groups and folks and so on. Such attributes suit the selection of the area for a case study to demonstrate the application of the methodology.

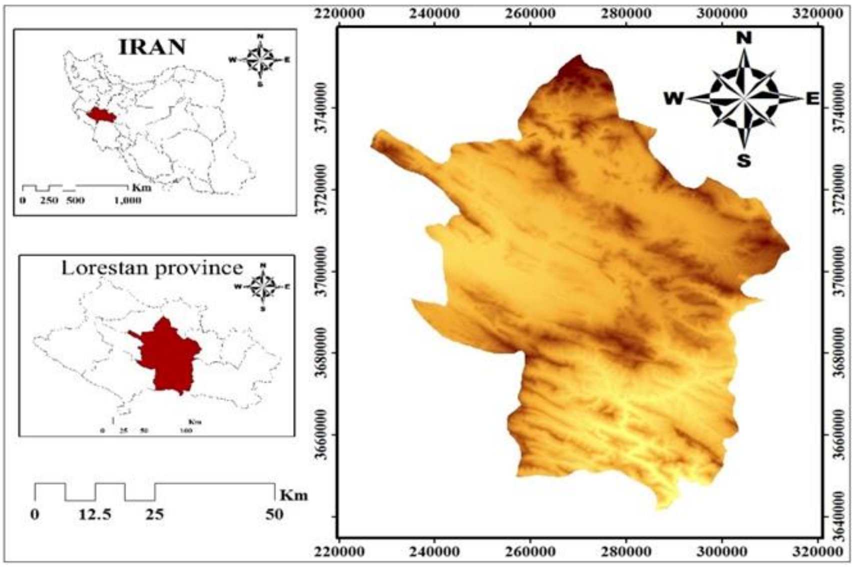

Fig. 1. The location of study area in Khorram-Abad province and Iran.

Data sources

Data used in the study were assembled from a variety of sources. Firstly, the primary data from the field survey were collected through interviews and questionnaires answered by experts in the related fields for identifying factors and criteria that are important for ecotourism in Khorram-Abad Province along with statistics data, Global Positioning System (GPS) field survey data and other GIS datasets and maps.

Methods

Basic concept of fuzzy analytical hierarchy process

The concept of fuzzy theory was introduced and addressed by Zadeh in 1965 for the first time Fuzzy theory is composed of three key factors; fuzzy set, membership function, and fuzzy number to change vague data into useful data efficiently.

The merit and strength of using fuzzy approach is to express the relative importance of the alternatives and the criteria with fuzzy numbers instead of using simple crisp numbers as most of the decision-making problems in the real world takes place in a situation where the pertinent data and the sequences of possible actions are not precisely known.

In this study the modified synthetic extent FAHP is utilized, which was originally introduced by Chang (1996). A brief explosion of triangular fuzzy numbers and the FAHP method are given next.

Triangular fuzzy numbers (TENs)

Triangular fuzzy numbers are the most utilized in FAHP studies (Tang & Beynon, 2005). We define a fuzzy number M by a triplet (l, m, u) and membership function can be defined by Equation (1) (Chang, 1996):

$$\mu_M(x) = \begin{cases} \frac{x}{m-l} - \frac{l}{m-l}, & x \in [l, m], \\ \frac{x}{m-u} - \frac{u}{m-u}, & x \in [m, u], \\ 0, & \text{otherwise}, \end{cases} \quad (1)$$

Two important operations used in this paper are illustrated. Define two TFNs M1 and M2 by the triplets
M1 = (l_1, m_1, u_1) and M_2 = (l_2, m_2, u_2).
Then: (1) Addition:
M_1 (+) M_2 = (l_1, m_1, u_1) (+) (l_2, m_2, u_2) = ($l_1 + l_2$, $m_1 + m_2$, $u_1 + u_2$),
(2) Multiplication:
M_1 * M_2 = (l_1, m_1, u_1) * (l_2, m_2, u_2) = (l_1 l_2, m_1m_2, u_1 u_2),

Set up fuzzy paired comparison matrices

Central to the FAHP method is a series of pair-wise comparisons indicating the relative preferences between pairs of criteria in the same hierarchy. Using triangular fuzzy numbers with the pair-wise comparisons made, the fuzzy comparison matrix X = $(x_{ij})_{n*m}$ is constructed. The pair-wise comparisons are described by values taken from a pre-defined set of ratio scale values as presented in Table 1 and Fig. 2.

The ratio comparison between the relative preference of elements indexed i and j on a criterion can be modeled through a fuzzy scale value associated with a degree of fuzziness. Then an element of X, x_{ij} (i.e., a comparison of the ith decision alternative (DA) with the jth DA) is a fuzzy number defined as xij (l_{ij}, m_{ij}, u_{ij}) where, mij, lij, and uij are the modal, lower bound, and upper bound values for xij respectively.

Let $C = \{C_1, C_{2\ldots}\ C_n\}$ be a criteria set, where n is the number of criteria and A = $\{A_1, A_2\ldots\ Am\}$ is a DA set with m the number of DAs. LetM_c^1 ,M_c^2,… M_c^m be values of extent analysis of the ith criteria for m DAs.
Here i = 1, 2… n and all the M_c^1 (j = 1, 2… m) are triangular fuzzy numbers (TENs).
The value of fuzzy synthetic extent $_{si}$ with respect to the $_i$th criteria is defined as:

$$S_k = \sum_{j=1}^{n} M_{kj} \times \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1} = \left(\frac{\sum_{j=1}^{n} l_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} u_{kj}}, \frac{\sum_{j=1}^{n} m_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} m_{kj}}, \frac{\sum_{j=1}^{n} u_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} l_{kj}} \right) \quad (2)$$

Table 1. Linguistic variables describing weights of criteria and values of ratings.

Triangular Fuzzy scale (*l,m,u*)	Fuzzy numbers	Definition
(1,1,1)		Just equal
($\frac{1}{2}$, 1 , $\frac{3}{2}$)	1	Equally Important (EI)
(1 , $\frac{3}{2}$, 2)	3	Weakly more Important (WMI)
($\frac{3}{2}$, 2 , $\frac{5}{2}$)	5	Strongly more Important (SMI)
(2 , $\frac{5}{2}$,3)	7	Very strongly more Important (VSMI)
($\frac{5}{2}$, 3 , $\frac{7}{2}$)	9	Absolutely more Important (AMI)

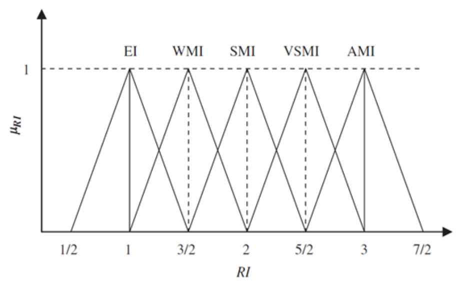

Fig. 2. Linguistic variables for the importance weight of each criterion.

Where superscript -1 represents the fuzzy inverse. For more information about the concepts of synthetic extent, refer to Chang (1996).

Calculation of the sets of weight values of the FAHP

To obtain the estimates for the sets of weight values under each criterion, it is necessary to consider a principle of comparison for fuzzy numbers (Chang, 1996). For example, for two fuzzy numbers M_1 and M_2, the degree of possibility of $M_1 \geq M_2$ is defined as:

$V(M_1 \geq M_2) = \sup_{x \geq y} [\min (\mu M_1 (x), \mu M_2 (y))]$, (3) where sup represents supremum (i.e., the least upper bound of a set) and when a pair (x, y) exists such that $x \geq y$ and ($\mu_{M1} (x) = \mu_{M2} (y)$ =1, it follows that $V(M_1 \geq M_2)$ =1 and $V(M_2 \geq M_1)$ =0. Since M_1 and M_2 are convex fuzzy numbers defined by the TFNs (l_1, m_1, u_1) and (l_2, m_2, u_2) respectively, it follows that:

$V(M_1 \geq M_2) = 1$ iff $m_1 \geq m_2$;
$V(M_2 \geq M_1) = \text{hgt} (M_1 \cap M_2) = \mu M_1 (x_d)$, (4)

where iff represents "if and only if" and d is the ordinate of the highest intersection point between the μ_{M1} and μ_{M2} TFNs (see Fig. 3) nd xd is the point on the domain of μ_{M1} and μ_{M2} where the ordinate d is found. The term hgt is the height of fuzzy numbers on the intersection of M_1 and M_2. For $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$, the possible ordinate of their intersection is given by Equation (4). The degree of possibility for a convex fuzzy number can be obtained from the use of Equation (5)

$$V(M_2 \geq M_1) = \text{hgt} (M_1 \cap M_2) = \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} = d. \quad (5)$$

The degree of possibility for a convex fuzzy number M to be greater than the number of k convex fuzzy numbers M_i (i = 1, 2,…, k) can be given by the use of the operations max and min (Dubois and Prade, 1980) and can be defined by:

$V (M \geq M_1, M_2, \ldots M_k) = V[(M \geq M_1)$ and $(M \geq M_2)$ and…… $(M \geq M_k)]$

Assume that $d'(A_i) = \min V(S_i \geq S_k)$, where k = 1, 2, …, n, $k \neq i$, and n is the number of criteria as described previously. Then a weight vector is given by:

$W' = (d' (A_1), d' (A_2), \ldots, d' (A_m))$,

where A_i (i = 1, 2, …, m) are the m DAs. Hence each $d'(A_i)$ value represents the relative preference of each DA. To allow the values in the vector to be analogous to weights defined from the AHP type methods, the vector W' is normalized and denoted:

$W = (d (A_1), d (A_2), \ldots, d (A_m))$.

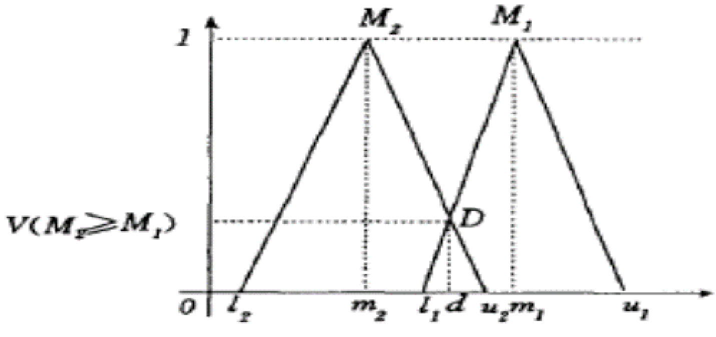

Fig. 3. The comparison of two fuzzy number M_1 and M_2.

Consistency test

The important thing about the pair -wise comparison matrixes is their incompatibility. According to Saaty (1980), it should be taken In to consideration that for stability arbitrations it is necessary that the rate of their incompatibility matrixes be less or equal to 0.1. Otherwise, the respective expert is required to repeat its adjudication as a stable matrixes (Amiri *et al.,* 2008). The Consistency index (CI) is performed as follows:

$$CI = \frac{\overline{\lambda}_{\max} - n}{n-1},$$

Where λmax is the maximum eigenvalue, and n is the dimension of matrix.

The consistency ratio (CR) was introduced to aid the decision on revising the matrix or not. It is defined as the ratio of the CI to the so-called random index (RI), which is a CI of randomly generated matrices:

$$CR = \frac{CI}{RI}.$$

Determination and weighting of effective criteria and sub-criteria for ecotourism development using fahp identifying criteria and sub-criteria

This study selected 5 main criteria and 14 sub-criteria in the form of GIS-based layers in determining what areas are best suited for ecotourism development.

In order to identify the effective criteria and sub-criteria for ecotourism development in the study area, They were based on literature review and previous studies (Bunruamkaew & Murayama, 2011; Lawal *et al*., 2011; Anane *et al*., 2012), special conditions of the region and expert's opinions, 5 main criteria and 14 sub criteria were selected. The selected criteria and sub criteria are shown in Table 2.

Table 2. Hierarchical structure, Criteria and sub-criteria in land suitability analysis for ecotourism.

Goal	criteria	Sub-criteria	Suitability rating (assigned fuzzy amounts for the classes in parentheses)				
			Class 1 (255)	Class 2 (191)	Class 3 (128)	Class 4 (64)	Class5 (26)
Suitable location for ecotourism development	Climate	Precipitation (mm)	912<	778-912	645-778	512-645	379-512
		Temperature (o C)	11-14	14-17	-	-	-
	Topography	Slop	0-5	5-15	15-25	25-50	50<
		Aspect	West	North	South	East	-
		Elevation (m)	458-1050	1050-1650	1650-2250	2250-2850	>2850
	Geo-pedology	Soil type	alluvium	lithosol	braun soil	-	-
		petrology	limestone	conglomerate	alluvium	Gypsum	-
		Erosion	Very low	Low	Moderate	Much	Very much
	Environmental	Vegetation type and density	Forest (26-50% density)	Forest (6-25% density)	Forest (1-5% density)	Rangeland	Others
		Water resources (m)	0-300	300-600	600-1200	1200-2000	2000<
	Socio-economy	Distance from rood (km)	0-5	5-10	10-15	15-20	20<
		Distance from settlements (km)	0-3	3-6	6-9	9-12	12<
		Distance from negative factors (km)	0-5	5-10	10-15	15-20	20<
		Distance from recreational tourist attractions (km)	0-5	5-10	10-15	15-20	20<

Delphi method and estimating the relative weights of criteria and sub-criteria

Delphi method mostly aims at easy common understanding of group decisions through twice provision of questionnaires (Hsu *et al*., 2010). This study also conducted a Delphi method based on FAHP questionnaire survey with 10 expert scholars specializing in the field of ecotourism and government tourism offices for weighting the criteria and sub-criteria. We sent 15 questionnaires to the experts that 10 from them were acceptable. In addition, for some cases that requested for more information, we conducted the face to face interview with experts based on the questionnaires. Weighting the criteria and sub criteria were performed based on pair-wise comparison technique and fuzzy values taken from a pre-defined set of ratio scale values as presented in table 1 and Fig. 2. Questionnaires were properly evaluated and the criteria weighted in the Matlab 2009 software. After normalized weight of each criterion, the aggregation of ten experts' opinions for the five main criteria and 14 sub-criteria were performed using the geometric mean approach (Kabir & Sumi, 2013).

Providing the maps

In mapping the suitable areas for ecotourism development in the study area, the respective layers to selected criteria should be prepared first. In this regard, some maps (topography, soil, geology and vegetation) as hardcopy were provided by related offices. All these maps were digitized and classified using Arc GIS 9.3 software in GIS environment.

After providing a digital elevation model (DEM) from topography map, different layers such as slop, aspect and elevation were extracted. The layers for other used criteria in this study like distances from recreational tourist attractions, negative factors, roods, water sources and settlements were created in GIS environment after providing some maps, field visiting and recording their location with GPS.

After providing relevant meteorological information, the Inverse Distance Weighted interpolation method in GIS environment was used to construct Isohyetal map and Isotherms map for the study area. After that, standardization of maps was accomplished for all the map layers taking into consideration the units and scales in order to make them comparable.

Then, the pixel values of all sub-criteria raster layers were transformed on a scale suitability ranging from 0 (least suitable) to 255 (most suitable) using fuzzy membership functions extension in IDRISI software.

However each sub-criteria value is processed differently depending on their continuous or discrete form or the defined suitability classes in Table 2.

Extracting the final composition map of potential area for ecotourism

After creating different layers and determining of their final weights by FAHP, the layers were integrated with their assigned weights using Weighted Linear Combination technique in GIS environment (Sante-Riveira *et al.*, 2008). This technique can be done by calculating the composite decision value (Rij) for each pixel (ij) as follows:

$$Rij = \sum w_k \, r_{ijk}$$

Where, W_k is the assigned weight for sub-criteria k and r_{ijk} is the standardized value of pixel (i,j) in the map of sub-criterion k. r_{ijk} varies between 0 and 255 where 0 is the least suitable value and 255 is the most suitable value. (Anane *et al*., 2012).

RESULTS AND DISCUSSION

The fuzzy analytical hierarchy process (FAHP)

The results of the weighting criteria based on FAHP method and analysis performed by using MATLAB software is shown in Table 3. These weights are obtained based on Delphi method and mathematical relations in FAHP. Inconsistency ratio (CR) calculated is less than 0.1 that is indicating an acceptable level of pair wise comparisons in the FAHP matrix.

Using this method in the study area as shown in Table 3, the distance from water resources (with final weight of 0.205), the distance from the access roods (with final weight of 0.117), and vegetation type and density (with final weight of 0.114) are the most effective criteria in evaluating capability of ecotourism in the Khorram-Abad county, respectively.

Criteria layers creation and their classification

The related criteria and sub-criteria as seen in Table 2 were created and kept as GIS layers (Fig. 4 to 17). The layers were classified based on Table 2 and fuzzy concept theory, as the biggest fuzzy number value was assigned for the most suitable class. For instance, between slop classes, the class that has the least slop was assigned the biggest value.

Extract the most suitable areas based on their composite decision value

From the suitability map for ecotourism as seen in Fig.18, it was found that the total area of excellent and good suitable areas (C_1 and C_2) for ecotourism development is about 45.22% and these are located mostly in the eastern part of the county. The area of moderately suitable (C_3) is about 48.44% and these are in the central, northern and southern parts of the county. Only a few percentages (4.54% and 1.8%) of the area were classified as weak and not suitable (C_4, C_5) respectively (Table 4).

Table 3. Criteria, sub-criteria and their final layer weight.

Goal	criteria	Sub-criteria	Final weight
Suitable location for ecotourism development	Climate	Precipitation (mm)	0.064
		Temperature (o C)	0.082
	Topography	Slop	0.094
		Aspect	0.058
		Elevation (m)	0.016
	Geo-pedology	Soil type	0.021
		petrology	0.020
		Erosion	0.035
	Environmental	Vegetation type and density	0.114
		Water resources (m)	0.205
	Socio-economy	Distance from rood (km)	0.117
		Distance from settlements (km)	0.059
		Distance from negative factors (km)	0.039
		Distance from recreational tourist attractions (km)	0.080

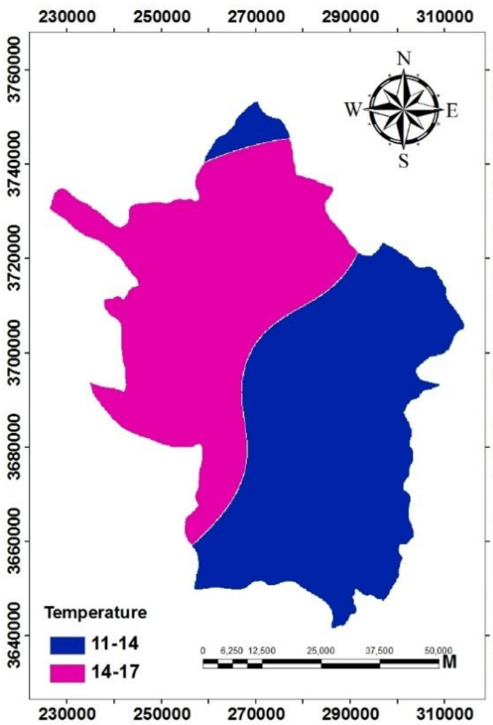

Fig. 4. Temperature map.

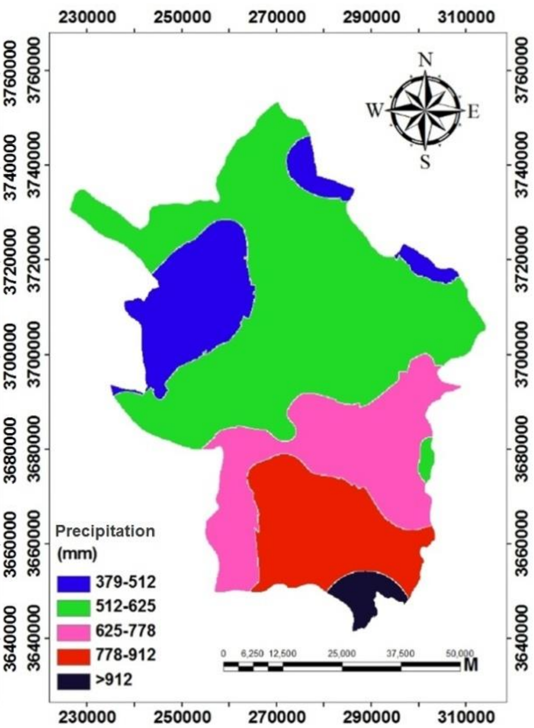

Fig. 5. Precipitation map.

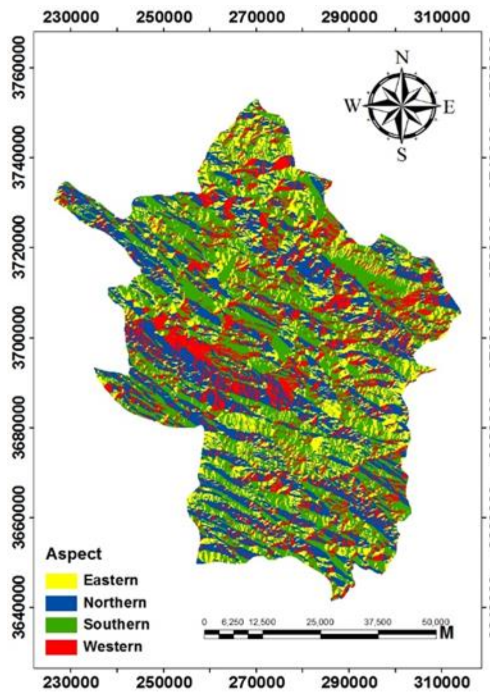

Fig. 6. Aspects classes map.

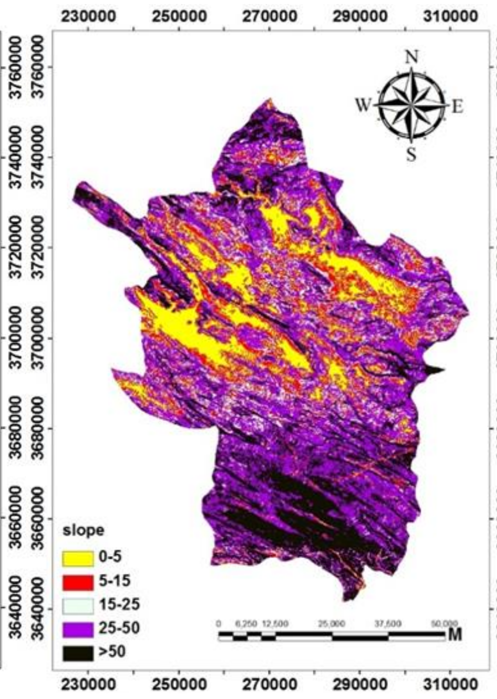

Fig. 7. Slop classes map.

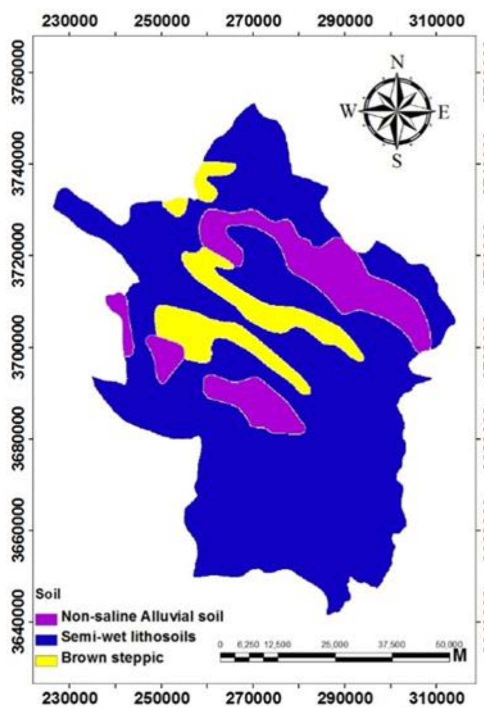

Fig. 8. Soil types map.

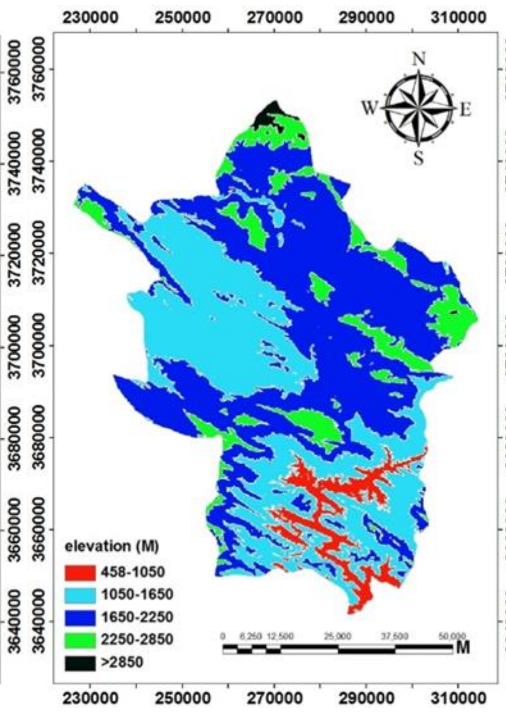

Fig. 9. Elevation classes map.

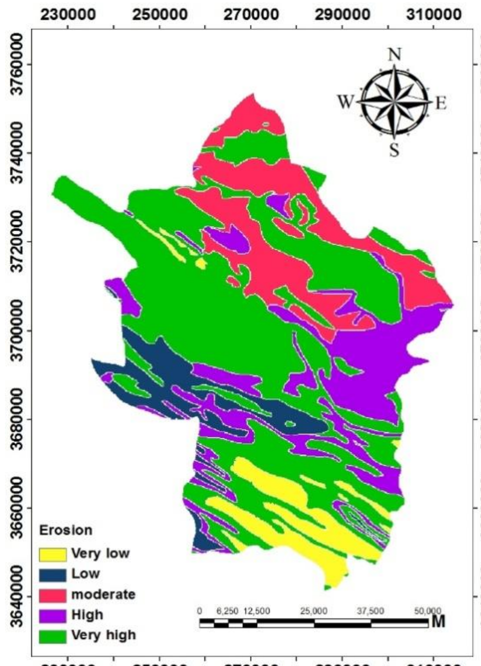

Fig. 10. Erosion intensity classes map.

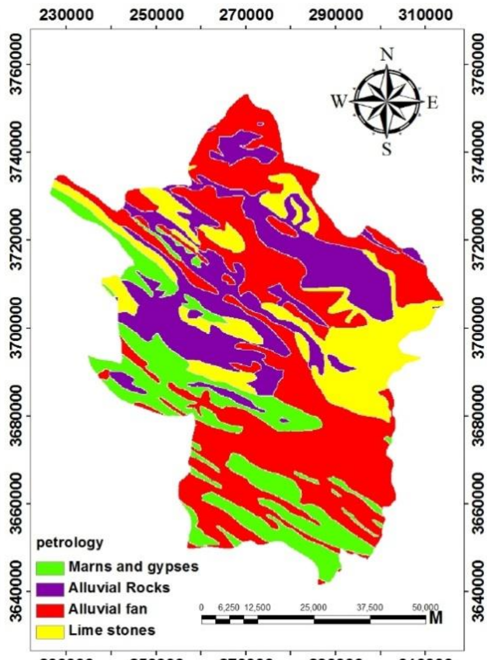

Fig. 11. Petrology map.

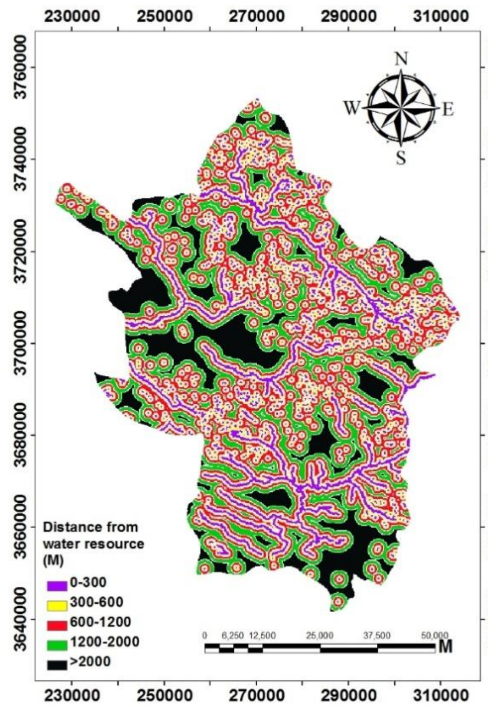

Fig. 12. Distance from water sources map.

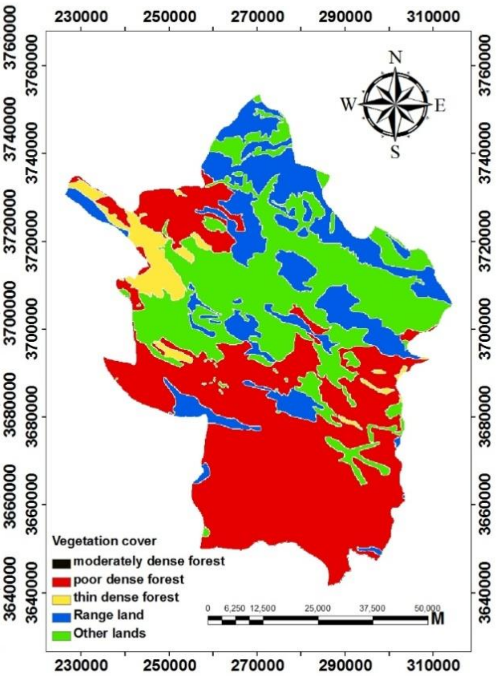

Fig. 13. Vegetation classes map.

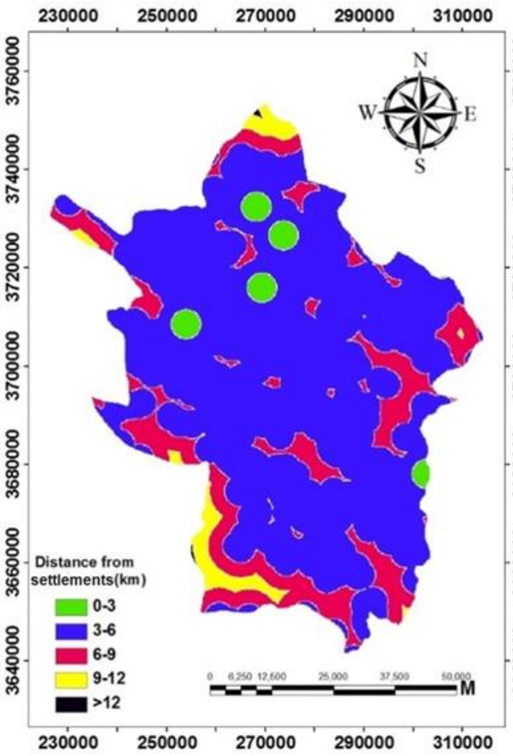

Fig. 14. Distance from settlements map.

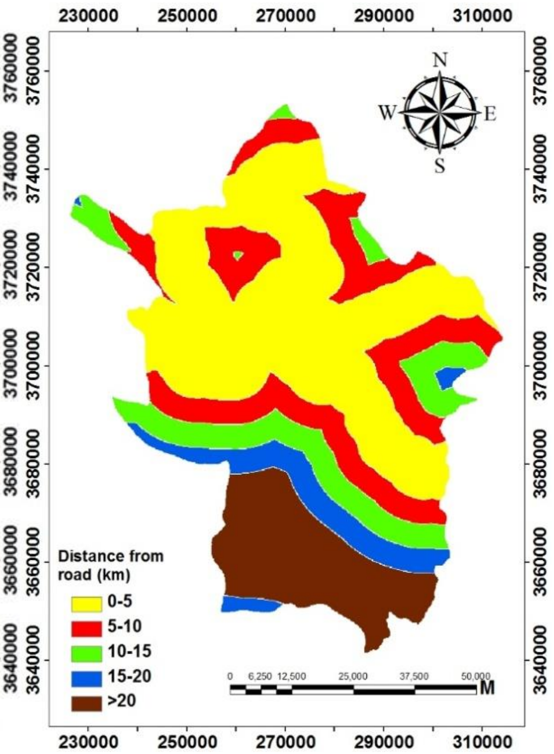

Fig. 15. Distance from roods map.

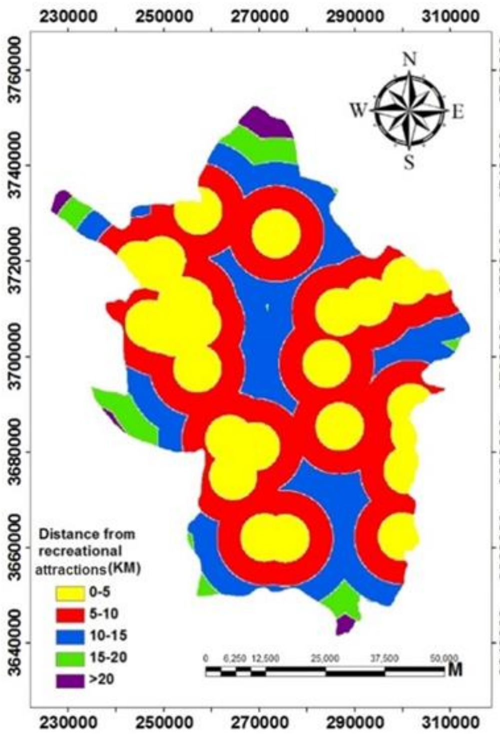

Fig. 16. Distance from recreational attractions map.

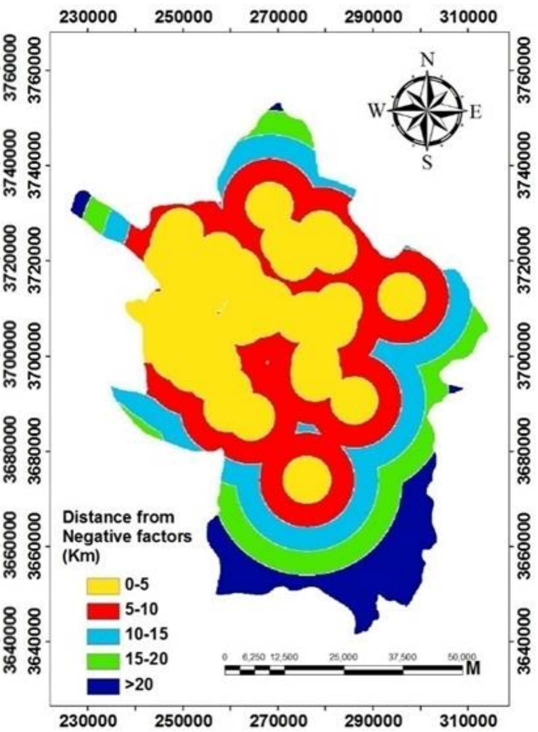

Fig. 17. Distance from negative factors map.

Extract the most suitable areas based on their composite decision value

From the suitability map for ecotourism as seen in Fig.18, it was found that the total area of excellent and good suitable areas (C_1 and C_2) for ecotourism development is about 45.22% and these are located mostly in the eastern part of the county. The area of moderately suitable (C_3) is about 48.44% and these are in the central, northern and southern parts of the county. Only a few percent ages (4.54% and 1.8%) of the area were classified as weak and not suitable (C_4, C_5) respectively (Table 4).

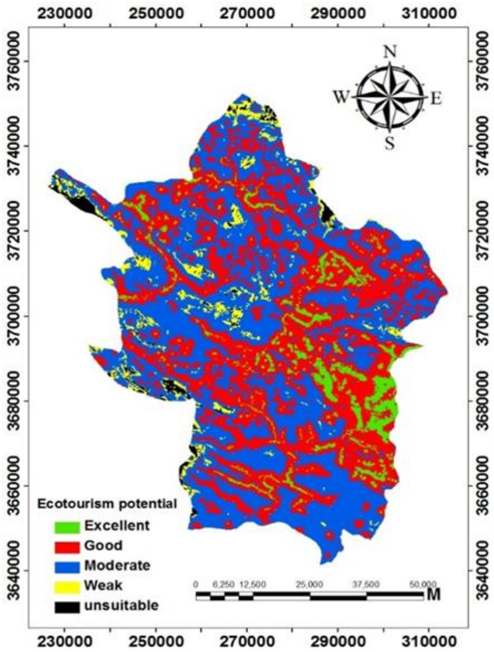

Fig. 18. Final map of suitable areas for ecotourism development in the region.

Table 4. The area and percentages of different suitable classes for ecotourism development.

Classes	Area (ha)	Area (%)
C_1 (Excellent suitability)	32819.77	6.57
C_2 (Good suitability)	193145.51	38.65
C_3(Moderate suitability)	242031.44	48.44
C_4 (Weak suitability)	22615.45	4.54
C_5 (not-suitable)	8497.95	1.8

DISCUSSION

The sustainable planning of ecotourism development in the county of Khorram-Abad is a complex problem that involves subjective assessments with multiple criteria. This paper has presented an integrated FAHP approach for effectively solving this problem. Multi criteria evaluation has been applied to compare the set of identified criteria and sub-criteria whereas GIS has been used for the detailed analysis of the spatial decision context. In the proposed methodology, the criteria weights are produced by a fuzzy AHP procedure. This study conducted statistical analyses using MATLAB software to determine and rank the weights values for all 5 main criteria and 14 sub-criteria. The result indicates that the sub-criteria distance from water resources (mineral springs, rivers and waterfalls) was the most effective criteria in evaluating the capability of ecotourism in the area and had the highest priority and weight (0.205) within sub-criteria (Table 3). It is clear that different water resources like mineral springs, rivers and waterfalls belong to the main recreational natural attractions and distance from these resources is an important factor for ecotourism development as the closer areas to these resources could have a high priority for ecotourism development. This result is in accordance with the findings of Gengiz & Celem (2006); Nahuelhual *et al*., (2013). The existence of access roods is one of the important factors in selecting suitable areas for recreational purposes. In fact, without access roads there is not much possibility for recreational planning for the areas even though they are good potential for ecotourism. The result of this study also shows a high weight and priority for distance from the access roads criteria (final weight of 0.117). This criterion in many ecotourism studies was an important factor for consideration (Boyd *et al*., 1994; Bunruamkaew & Murayama, 2011; Safari *et al.,* 2011; Dashti *et al.,* 2013). Another criterion with high priority in this study was vegetation type and density (with final weight of 0.114). Vegetation characteristics in many studies were mentioned (density and diversity of species) to have an important role in absorption of eco-tourists as a key factor in ecotourism evaluation (Boyd *et al*., 1994; Kumari *et al.,* 2010; Bunruamkaew & Murayama, 2011). The result indicates that 6.57% (32819.77 ha) of the total study area belongs to the excellent suitable class. These areas are mainly located in the eastern part of the county that are characterized with a rich diversity in terms of rare fauna and flora, beautiful forest landscapes and many mineral springs and waterfalls. Although, these areas can be considered as the most ecotourism attractions, the visitors should be under control and limitations to protect and preserve most of the biodiversity value of these areas and their ecological conditions. Additionally, the good suitable class was found to be 38.65% (193145.51ha) of the territory which can be considered as good attraction for ecotourism. These areas are also mainly in the eastern regions of the county that have recreational potential for ecotourism, such as beautiful scenery, abundant and different plant communities and diversity in culture and folks. Both of the excellent and good suitable classes are 45.22% (225962.28 ha) of the total study area. These areas can provide eco-tourist facilities by facilitating proper ecotourism infrastructures and services under the controlled policy. Nevertheless, infrastructure as far as possible should be developed in accordance with the local community and nature conditions. The development of ecotourism infrastructure in the good class should be with minimal impacts on originality of the nature and provide safe, reliable, sustainable and appropriate access to ecotourism attractions in and nearby natural areas. Therefore, these results highlight that the county of Khorram-Abad is a good potential for ecotourism development. In addition, the findings of this study confirm that the combination of FAHP method and GIS could be powerful to apply for land use planning. The FAHP method can deal with inconsistent judgments and provides a measure of the inconsistency, so it is more superior to other multi criteria evaluation methods. The results of this study will provide benefits for nature conservation which might otherwise be allocated to more environmentally damaging land uses. Such a method may reduce costs and time involved in the early planning stage of identifying potential new areas for ecotourism development.

CONCLUSION

Khorram-Abad Province is considered one of the most attractive ecotourism destinations in Iran. It has fascinating and incredible mountain landscapes, original Zagros forests, diversity of fauna and flora, mineral springs, waterfalls and rivers, variety of folks and cultures and many historical and cultural places. Based on the research findings, low-level environmental knowledge among decision makers and managers and lack of financial resources needed in the county and the province are two main preventives toward achieving a sustainable ecotourism development in Khorram-Abad. In addition, inadequate infrastructure and regional facilities to meet the requirements of visitors also face sustainability with challenge. Therefore, giving priority to ecotourism projects in suitable sites and presenting a conservation plan that prevents the negative effects on the quality of sensitive ecosystems would be necessary and helpful for a sustainable ecotourism development in the county. Finally, it can be suggested that successful ecotourism management will not be achieved without the cooperation and support of local communities. Moreover, local communities must be empowered and involved in making important ecotourism development decisions. This suggestion has been also verified in many studies about ecotourism development (Nyaupane *et al.* 2006; Somarriba-Chang & Gunnarsdotter, 2012; Lin, & Lu, 2013).

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یک روش تصمیم‌گیری چند معیاری فازی برای مکان‌یابی توسعه اکوتوریسم

ع. مهدوی[1*]، م. نیک‌نژاد[1]، الف. کرمی[2]

۱- گروه علوم جنگل، دانشکده‌ی کشاورزی، دانشگاه ایلام، ایلام، ایران
۲- گروه علوم جنگل، دانشگاه علوم کشاورزی و منابع طبیعی ساری، ساری، ایران

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چکیده

شهرستان خرم آباد به واسطه داشتن کوه‌ها، جنگل‌ها، چشمه‌های آب معدنی طبیعی، آبشارهای طبیعی و تنوع قومی و فرهنگی دارای پتانسیل بالایی در اکوتوریسم است. با این حال عدم برنامه‌ریزی و نظارت مناسب برای توسعه اکوتوریسم ممکن است اثرات منفی برروی محیط زیست، اقتصاد، فرهنگ و امنیت گردشگران داشته باشد. هدف اصلی این مطالعه استفاده از روش تصمیم‌گیری چند معیاره فازی (FMCDM) در تعیین مناطق مناسب توسعه گردشگری است. در این مطالعه ما ۵ معیار اصلی و ۱۴ زیرمعیار برای تعیین مناطق مناسب با استفاده از مطالعات پیشین و نظرات کارشناسان انتخاب کردیم. برای تعیین اهمیت معیارها و زیرمعیارها از روش دلفی و استفاده از نظرات متخصصان و مدیران مرتبط با موضوع مورد مطالعه استفاده شد. سپس جهت تعیین وزن نسبی و نهایی و تعیین درجه اهمیت معیارها و زیرمعیارها از تئوری مجموعه فازی، مقیاس‌های زبانی، ارزیابی ساختار سلسله مراتبی و فرآیند تحلیل سلسله مراتبی فازی (FAHP) استفاده شد. نقشه‌های متناظر با هر زیرمعیار تهیه و سپس با وزن متناظر با خود با استفاده تکنیک خطی وزنی (WLC) تلفیق و نقشه نهایی مناطق مناسب برای توسعه اکوتوریسم در محیط GIS تهیه شد. نتایج نشان داد که ۶/۵۷ و ۳۸/۶۵ درصد از مساحت منطقه مورد مطالعه به ترتیب دارای پتانسیل عالی و خوب برای توسعه اکوتوریسم است. همچنین این مطالعه نشان داد که تلفیق FAHP و GIS ابزار قدرتمندی برای ارزیابی و برنامه‌ریزی برای انواع کاربری‌ها است.

*مولف مسئول