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Forest park site selection based on a Fuzzy analytic hierarchy process framework (Case study: the Galegol Basin, Lorestan province, Iran)

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ABSTRACT: The aim of this study is to solve the forest park site selection problem using a Fuzzy analytic hierarchy process (FAHP) framework in the Galegol Basin, Lorestan province, Iran. The Delphi screening method was used to select the most relevant criteria and sub-criteria to the forest park problem. Using the FAHP weighting approach, the weight of each criterion and sub-criterion was calculated. Then, the suitability map of forest park location was mapped by the weighted linear combination (WLC) method. The results revealed that 7 criteria (climate, water resources, physiography, landscape, vegetation cover, wildlife and economic criteria) and 16 sub-criteria received the required values and can be involved into the decision-making process of the forest park site selection problem. Using the derived weights of sub-criteria by FAHP and the WLC method, the final results showed that most of the study area is moderately suitable for the forest park location problem. The results of this study can be valuable in the planning of local forest park and future land use planning.

Keywords: suitability map; weighted linear combination; criteria; decision-making; Delphi method

Sustainable development is concerned with acknowledging economic, social and environmental development aspects, providing for the current needs of society without damaging the well-being of future generations (Eriksson, Lidstrom 2013). Nowadays, ecotourism is the fastest growing sector of the world's largest service industry and it has a strong connection with sustainable tourism while sustainability depends on the relationship between tourism and environment (Bunruamkaew, Murayama 2011). Suitable management for ecotourism development is essential in order to conserve and maintain the biological richness as well as economic upliftment of the local people. In addition, ecotourism can be defined as an opportunity to promote the values in the protected areas and to finance related stakeholders (Ok 2006). As with all types of developments, ecotourism has positive and negative effects on the environment, culture and economics of society. One of the main strategies to minimize the negative impacts and enhance the positive effects of the ecotourism is proper land use planning with regard to the natural capacity and environmental criterion of a given region. Ecotourism development along with the land environmental capabilities as an effective strategy plays a key role in sustainable development, promotion of human welfare and maintaining of natural resources balance. Ecotourism in the form of forest park is the most extensive mode of the forest management planning. Principally, the selection of forest park location has not been based on scientific and technical criteria and indicators and in most cases it has been influenced by personal interests. Therefore, this problem has brought many problems dealing with the stability of forest park functions. Hence, locating suitable areas for the establishment of forest parks is especially important with regard to effective criteria and indicators. The term "forest park" was defined by the Forest and Range Organization of Iran and is specifically applicable to Iran. The forest park is a vast natural area when some parts of it are virgin and untouched by humans and that is managed by the government with recreational function, watershed conservation, fodder production, and so on (FROI 2010).

The site selection is a spatial analysis process that is extremely important in reducing costs and launching various activities. For this reason, the implementation of executive projects plays an important role. Today, regarding the ability of geographical information systems (GISs) in the management and analysis of spatial data, a good situation has been provided for doing spatial analyses such as locating the forest parks. In relation to locating different areas using GIS capabilities and also combining them with decision-making techniques, a lot of research has been conducted in this field. Multi-criteria analysis (MCA) was used to locate the most suitable area for forest management planning such as urban forestry (Van Elegem et al. 2002; Gul et al. 2006), forest parks (Sharifi et al. 2002; Zucca et al. 2008), community forest management (Khadka, Vacik 2014). Minagawa and Tanaka (1998) used GIS to locate areas suitable for tourism development in Indonesia. Zhou et al. (2005) found that the multi-attribute utility theory in conjunction with analytic hierarchy process (AHP) is suitable for most application areas.

The present study uses a Fuzzy analytic hierarchy process (FAHP) framework for the problem of forest park site selection in Lorestan province, Iran.

MATERIAL AND METHODS

Study area. The Galegol Basin located between 33°10'' and 33°20'' east longitudes and 48°10'' and 48°20'' north latitudes, in the central part of Lorestan province, Iran, covers approximately 9,491 ha (Fig. 1). The topography of the area is mountainous without plain or flat lands. It has attractive landscapes and natural attractions including springs, caves, rivers and forest covers.

Criteria and indicators development. In general, criteria define the essential elements or principles against which a thing or issue is judged. One that adds the meaning to a principle without itself being a direct measure of performance (Stork et al. 1997). An indicator is any component of the relevant management systems used to infer attributes and criteria. Indicators are usually quantitative aspects of criteria and changes of indicators are monitored over time. The greater the number of selected indicators, the more difficult and costly will be the feasibility and their implementation. Evaluation criteria are divided into two categories. Direct criteria from literature sources that are directly related to the given ecotourism problem and have been reported in scientific resources. Indirect ones are used for better understanding and configuring of a related criterion. To identify and develop criteria and indicators, in-

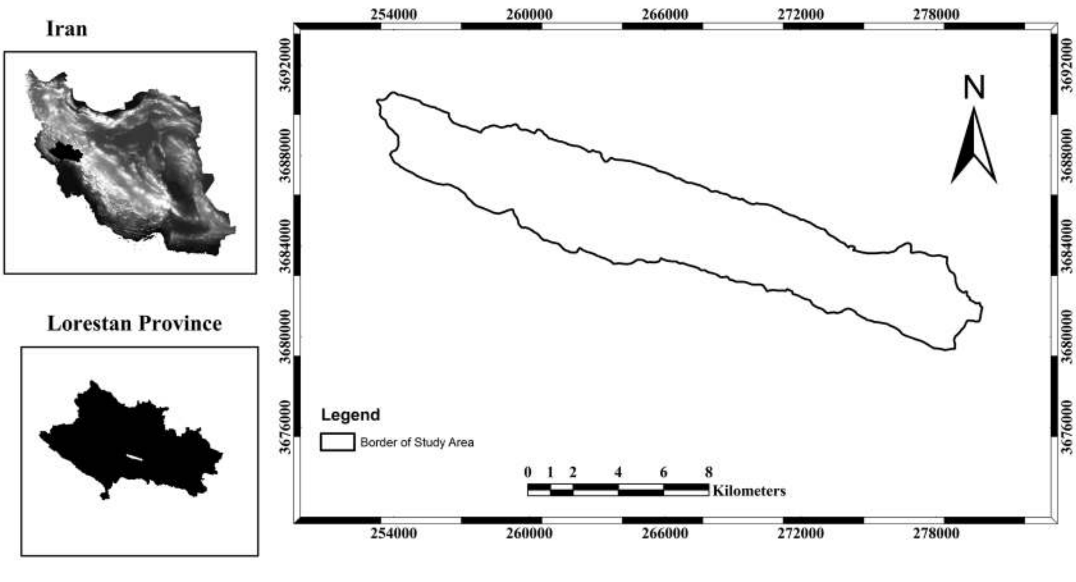

Fig. 1. The Galegol Basin study area in the Lorestan Province, Iran

structions on the country's political and economic objectives must be considered. The next thing on the set criteria and indicators is the full understanding of the target region properties such as social, cultural, economic and environmental dimensions. Therefore by taking into account these two tips, the appropriate criteria and indicators of a subject and study area can be reached. In this study, a comprehension checklist of criteria and sub-criteria is developed (Salehnasab 2013).

Delphi screening stage. A survey of opinions and comments can be a useful way in the selection of criteria for the spatial location of sites. In this approach, expert groups can be created for the determination of a criterion that must be included in a decision analysis. The Delphi screening method is a structured communication technique originally developed as a systematic, interactive forecasting method which relies on a panel of experts and is well suited as a means and method for consensus-building by using a series of questionnaires to collect data from a panel of selected subjects (Dalkey, Helmer 1963). Based on the questionnaire, the importance of each criterion is ranked by numerical values. The "better" value is from the point of view of an expert that participates in the survey and filled in the questionnaire. Anonymous response, iteration and controlled feedback and finally statistical group response are the main components of the Delphi method (Hsu et al. 2010). The results of the Delphi questionnaires are used to calculate the mean criterion importance degree (CID) and the mean percent of CID indices as follows (Eqs 1 and 2):

$$\text{CID} = \frac{\sum (x_i \times n)}{N} \quad (1)$$

where:

x_i – initial importance degree of each criterion (1, 3, 5, 7 and 9) in the questioner; based on these values (1, 3, 5, 7 and 9), respondents determined the initial importance of each criterion, 1 denotes the lowest importance and 9 shows the highest importance),

N – number of questionnaire recipients,

n – number of recipients that vote the x_i of each criterion.

$$\text{PC} = \frac{\sum z_i}{\bar{N}} \times 100 \quad (2)$$

where:

PC – mean percent of CID,

z_i – weighted score.

Based on these indices, a possibility of selecting relevant criteria among many of them will be provided.

Fuzzy analytic hierarchy process weighting stage. Making decisions in the presence of multiple criteria (often conflict) is complex. A compensatory approach to deal with multi-criteria decision-making problems is the AHP scoring method that was originally introduced by Saaty (1997). To convey the decision maker's preference, scores in a pairwise comparison between different criteria are used. This traditional method has some limitations to deal with multi-criteria decision-making problems. First, this method deals with an unbalanced scale of judgment. Second, the AHP method ignores the uncertainty associated with the judgment. Third, ranking in this method is imprecise (Kabir, Hasin 2011). Therefore, an extension of the AHP method, called FAHP, was used to overcome the above-mentioned limitations of the traditional AHP method. In fact, AHP based weighted maps were standardized by the FAHP method. At first, Buckley (1985) developed the analysis of FAHP. Chang's extent analysis is one of the approaches to solution processes of FAHP methodology (Celik et al. 2009). In this approach, triangular fuzzy numbers are used for a pairwise comparison by the FAHP method. Here, we briefly describe the theoretical principle of the approach.

Assumption 1: suppose, M to be a triangular fuzzy number with the membership function below (Eq. 3):

$$Triangular\,(x; l,m,u) = \begin{cases} 0, & x \le l \\ \dfrac{x-l}{m-l}, & l \le x \le m \\ \dfrac{x-u}{m-u}, & m \le x \le u \\ 0, & u \le x \end{cases} \quad (3)$$

where:

x – independent variable,

l – lower value of the support of M ($l \le m$),

m – modal value,

u – upper value of the support of M ($m \le u$).

Then, operational laws between $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ triangular fuzzy numbers can be written as Eq. 4:

$$\begin{aligned} &M_1 + M_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2), \\ &M_1 \times M_2 = (l_1 l_2, m_1 m_2, u_1 u_2), \\ &(\lambda, \lambda, \lambda)M_1 = (\lambda l_1, \lambda m_1, \lambda u_1), \lambda > 0, \\ &M_1^{-1} \approx (1/u_1, 1/m_1, 1/l_1) \end{aligned} \quad (4)$$

where:

λ – element of real numbers.

Assumption 2: let $X = \{x_1, x_2, x_3, ..., x_n\}$ and $G = \{u_1, u_2, u_3, ..., u_n\}$ represent object and goal sets, respectively. Then, according to Chang's extent analysis, values of the m extent analysis for each goal (g_i) can be denoted by:

$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^j$

where:

$i = 1, 2, 3, \ldots, n$,

$j = 1, 2, 3, \ldots, m$.

Assumption 3: the value of fuzzy synthetic extent (S_i) of the i-th object is presented by Eq. 5:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \quad (5)$$

With the above-mentioned assumptions and S_i calculations, the degree of magnitude M_1 to M_2 can be obtained by the following relation (Eq. 6):

$$\bigvee(M_1 \geq M_2) = 1, \text{ if: } m_1 \geq m_2 \quad (6)$$

$$\bigvee(M_2 \geq M_1) = hgt(M_1 \cap M_2)$$

where:

hgt – height of a fuzzy set A, hgt(A) is defined by hgt(A) = supremum {A(x) |$x \in X$|}. If hgt(A) = 1, then A is called normalized.

Consequently, the degree for a triangular fuzzy number to be greater than k ones (M_i (i = 1, 2, 3, k) is dedicated by Eq. 7:

$$\bigvee(M \geq M_1, M_2, M_3, \ldots, M_k) = \bigvee[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } (M \geq M_3) \text{ and } \ldots \text{ and } (M \geq M_k)] \quad (7)$$

Then, the weight vectors of indices ($W(x_i)$) are given by Eq. 8:

$$W(x_i) = \min \{\bigvee(S_i \geq S_k)\}, k = 1, 2, 3, \ldots, k \neq 1 \quad (8)$$

Weighted linear combination (WLC) based site selection stage. Because of different scales of the map layers involved into the MCA analysis, it is necessary that the values of layers be transformed to comparable scales. There are some methods to make input map layers comparable. According to the types of information for creating the map layers, three approaches were developed for assigning new scales: deterministic, probabilistic or fuzzy (Malczewski 1999). Here a fuzzy approach was used for standardizing the input map layers. The fuzzy logic theory gives the multi criteria evaluation (MCE) process more flexibility and takes into account the continuity and uncertainty (Dashti et al. 2013). Here, a simple linear scaling as expressed below is used (Eq. 9):

$$x_i = [(R_i - R_{min})/(R_{max} - R_{min})] \times \text{standardized range} \quad (9)$$

where:

R – raw score of the input map layer.

This equation gives the option of standardizing factors to either a 0–1 scale or a 0–255 byte scale for the input map layer. Since, the MCE process has been optimized for speed using a 0–255 level standardization, the latter scale was used for the standardization stage (Eastman 2009). Then, the standardized maps with their related weights from the Fuzzy analytic hierarchy process analysis were combined based on the WLC technique (Ayalew et al. 2005). The weighted linear combination model is one of the most widely used decision rules that are often applied in suitability and site selection analysis problems. Easy to implement and understand are the primary reasons for its popularity (Malczewski 2000). The mathematical expression of the WLC model as Eq. 10:

$$\bigvee(x_i) = \sum_{j}^{n} w_j r_j(x_i) = \sum_{j}^{n} w_j r_{ij}, \ \sum w_j = 1 \quad (10)$$

where:

w_j – weight of map layer j,

r_j – map j transformed into the comparable scale,

n – total number of map layers involved into the WLC analysis,

$r_j(x_i)$ – value function for the j^{th} attribute, $x_i = (x_{i1}, x_{i2}, \ldots, x_{in})$,

r_{ij} – attribute transformed into the comparable scale.

Up to this stage, the WLC final map of suitability would provide a scattered spatial pattern of adjacent cells. Therefore, adjacent cells were grouped into zones (areas < 20 ha eliminated) and their areas were calculated. Finally, the average of the suitability of a certain zone calculates as follows (Leao et al. 2004; Eq. 11):

$$S_z = \frac{\sum (L_i)_z}{n_z} \quad (11)$$

where:

S_z – average land suitability of zone z,

$(L_i)_z$ – cells i of zone z,

n_z – number of cells of zone z.

RESULTS

Criteria and indicators development stage

As mentioned in the previous section, choosing appropriate criteria and indicators for the forest park selection problem is the main and first step of this type of studies. Hence, we extract the main criteria and indicators by a comprehension and precise literature review. Based on 28 literature reviews, we developed three groups of criteria: physical, biological and socio-economic. Also, 10 criteria and 36 sub-criteria were identified (Fig. 2). It is noteworthy that this figure is presented only as a general checklist and based on the condition of the studied area, 7 criteria (climate,

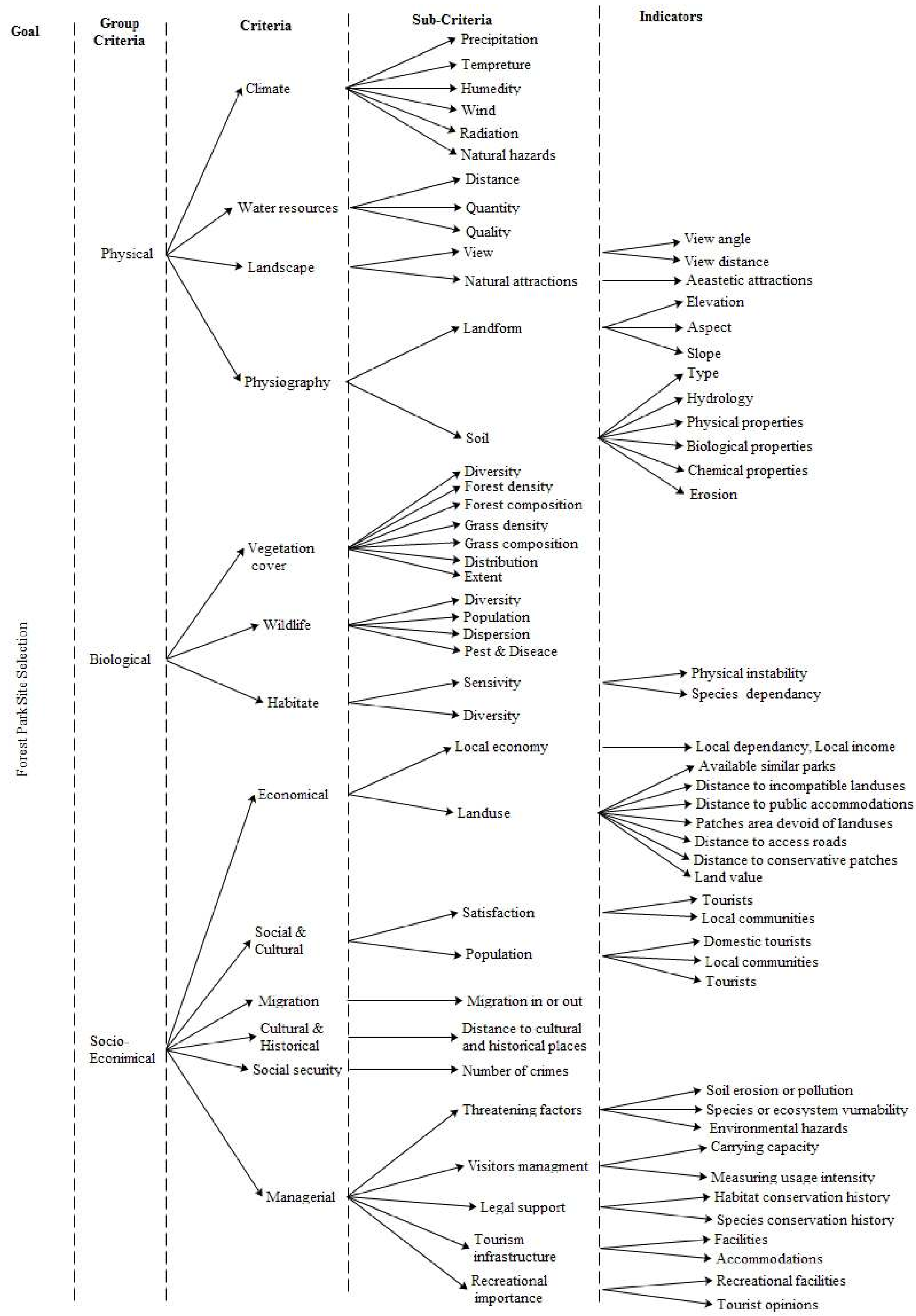

Fig. 2. Group criteria, criteria, sub-criteria and indicators derived from reviewing different literature sources

water resources, physiography, landscape, vegetation cover, wildlife and economic criteria) were selected to perform the Delphi screening stage (a sample of Delphi questionnaire is presented in Appendix).

Delphi screening stage

According to the carried out investigations, opinions of experts and different aspects of the study

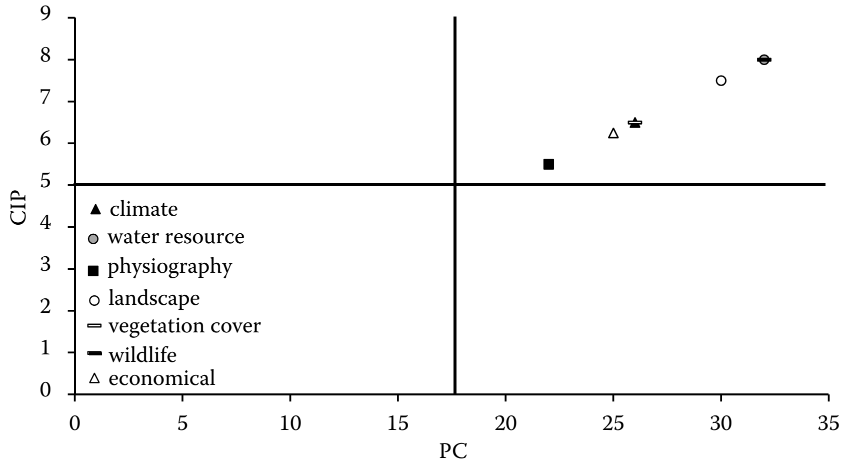

Fig. 3. Criteria screening by Delphi method (CIP – mean criterion importance degree, PC – mean percent of CIP)

area, among criteria and sub-criteria that are identified in Table 2, only 7 criteria (climate, water resources, physiography, landscape, vegetation cover, wildlife and economic criteria) were selected to perform the Delphi screening stage. Similarly, for choosing the most related sub-criteria for the forest park problem in Golestan Basin, only 14 sub-criteria were selected. Using Eqs 1 and 2, the CID and PC of all criteria and sub-criteria were calculated. By drawing a 2D graph, each criterion or sub-criterion which gets a percentage of importance or a degree of importance less than the median value of both axes of the Delphi graph should be omitted from the selection process. Figs 3 and 4 show the results of the screening process that was conducted by Delphi method. As illustrated in Fig. 3, all of the criteria received the required values and can be involved into the decision-making process of forest park site selection problem. But, among the sub-criteria, grass composition and density should be omitted in the screening procedure (Table 1).

Table 1. Criteria and sub-criteria determined by the Delphi method

Criteria	Sub-criteria
Climate	temperature climate hazard
Water resources	water quality water quantity distance to water
Physiography	landform soil
Landscape	view
Vegetation cover	forest composition forest density grass composition grass density (S54)
Wildlife	diversity wildlife dispersion animal sensitivity
Economic	local economy land use

Weighting stage

To determine the different priority weights of each criterion and sub-criterion, linguistic comparison terms and their corresponding triangular fuzzy numbers were used (Gumus 2009) (Table 2). In Tables 3–10, the fuzzy comparison matrices of criteria and sub-criteria and their weights are given.

The results of the fuzzy comparison matrix of criteria for forest park site selection (Table 3) in the Lorestan province, Iran shows that the climate criterion has the maximum weight (0.320) in comparison with the other criteria and it is considered to be the most important factor for assigning a forest park to the studied area. The water resources criterion is the second important criterion (0.197) for the forest park locating problem that should be taken into account by environmental planners. Also, results from this matrix revealed that the economic criterion from the respondent's point of view has a

Table 2. Triangular fuzzy numbers of linguistic comparison measures

Linguistic terms	Triangular fuzzy numbers
Perfect	(8, 9, 10)
Absolute	(7, 8, 9)
Very good	(6, 7, 8)
Fairly good	(5, 6, 7)
Good	(4, 5, 6)
Preferable	(3, 4, 5)
Not bad	(2, 3, 4)
Weak advantage	(1, 2, 3)
Equal	(1, 1, 1)

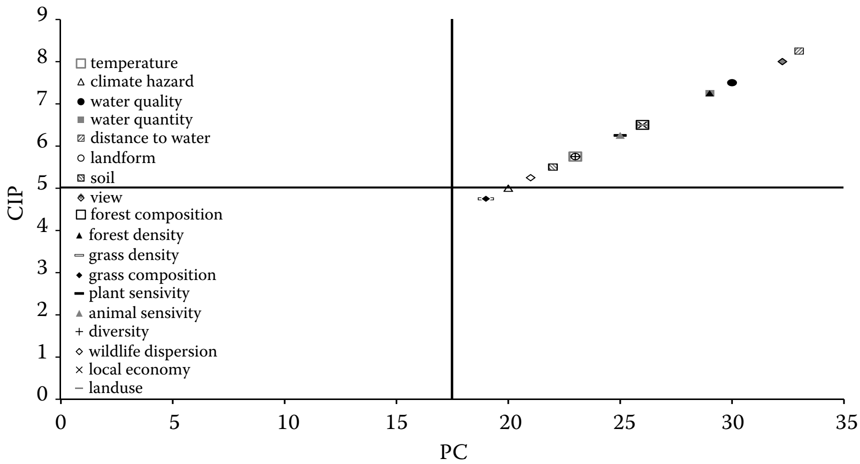

Fig. 4. Sub-criteria screening by Delphi method (CIP – mean criterion importance degree, PC – mean percent of CIP)

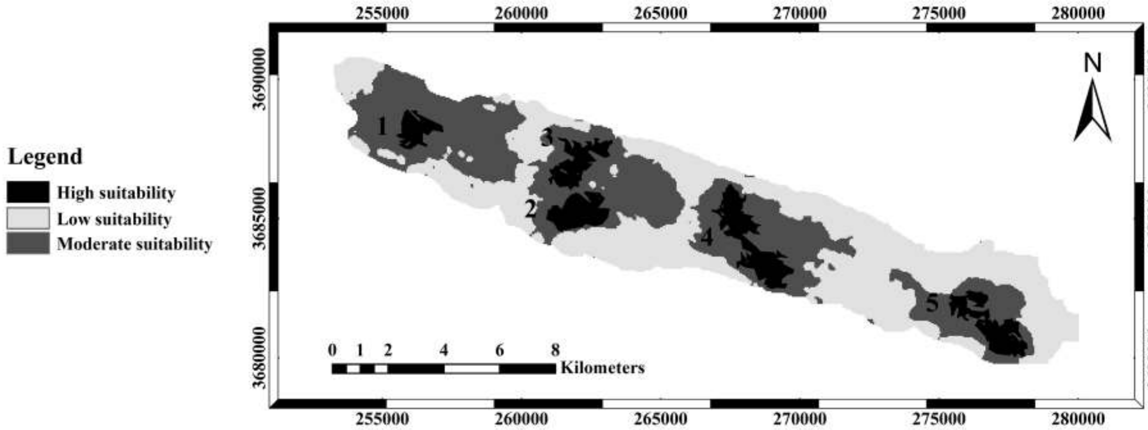

Fig. 5. Map of suitability for the forest park site selection in Galegol Basin, Lorestan province, Iran

lower priority (0.070) to design a forest park in the studied area. The results of the fuzzy comparison matrix of each sub-criterion with respect to each criterion are given in Tables 3–10. For instance, the weights of the sub-criteria of water resources criterion indicate that the importance of water quality, water quantity and distance to water sub-criteria is 0.721, 0.197 and 0.082, respectively.

Weighted linear combination based site selection map

The map of forest park site suitability using the WLC method is given in Fig. 5. According to this analysis, the study area classified into three suitability classes includes high suitability, moderate suitability and low suitability. The area of each class was calculated

Table 3. Criteria of the fuzzy comparison matrix

	C1	C2	C3	C4	C5	C6	C7	Weight
C1	(1, 1, 1)	(2, 2.5, 3)	(1, 1.5, 2)	(1, 1, 1)	(0.5, 1, 1.5)	(0.5, 0.4, 0.33)	(0.67, 0.5, 0.4)	0.320
C2		(1, 1, 1)	(0.28, 0.25, 0.22)	(0.4, 0.23, 0.28)	(1, 0.67, 0.5)	(0.22, 0.2, 0.18)	(0.25, 0.22, 0.2)	0.197
C3			(1, 1, 1)	(0.5, 1, 1.5)	(2, 2.5, 3)	(2, 1, 0.67)	(1, 1, 1)	0.144
C4				(1, 1, 1)	(1, 1.5, 2)	(0.67, 0.5, 0.4)	(1, 0.67, 0.5)	0.112
C5					(1, 1, 1)	(0.33, 0.28, 0.25)	(0.4, 0.33, 0.28)	0.084
C6						(1, 1, 1)	(1, 1, 1)	0.072
C7							(1, 1, 1)	0.070

criteria determined by Delphi method: C1 – climate, C2 – water resources, C3 – physiography, C4 – landscape, C5 – vegetation cover, C6 – wildlife, C7 – economic

Table 4. The fuzzy comparison matrix of climate sub-criteria

	S11	S12	Weight
S11	(1, 1, 1)	(4.5, 5, 5.5)	0.83
S12	(0.22, 0.2, 0.18)	(1, 1, 1)	0.17

sub-criteria determined by Delphi method: S11 – temperature, S12 – climate hazard

Table 5. The fuzzy comparison matrix of water resources sub-criteria

	S21	S22	S23	Weight
S21	(1, 1, 1)	(4.5, 5, 5.5)	(7, 7.5, 8)	0.721
S22	(0.22, 0.2, 0.18)	(1, 1, 1)	(2, 2.5, 3)	0.197
S23	(0.14, 0.13, 0.12)	(0.5, 0.4, 0.33)	(1, 1, 1)	0.082

sub-criteria determined by Delphi method: S21 – water quality, S22 – water quantity, S23 – distance to water

Table 6. The fuzzy comparison matrix of physiography sub-criteria

	S31	S32	Weight
S31	(1, 1, 1)	(4.5, 5, 5.5)	0.83
S32	(0.22, 0.2, 0.18)	(1, 1, 1)	0.17

sub-criteria determined by Delphi method: S31 – landform, S32 – soil

Table 7. The fuzzy comparison matrix of landscape sub-criteria

	S41	Weight
S41	(1, 1, 1)	1

sub-criterion determined by Delphi method: S41 – view

Table 8. The fuzzy comparison matrix of vegetation cover sub-criteria

	S51	S52	S53	Weight
S51	(1, 1, 1)	(3.5, 4, 4.5)	(6, 6.5, 7)	0.69
S52	(0.28, 0.25, 0.22)	(1, 1, 1)	(2, 2.5, 3)	0.22
S53	(0.17, 0.15, 0.14)	(0.5, 0.4, 0.33)	(1, 1, 1)	0.09

sub-criteria determined by Delphi method: S51 – forest composition, S52 – forest density, S53 – grass composition

Table 9. The fuzzy comparison matrix of wildlife sub-criteria

	S61	S62	S63	Weight
S61	(1, 1, 1)	(1, 1.5, 2)	(3, 3.5, 4)	0.529
S62	(0.1, 0.75, 0.5)	(1, 1, 1)	(1, 1.5, 2)	0.288
S63	(0.33, 0.28, 0.25)	(0.1, 0.75, 0.5)	(1, 1, 1)	0.183

sub-criteria determined by Delphi method: S61 – diversity, S62 – wildlife dispersion, S63 – animal sensitivity

Table 10. The fuzzy comparison matrix of economic sub-criteria

	S71	S72	Weight
S71	(1, 1, 1)	(2, 2.5, 3)	0.71
S72	(0.5, 0.4, 0.33)	(1, 1, 1)	0.29

sub-criteria determined by Delphi method: S71 – local economy, S72 – land use

Table 11. Average land suitability of Galegol Basin, Lorestan province, Iran, for the forest park problem

Zone	Area (ha)	Average land suitability
1	115.95	179.22
2	178.34	180.45
3	201.71	183.42
4	322.33	178.43
5	240.59	174.37

as 3,762.62, 4,328.61 and 1,399.77 ha, respectively. In fact, most of the study area is moderately suitable for the forest park location problem. Also, the result of zonal land suitability corresponds to high suitability class presented in Table 11. Accordingly, 5 zones were created in terms of 0–255 scale.

DISCUSSION

Better decision-making quality is achieved by more thought. When the land use planning task such as forest park site location is carried out in the context of MCE process, a checklist of criteria and sub-criteria gives a general background of what we have currently. The checklist shows what is important and outlines an approach and can be adapted to the variety of regions (Anonymous 1995). Hence, in this study a comprehension list of criteria and sub-criteria through various sources is provided (Fig. 2).

In this study, a set of criteria and sub-criteria was identified by the Delphi screening approach for the forest park site location problem in Galegol Basin, Lorestan province, Iran (Figs 3 and 4, Table 1). Totally, 15 experts participated in the Delphi survey. The Delphi method is thought to obtain a consensus among individuals who have the special knowledge of an issue of interest, in contrast to opinion polls which use a random choice of participants and lack the opinion feedback (Fürst et al. 2010). Also, this method of screening provides a suitable way of bridging the gap between regional analysis and its incorporation into public policy (Miller 1993). Based on this analysis, all of the 7 criteria (climate, water resources, physiography, landscape, vegetation cover, wildlife and economic criteria) received the required values and were involved into the decision-making process of the forest park site selection problem. On the other hand, the grass composition and density sub-criteria were omitted from the primarily 18 sub-criteria imported to the Delphi screening process, because these criteria have received the lowest percentage of importance and degree of importance values in comparison with the other sub-criteria. The most important sub-criteria related to the forest park locating problem were temperature (0.83), water quality (0.721), land form (0.83), forest composition (0.69), diversity (0.52) and local economy (0.71). Overall, the results of the FAHP weighting method in this study delineate that physical aspects of the studied region are the most determinant agents to locate the forest park. In Lawal et al. (2011), water bodies and green spaces were considered for locating recreational areas. Also, in Piran et al. (2013), it is concluded that vegetation cover and water resources are most important in the selection of the forest park location. Since, in the AHP method, the subjective descriptions of reviewers' decisions often correspond to an exact value, the possible benefits of handling vagueness in judgments during the conversion of verbal scales into a numeric scale (Ishizaka 2014). To make the analysis results more reasonable, using the fuzzy set theory to deal with the problems of fuzziness is very important.

Performing a complex multiple criteria problem without spatial analytical and visualization tools could be computationally challenging. Hence, this study presented a framework for the planning process using GIS and FAHP for the forest park locating problem and its outputs can be valuable in the planning of local forest park and future land use planning.

APPENDIX

First round of Delphi questionnaire

On behalf of the University of Tehran, I have the honour to invite you to participate in the first round of a study to select relevant forest park criteria. Here, based on scientific resources I list some of them. Please modify or complete this list.

We appreciate your willingness to participate in this initiative.

Sincerely yours,

Abotaleb Salehnasab
Ph.D. student of Department of Forestry and Forest Economics, University of Tehran

1. Participant's background:

Name:
Address:
Phone:
My primary employment is in:
Government Agency ☐
Non-Government Organization ☐
University ☐
Other ☐

2. Years of experience in the following fields:

Forest management -------
Landscape management -------
GIS -------
Forest ecology -------
Tourism -------
Forest socioeconomic issues -------

3. Proposed group criteria for the forest park site selection (please extend this to criteria, sub-criteria, and indicators):

Group criteria	Criteria	Sub-criteria	Indicators
Physical	climate	precipitation temperature wind	
	water resources	distance quantity	
	landscape	view natural attraction	
Biological	vegetation cover	diversity	
	habitat	sensitivity	physical instability species dependence
Socioeconomic	economic	local economy land use	
	social security	number of crimes	

Second round of Delphi questionnaire

On behalf of the University of Tehran, I have the honour to invite you to participate in the second round of a study to select relevant forest park criteria. Here, based on scientific resources and the first round of the questionnaire I list them as criteria, sub-criteria and indicators. Please determine their initial importance degree based on the ranking order below:

Unimportant = 1
Less important = 3
Important = 5
Highly important = 7
Very highly important = 9

Table 1. Initial importance degree of criteria

Criteria	Initial importance ranks				
	1	3	5	7	9
Climate					
Water resources					
Landscape					
Physiography					
Vegetation cover					
Wildlife					
Habitat					
Economic					
Social and cultural					
Migration					
Cultural and historical					
Social security					
Managerial					

Table 2. Initial importance degree of sub-criteria

Sub-criteria	Initial importance ranks				
	1	3	5	7	9
Precipitation					
Temperature					
Humidity					
Wind					
Radiation					
Natural hazard					
Distance					
Quantity					
Quality					
View					
Natural attraction					
Landform					
Soil					
Diversity					
Forest density					
Forest composition					
Grass density					
Grass composition					
Distribution					
Extent					
Diversity					
Population					
Dispersion					
Pests and diseases					
Sensitivity					
Diversity					
Local economy					
Landuse					
Satisfaction					
Population					
Migration in or out					
Distance to cultural and historical place					
Number of crimes					
Threatening factors					
Visitor management					
Legal support					
Tourism infrastructure					
Recreational importance					

Table 3. Initial importance degree of indicators

Indicators	Initial importance ranks				
	1	3	5	7	9
View angle					
View distance					
Aesthetic attraction					
Elevation					
Aspect					
Slope					
Type					
Hydrology					
Physical properties					
Biological properties					
Chemical properties					
Erosion					
Physical instability					
Species dependence					
Local dependence, local income					
Available similar parks					
Distance to incompatible land uses					
Distance to public accommodation					
Area of patches devoid of land uses					
Distance to access roads					
Distance to conservative patches					
Land value					
Tourists					
Local communities					
Domestic tourists					
Tourists					
Soil erosion or pollution					
Species or ecosystem vulnerability					
Environmental hazards					
Carrying capacity					
Measuring usage intensity					
Habitat conservation history					
Species conservation history					
Facilities					
Accommodation					
Recreational facilities					
Tourists opinions					

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