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Modeling and Prioritizing Ecotourism Potential in National Park and Protected Area of Sarigol with Fuzzy-AHP in GIS

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ABSTRACT

Aims: Tourism can significantly contribute to protecting and developing the environment and national parks as essential sites. Ecotourism, one sustainable tourism form, is based on natural attractions. This study identifies and prioritizes appropriate ecotourism sites in Sarigol National Park and Protected Area.

Materials & Methods: To this end, some criteria, including landform, climate, wildlife habitats, vegetation type and density, and soil of the area, were investigated. Elevation, slope, aspect, precipitation, sunny days in a month, soil erosion, soil depth, vegetation type, vegetation density, and animal type were assessed as sub-criteria, too. The potential ecological map was drawn using the Fuzzy-Analytical Hierarchy Process (Fuzzy-AHP) based on the criteria and sub-criteria. Also, its regional attractiveness map was identified by field investigation with Global Positioning System (GPS) and weighting via a questionnaire and Geographic Information System (GIS), then was compared with the potential ecological map. Finally, appropriate and potential tourism and ecotourism sites were identified.

Findings: The results indicated that northern parts of the area, Izi Waterfall, and some parts of the National Park enjoy capabilities of ecotourism development; these sites enjoy ecological capabilities and attractions to attract tourists.

Conclusion: Identifying ecotourism sites in the present study contributes to better management, tourism development, and protection of the study area.

Keywords: Potential Mapping; Ecotourism; Fuzzy-AHP; Remote Sensing; National Park.

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Introduction

Creating a link between protected areas and tourism is as old as the history of protected areas. Protected areas need tourism, and tourism needs protected areas. Protected areas typically achieve recognition and enhanced protection, but when sufficient numbers of people visit the areas, they appreciate and take political action to ensure their survival. Tourism can help sustain protected areas as a market-based alternative catering to the growing number of discriminating travelers trying to find, understand and enjoy a natural environment. Tourism can support the protection of natural resources as residents realize the value of their assets and want to preserve them [1]. Tourism revenue (such as entrance fees, concessions for tourism services, selling of souvenirs, and guidebooks), if handled correctly, can be channeled into the maintenance of the protected area and used to pay the salaries of rangers, for road and trail maintenance, for interpretation, to fund research, build appropriate tourism facilities, and so on. Tourism can also serve to preserve and strengthen indigenous cultural identity while at the same time making a positive contribution to economic development [2]. The world's tourism and recreation industry benefits protected areas and the communities adjacent to or within them. These benefits lead to a greater appreciation of 17 cultural and natural heritage and more excellent knowledge of the interplay between humans and their environment. High-quality recreational, spiritual, and educational experiences for park visitors will foster increased interest and commitment to protecting and conserving biodiversity and cultural values [3]. Protected areas' opportunity to see, touch, and experience the natural world frequently "converts" their visitors into faithful and active supporters [2]. Tourism is at the heart of most national park strategies. Nevertheless, it brings perils as well as benefits. Visitor management is how the park manager seeks to maximize the benefits and minimize the harm. The parks must help local people improve their livelihoods to justify their existence and maintain political credibility. Tourism is nearly always the best way to do this with the most minor damage to nature. It creates jobs, generates income for the local economy, and makes peripheral regions less isolated, opening their residents to new influences and cultures and encouraging an intense valuation of the local culture and natural assets. A strong focus on sustainable nature tourism is the best argument against building new and damaging infrastructure like ski lifts and hydro dams [4]. Nevertheless, the benefits of tourism in protected areas depend on appropriate planning and monitoring. Planning with low accuracy and poor implementation of ecotourism projects have made ecotourism a set of tourism projects with adverse effects such as soil erosion [5, 6], soil compaction [7], elimination and removal of plant species [5, 8], and destruction of wildlife [9,10]. Proper implementation of tourism in protected areas can have results such as an increase in the significance of the areas and enhancement in their economic values [11, 12, 13]. It also can make direct revenues from protected zones and promote motivations of local communities to safeguard the environment [14, 15, 16], enhancing the culture of sustainable use of natural resources and reducing threats to biological communities [17]. Therefore, evaluating the capacities of tourism in a protected zone contributes to better management, tourism development, and protection. Some essential aims of determining areas with a potential for ecotourism are appropriate planning and management and more rapid access to the primary purposes of ecotourism [18]. Arrowsmith et al. [19] developed a model for the potential assessment of ecotourism using the multivariate evaluation method and GIS in a national park in Australia. Then they zoned the area in terms of tourism. The AHP and GIS were employed in the research. Slope, direction, elevation, vegetation type, and density, sunshine hours, precipitation, and soil patterns were the employed criteria. The areas with attractions were identified in the same park, and then the two maps were compared to identify areas with the capacity to develop ecotourism. KianiSadr et al. [20] determined the ecotourism potential of Oshtorankouh using the AHP, Delphi method, and weighting by GIS. They provide appropriate results following the potential of the area. Meanwhile, Mousavi et al. [21] identified areas best suited for tourism using the WLC and Fuzzy-AHP. They considered three criteria, accessibility, proximity to the river, and natural attractions, as the most important environmental variable for recreational purposes.

Besides, Motiei Langroudi et al. [22] surveyed the ecological potential of Marvdasht Township using the Fuzzy-AHP method in a GIS environment. In their study, environmental variables such as landforms were used. Finally, the area was divided into six classes with different capacities for agricultural development. Sajjadian et al. [23] analyzed and rated rural tourism based on river ecotourism in Amol Township using AHP, data network, and sensitivity analysis. According to the research findings, rural districts of Amol Township enjoy the capacity of river-based ecotourism and use this attraction in rural tourism. Shojaei et al. [24] examined Qom

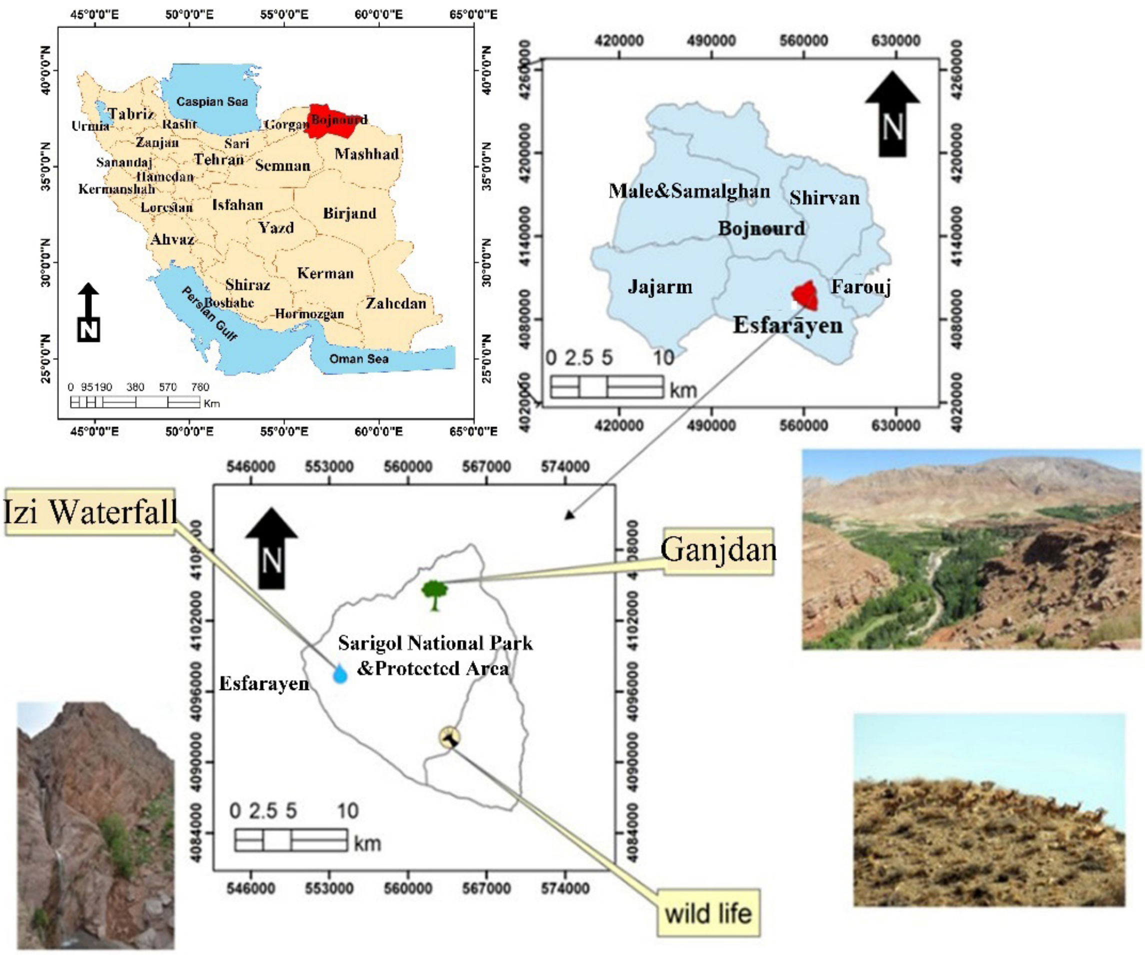

Figure 1) Location of Sarigol Area in North Khorasan Province and Iran.

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Province's potential for nature tourism development. Using AHP and the Makhdoum ecological model in GIS, they identified capable areas for ecotourism development and divided the study area into six zones with different potentials for ecotourism development. Rahayuningsih et al. [25] evaluated resources for nature-based tourism in Bogor using GIS. The study aimed to construct a model for nature tourism planning based on two main criteria: attraction and accessibility. Based on the model, the study area was divided into seven classes. Besides nature planning, Zabihi et al. [26] evaluated the relative importance of physical, natural, environmental, and socio-economic factors in Iran for determining the suitability of ecotourism sites using the fuzzy-AHP method. Bire et al. [27] used human factors to assess tourist attractions by the fuzzy-AHP method. Wu et al. [28] evaluated agritourism based on economic, social, and environmental factors via fuzzy AHP. Researchers have employed the fuzzy-AHP method to assess and determine the suitability and potential of ecotourism sites in recent years regarding different factors.

This study employed criteria such as landform, climate, wildlife habitats, vegetation type and density, and soil of the area to identify and prioritize appropriate parts of Sarigol National Park and Protected Area regarding ecotourism. Elevation, slope, aspect, precipitation, sunny days in a month, soil erosion, soil depth, vegetation type, vegetation density, and animal type were assessed as sub-criteria, too. The potential ecological map was assessed using fuzzy-AHP, then the regional attractiveness map for tourists was prepared via the questionnaires and field investigation with GPS. The novelty of this research is the comparison of regional attractiveness classes and the potential ecological map of Sarigol National Park using the intersection analysis method in GIS. So, they compared and concluded the tourism situation by intersecting these maps. Using this comparison, we could pay more attention to which places attract tourists.

Materials & Methods

Study Area

Sarigol National Park and Protected Area is located in the east of Esfarāyen Township in North Khorasan (57.76° to 57.47° E and 36.55° to 27.08° N) (Figure 1). The national park covers an area of 6000 Ha, and the protected area covers an area of 22000 Ha (total 28000 Ha). Sarigol National Park and Protected Area, an outstanding collection of attractions in North Khorasan, covers diverse habitats, high cold mountains, and hills, and a low-level plain with relatively warmer climates compared to mountainous regions of the area. Sarigol is currently one of Iran's wealthiest protected areas in terms of biodiversity and includes a relatively intact ecosystem. Sarigol has diverse and interesting flora, fauna, natural landscapes, and habitats. This area is one of the most important habitats of Galbanum (*Ferula galbaniflua*) in Khorasan Province. Moreover, it is a habitat of the urial sheep (*Ovis orientalis vignei*).

Criteria such as landform, climate, wildlife habitats, vegetation type and density, and soil of the area were used to identify and prioritize appropriate parts of Sarigol National Park and Protected Area regarding ecotourism. Elevation, slope, aspect, precipitation, sunny days in a month, soil erosion, soil depth, vegetation type, vegetation density, and animal type were assessed as sub-criteria, too. These criteria and sub-criteria were selected based on the literature review and experts' opinions of environmental protection organizations. For creating the initial maps, the spatial analysis in GIS, i.e., triangulation irregular

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network (TIN) and digital elevation model (DEM) were used to create elevation, slope, and aspect based on topographic data. Based on meteorology data, the inverse distance weighting (IDW) method was used to create precipitation and sunny days in a month. Soil erosion and soil depth were created based on a geology map in GIS. Vegetation and animal types were produced based on environmental protection organization data in GIS. Landsat ETM+ of remote sensing data was used to create vegetation density based on the normalized difference vegetation index (NDVI) method in ENVI software.

Since the input of criteria layers is measured in different units, they must be normalized to use in multi-criteria decision-making [21]. The fuzzy sets and fuzzy logic are efficient and suitable tools for mathematical modeling and formulating ambiguity and uncertainty in human cognitive processes [29]. This theory was proposed by Zadeh [30, 31]. Fuzzy set theory is used for personal and obscure judgments about a unique phenomenon entered into probable or mathematical models [32].

The type of fuzzy functions and control points should be determined first for creating fuzzy maps for each factor. Determining control points for each criterion by fuzzy functions depends on the researcher's decisions. Selecting appropriate fuzzy functions (membership function) and determining the proper control points are essential in standardizing criteria [33]. In the present study, Increasing and Decreasing linear functions and S-shaped functions were used. After layers standardization using IDRISI software concerning each function type in order to obtain the fuzzy map, the AHP method (assigned weights obtained from Expert Choice software) and weighted linear combination (WLC) in GIS have been used to weight the layer and combine these layers, respectively. Finally, the potential ecological map for ecotourism development has been created in GIS.

Sub-criteria Standardization Using Fuzzy Method

This study selected the type of fuzzy functions and thresholds of sub-criteria of each criterion based on previous research and experts' opinions of environmental protection organizations (Table 1). The Increasing linear function was employed for the precipitation sub-criterion and the sunny days. The higher the precipitation rate in an area, is more appropriate for tourism. Moreover, the precipitation rate affects vegetation density and animal diversity. According to the Makhdoum ecotourism model, 7-15 and more than 15 sunny days are appropriate for ecotourism [34]. The Crisp function was employed for sub-criteria soil erosion, soil depth, animal, and vegetation types. These sub-criteria were discrete and assigned weight for their standardization of fuzzy based on experts' opinions of environmental protection organizations. The importance of soil is ecological, i.e., for the expansion of ecotourism, soil resistance should be paid attention. Soil erosion has negatively influenced ecotourism potential and decreased the regional attractiveness for tourism. So, medium to deep depths and low to medium erodibility are suitable for expanding ecotourism. Meanwhile, the presence of animal and vegetation species can attract many tourists to the region, so we considered this sub-criteria in evaluating ecotourism potential, too.

The Decreasing linear function was used for sub-criteria elevation and slope. These two sub-criteria are two crucial factors for evaluating the sites for ecotourism development. Slopes between 0 to 50% were considered equal to 0 to 1, and slopes higher than 50% were assigned a value of 0 because slopes less than 50% are appropriate for ecotourism development [35]. Since the elevation of the flattest regions of the area is 1200 m, this elevation is assigned to control point A. As the elevation increases, it becomes a negative factor for tourism development. Elevations ranging from 1200 to 2600 m were assigned values between 0 to 1, and elevations higher than 2600 were assigned a value of 0; elevation is an important criterion for determining appropriate tourism areas [36]. The Symmetrical sigmoidal function was used for vegetation density. Vegetation density equal to 0- 5%, 5-40%, 40-60%, 60-80%, and higher than 80% were assigned with values 0, 0- 1, 1, 1- 0, and 0, respectively [37].

Membership Functions

This theory can mathematically configure many fuzzy concept variables and systems, providing grounds for deductions, control, and decision-making under uncertain conditions [38]. Unlike classical logic, which has two values of zero and one, fuzzy logic indicates its values as membership percentages in the 0-1 range. The value 1 indicates full membership [30]. A fuzzy set is identified by its membership degree based on membership function, how it affects factors on standardization (Increasing/Decreasing), and threshold limit (i.e., control points). Four membership functions in the fuzzy set include S-shaped, J-shaped, linear, and user-defined [33, 39] (Figures 2-4).

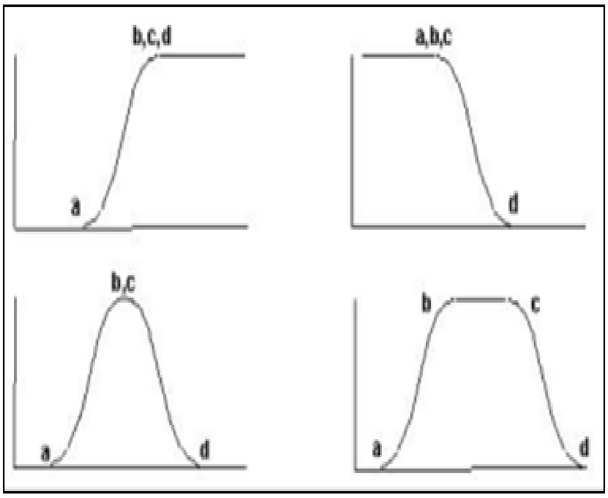

Figure 2) Sigmoidal membership function [40].

Table 1) Threshold and fuzzy functions type for standardization of sub-criteria in fuzzy logic.

Row	Sub-Criteria	Control Points A/B	Control Points C/D	Fuzzy Function Type	Fuzzy Function
1	(Precipitation(mm	0	200	Increasing	Linear
2	Number of Sunny Days in a Month	7	15	Increasing	Linear
3	Aspect	14	20	Increasing	Linear
4	(Elevation (m	1200	2600	Decreasing	Linear
5	(%) Slope	0	50	Decreasing	Linear
6	Soil Erosion				Crisp
7	Soil Depth				Crisp
8	Animal Types				Crisp
9	Vegetation Types				Crisp
10	(%) Vegetation Density	Based on text		Symmetric	Sigmoid

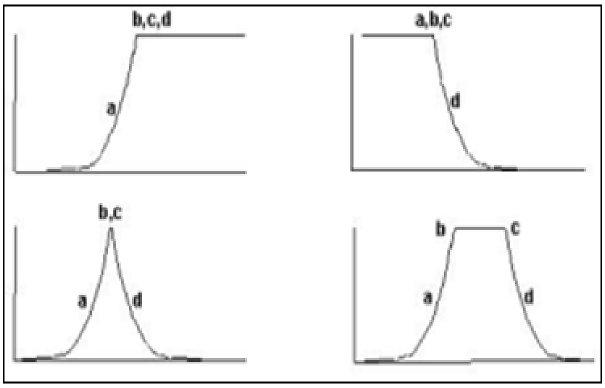

Figure 3) J-shaped membership function [40].

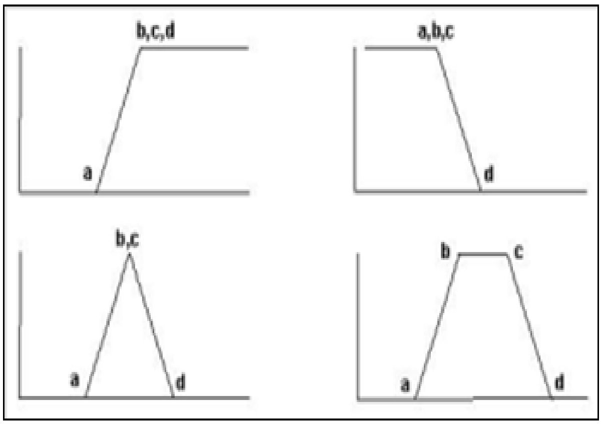

Figure 4) Linear membership function [40].

In fuzzy logic, each area receives a membership value regarding the degree of the criterion it observes. This value indicates the favorability degree of that area; that is, each area with a higher membership value has higher favorability. In fuzzy logic, each layer is rated on a 0-to-1 scale. In these scales, more significant values have higher favorability. So, 1 means the most favorability, and 0 presents the least favorability. A range of degrees is between these two values. Another factor affecting the standardization of fuzzy maps is the determination of thresholds (control points). However, the point worthy of being noticed in selecting functions is the Decreasing and Increasing types of the criterion [41]. The Sigmoidal membership function can be obtained from Eq. (1):

$$a = (x-a) / (b-a)*pi / 2 \quad \text{if } x > b \rightarrow \mu = 1 \qquad \text{Eq. (1)}$$

Eq. (2) calculates the j-shaped membership function:

$$\mu = 1/(1+((x-a) / (b-a))2 \text{ If } z > b \rightarrow \mu = 1 \qquad \text{Eq. (2)}$$

3-3- Drawing the Regional Attractiveness Map

In this stage, the area was investigated for its attractiveness for tourism. The area was surveyed, and tourism attractions were recorded by GPS (GPSMAP 76CSx). Tourist attractions fall into one of two categories: point attractions such as scenic lookouts, waterfalls, geological formations, villages, and ranger stations, and linear attractions comprise trails, rivers, streams, and valleys. Images with appropriate quality were prepared out of all area's attractions. Then, these images were submitted to tourists and experts of environmental protection organizations in image questionnaires (30 questionnaires), and preferential rates for each attraction were obtained via the questionnaires. The final weights of attractions were obtained according to Eqs. (3) and (4). Then, weights were applied to attractions in GIS, and consequently, the map of the area's attractions was obtained.

$$W_i = AT_i / AC_i \qquad \text{Eq. (3)}$$

Where AT_i indicates the attractiveness of each attraction, and AC_i indicates accessibility to the attraction.

$$AL_i = W_i / P_i \qquad \text{Eq. (4)}$$

In this Eq., W_i indicates the weight obtained from the attractiveness and accessibility of each attraction, and P_i indicates the preferential rate of the attraction. Al_i refers to the final weight of each attraction [19]. Finally, comparing the map of ecological potential for ecotourism and the regional attractiveness map using intersect tool in GIS, the study area was classified based on its poten-

Table 2) Criteria and sub-criteria weights by AHP.

Criteria and Weight		Sub-criteria and Weights			
Landform		Slope	Aspect	Elevation	Cr = 0.00877
0.385		0.54	0.163	0.297	
Climate		Precipitation	Sunny Days	Cr = 0.01	
0.229		0.8	0.2		
Vegetation		Vegetation density	Vegetation type	Cr = 0.002	
0.197		0.333	0.667		
Soil		Soil Erosion	Soil Depth	Cr = 0.0043	
0.056		0.75	0.25		
Wildlife Habitat		Ram and Ewe	Leopard	Cr = 0.002	
0.133	Cr = 0.09	0.667	0.333		

tial for ecotourism.

Findings

Initial Maps of the sub-criteria before standardization by the fuzzy method are displayed in Figure 5.

The fuzzy map was obtained for its layer in the next step using IDRISI software about threshold and fuzzy functions type to normalize sub-criteria in fuzzy logic in Table 1 (Figure 6).

Ecological Potential Map for Ecotourism Development Using the Fuzzy-AHP

Information layers were integrated via the AHP with their assigned weights (obtained from Expert Choice software) in GIS to prepare the fuzzy map. The weighted sum method overlayed all obtained fuzzy maps using weights obtained from the AHP (Table 2).

Table 3 presents the calculated area of each class: 6618 ha of the area has a very high potential for ecotourism development. These parts are located in the southwestern part of the area, including Izi Waterfall, some parts of Nasr Abad Valley, Rishi Valley, and northern parts of the area, including Gonjadan Valley and Bidovaz Valley. The sites with high potential for ecotourism development included Narimani Valley, some parts of Gonjadan Valley and Bidovaz Valley, Esfarāyen Dam, Baba Ghodrat, and Dahaneh Ojagh Village, covering 6270 ha of the area. 5970 ha of the area has moderate potential for ecotourism development. These sites cover some parts of the highly protected zone and some of Dahaneh Ojagh Valley. Finally, 7997 ha of the area has a low capacity for ecotourism development, covering the highest elevation, steep, and high lands. It covers some parts of Esfarāyen Dam and some parts of the highly protected zone. The lowest area is assigned to the class with very low potential, covering 1424 ha. Natural Break Classification classified the fuzzy-AHP map into five classes (Figure 7).

Table 3) The ecological potential of classes for ecotourism in fuzzy-AHP map.

Rank	Class	Area (hectare)	Percent (%)
1	Very low	1424.272333	5
2	Low	7997.551572	28
3	Moderate	5970.058503	21
4	High	6270.53323	22
5	Very high	6618.386873	24

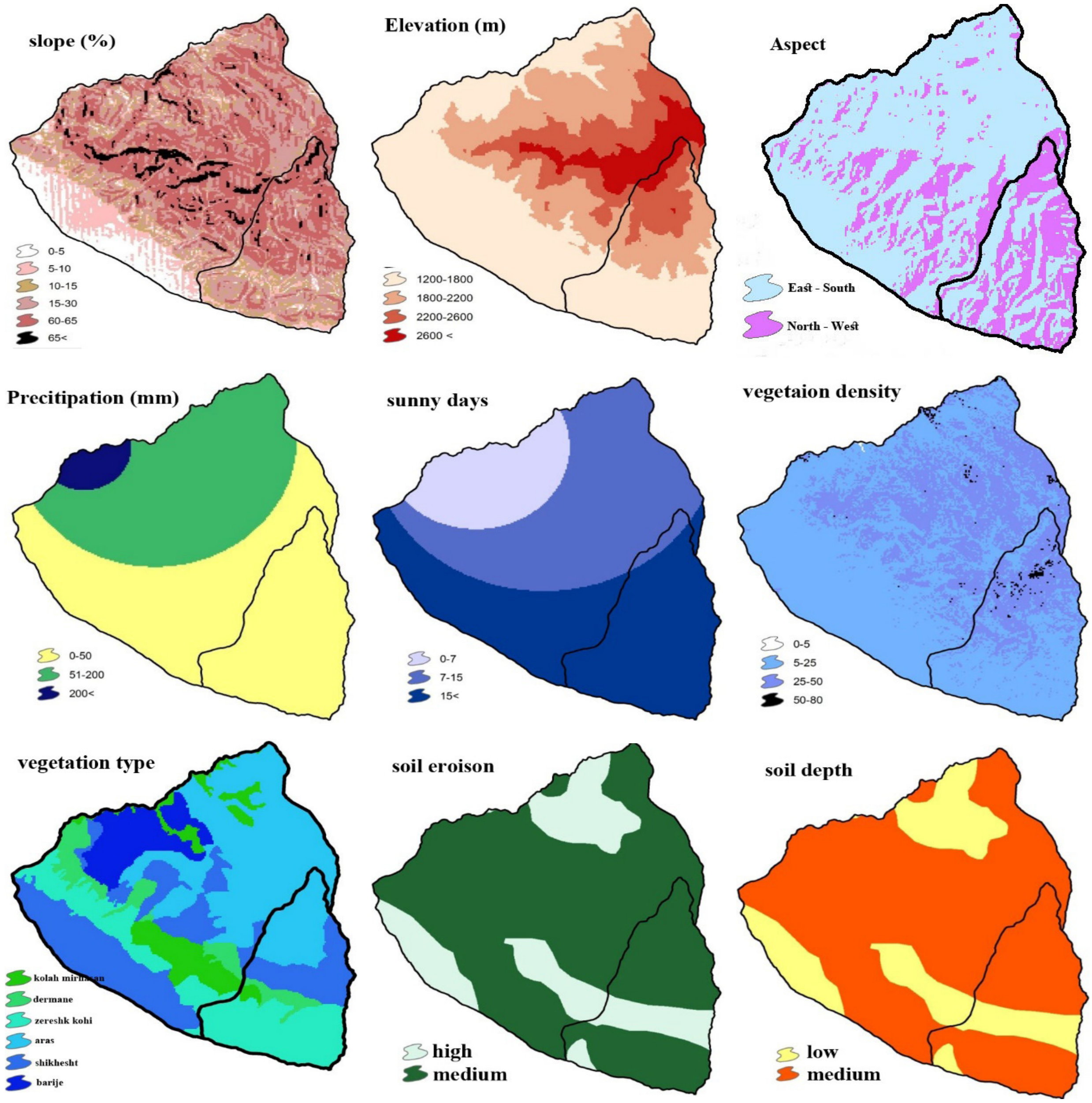

Figure 5) Initial maps of sub-criteria.

Table 4) Comparison of attractiveness classes and potential ecological classes of the area via the Fuzzy-AHP.

Attractiveness \ Ecological Capacities	High and Very High	Moderate	Low and Very Low
Low	42.89%	37.01%	25.07%
Moderate	50%	28.8%	48.26%
Favorable	4.08%	32%	13.55%
High	3.03%	2.19%	13.12%

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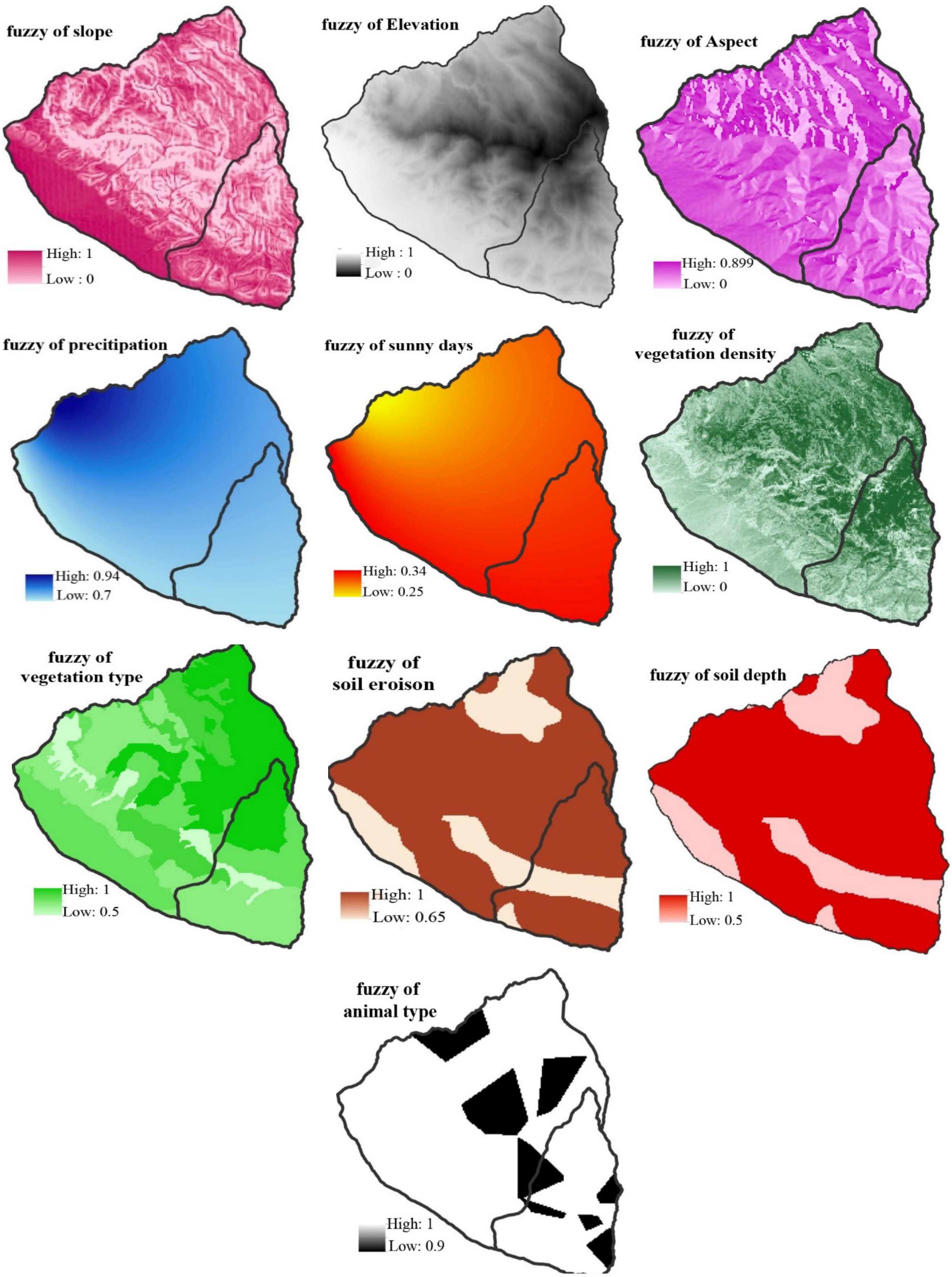

Figure 6) Fuzzy maps of sub-criteria.

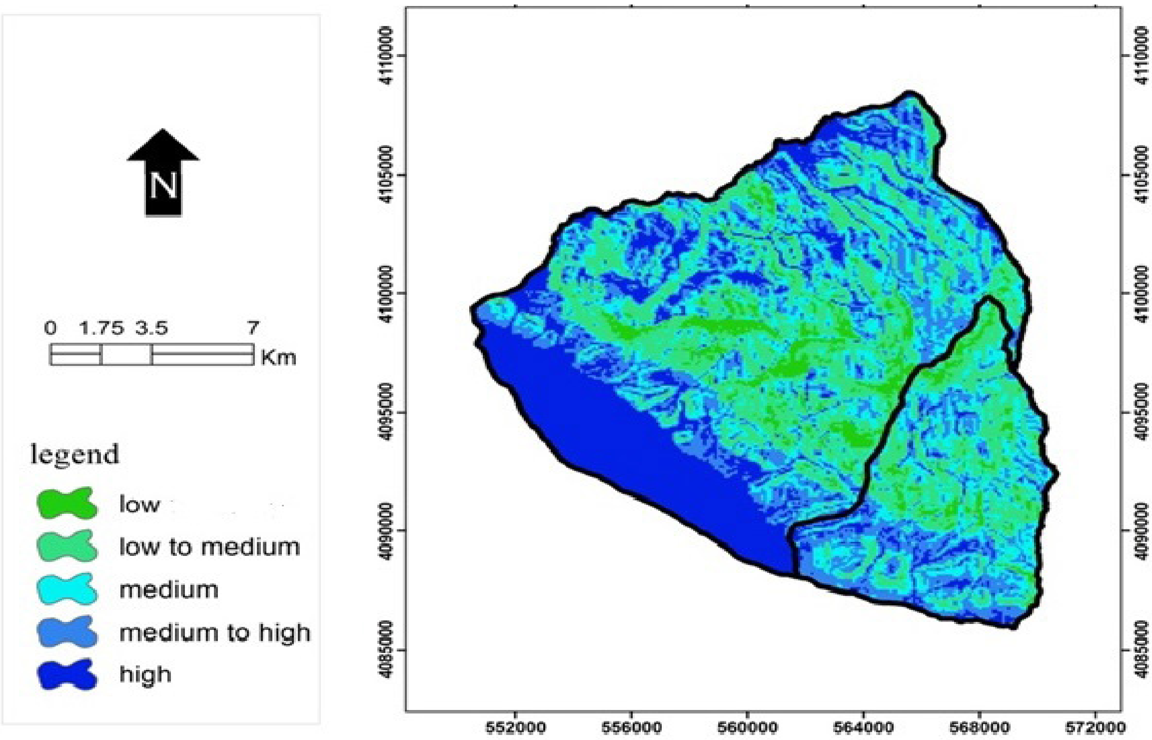

Figure 7) Zoning regions based on the ecological potential for ecotourism development via the Fuzzy-AHP.

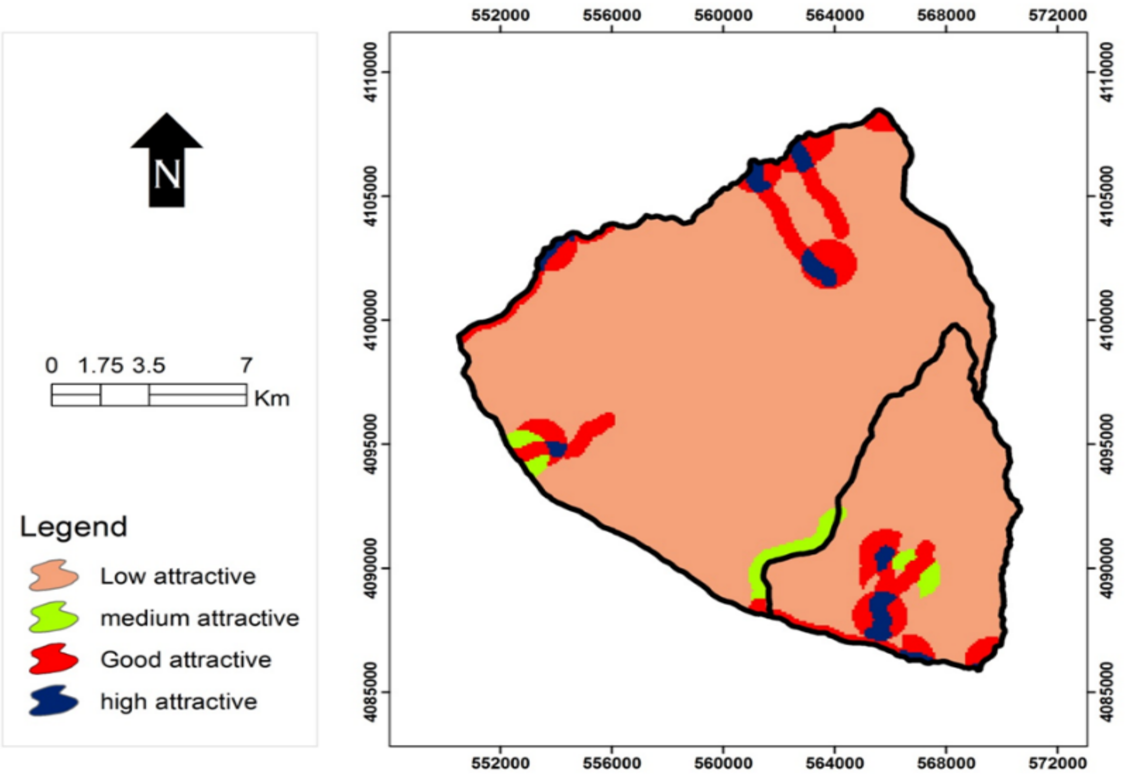

Figure 8) Zoning map based on attractiveness for ecotourism development.

Regional Attractiveness Map

In this stage, attractive regions were identified and recorded using GPS. The records were entered into GIS and assigned weights. As the resulting map represents, the most attractive parts are located in the north and some southern regions, such as Izi Waterfall (Figure 8). This map classified the area's attractiveness into four classes, high, favorable, moderate, and low. As observed in Figure 8, the central parts of the region have lower attractiveness. In this study protected zone (zone 1) is not evaluated because tourism development is impossible due to its protection status.

After preparing the ecological potential and regional attractiveness maps, they were compared using the intersection analysis method. As observed in Table 4, 3.03% of the regions with high and very high ecological potential are located in the class of high attractiveness. 4.08% of the areas with high and very high ecological potential are in an excellent and attractive class. This indicates that the potential of this region is high while ecotourism development is low, so it needs more attention for ecotourism development. The moderately attractive regions cover 50% of areas with high and very high capacities. 42% of the high ecological potential site is in a deficient attractiveness class.

Discussion

Five criteria, i.e., landform, climate, wildlife habitats, vegetation type, density, and soil, were used to evaluate the potential of the study area for ecotourism development. According to obtained weights, landform, climate, and vegetation are more effective than wildlife and soil. Spatial assessment of ecotourism potential based on Fuzzy-AHP indicates that identifying the most effective criteria depends on geographical location and region. So, Ahmadi Sani et al. [36] used these criteria to investigate ecotourism activities' possibilities. However, their study considers slope and elevation essential to developing ecotourism. The appropriate slope ranges from 0 to 50%, and accessibility to these regions and tourism facilities are limited on steep slopes. Koumari et al. [42] considered slope an influential factor in recreational zoning and planning. Using fuzzy logic, they identified parts with different potentials for ecotourism development in their study area. Wu et al. [28] assisted optimal solutions for agritourism destinations by Fuzzy-AHP based on economic, social, and environmental issues and showed that tourism resources and the environment were the most important evaluating criteria. Zabihi et al. [26] showed that landform, distance to a stream, and ambient temperature were three critical factors for ecotourism site selection by the Fuzzy-AHP method.

So, comparing the research have been indicated that tourism development has a close relationship with the environment; hence, if the environmental capability is assessed correctly, it can modify the plans and prevent failures in sustainable tourism development. As if, KianiSadr et al. [20] demonstrated a logical evaluation of environmental issues based on the ecological capabilities of the area. They facilitated decision-making processes that can achieve sustainable and efficient use of the area for ecotourism development. Other research results, like our study, confirmed the effectiveness of the Fuzzy-AHP method in ecotourist potential assessment. Also, environmental factors were identified as the most critical evaluation criteria.

According to the ecological potential for ecotourism development obtained from the Fuzzy-AHP method in the study, 46 % of the area has a high and very high potential for ecotourism. These sites are located in the northern parts and regions such as Izi Waterfall, Esfarāyen Dam, Gonjadan Valley, and Bidovaz Valley. Some 21% of the area has

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moderate potential and, to some extent, is appropriate for ecotourism development. Extensive recreational activities can be done in these regions. 5 % of the site has meager potential. These regions are vulnerable, and their tourism development may cause degradation.

The intersection between attractiveness classes and potential ecological classes obtained from Fuzzy-AHP has illustrated that 3.03% of the regions have high and very high ecological potential and high attractiveness, and 4.08% enjoy good attractiveness. Based on the regional attractiveness map, large parts of the area have low attractiveness. These regions have low attractiveness because of poor accessibility, lack of facilities, and lack of specific attractiveness in some regions. Generally, the degree of attractiveness of the protected zone of Sarigol National Park is higher. The results from comparing ecological potential and regional attractiveness maps indicated that the most highly attractive regions are also ecologically appropriate for ecotourism development.

Regarding the final results obtained from comparing the two attractiveness and potential ecological maps, northwestern, northeastern, and western parts of the area, including Dahaneh Ojagh Valley and Narimani Valley, and southwestern parts, such as Izi Waterfall, are appropriate for ecotourism development. About half of the zones estimated as best suited for ecotourism development have high ecological potential, while they could be more attractive. Since one of the primary factors of the presence of tourists in the area is its attractiveness (appearance attractiveness and accessibility), these parts have low potential.

Furthermore, by comparing ecological capacities and regional attractiveness maps with the zoning map of the area, it was identified that regions such as Gonjadan Valley, Gonjadan Village, Izi Waterfall, and Esfarāyen Dam are in the zone of intensive recreation. Ecotourism activities are allowed in this zone. Some parts of the region, such as Dahaneh Ojagh Valley, Nasr Abad Valley, and Izi Waterfall, are located in the recovery zone, and some other sites, such as Bidovaz Valley, Hassan Abad Village, Bidovaz Village, Ardaghan Village, Ghaleh Sefid Village, and Ghar Anoshirvan Village are located in multiple use zone. In Iran's protected areas, protection is the priority of management. Other allowed land uses, such as tourism, can be implied if they do not conflict with protective aims. In protected zones, no human activity (except for protecting species and ecosystems) is allowed; therefore, despite its high potential for ecotourism development, the protected zone of the area was set aside.

Conclusion

Tourism development can create many opportunities such as employment for local communities, sustainable revenues, enhancement of social and cultural levels of the society, protection of the environment via enhancing the level of public environmental knowledge and Increasing incomes for improving the protection condition of the area. If tourism development is conducted without assessing area potential and capacity, mass tourism and significant problems and threats such as pollution, damage to flora and fauna, and irreparable damage to the ecosystem emerge. Tourism development in the Sarigol Protected area causes the enhancement of the protection level and sustainable development. Each kind of tourism development and activity on the site should be based on protecting its environment. This study's results indicated GIS's capability to model and contribute to planning and integrating quantitative and qualitative criteria on different scales. So, site selecting and analyzing for modeling and prioritizing ecotourism potential using Fuzzy-AHP help planners to decide based on spatial

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data. By comparing ecological capacities and regional attractiveness maps with the zoning map of the area, the results indicated that regions such as Gonjadan Valley, Gonjadan Village, Izi Waterfall, and Esfarāyen Dam are in the zone of intensive recreation. Some parts of the region, such as Dahaneh Ojagh Valley, Nasr Abad Valley, and Izi Waterfall, are located in the recovery zone, and some other sites, such as Bidovaz Valley, Hassan Abad Village, Bidovaz Village, Ardaghan Village, Ghaleh Sefid Village, and Ghar Anoshirvan Village are located in multiple use zone. Identifying ecotourism sites in national parks and protected areas contributes to tourism development, better management, and area protection.
In addition to the factors considered in this study, there were more related factors for assessing the potential of ecotourists. However, in this study, we prepared the criteria and sub-criteria mentioned in the manuscript, so we suggest assessing more factors in future work.

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