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Ecological Potential Evaluation of the Kan Watershed for Ecotourism Development using AHP and Fuzzy Logic in GIS

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Abstract

Ecotourism is a popular aspect of tourism that gives economic value to biodiversity and allows tourists to gain knowledge about the importance of environmental conservation. The rapid and imbalanced growth of the tourism industry and the prioritization of economic benefits in the areas around Tehran have disturbed the ecosystem and led to increasing pressure on the environment. Hence, ecological potential evaluation is recommended as a practical solution. The current study aims to evaluate the ecological potential of the Kan watershed for ecotourism development using the Analytical Hierarchy Process (AHP) and Geographic Information Systems (GIS). The case study is located between the Tehran in the south, Darakeh watershed in the east, Jajrud watershed in the north, and Karaj river watershed in the west. In the first step, the effective criteria were selected based on literature review and expert interviews. Then, the criteria were weighted and prioritized using AHP. Afterwards, Fuzzy logic and Weighted Linear Combination (WLC) methods in GIS were used to zonate intensive and extensive ecotourism development. The results showed that 1.3% (273 ha) and 11.3% (2327 ha) of the Kan watershed is very suitable for intensive and extensive ecotourism development, respectively. Also 2.3% (475 ha) and 14.1% (2903 ha) of the region falls in the category suitable for intensive and extensive ecotourism development. Suitable areas for intensive ecotourism are mostly located in the southeastern part of Sulqan rural district, Keshar-e Sofla, and Keshar-e Olya villages. Potential zones of extensive ecotourism are located throughout the watershed along riparian areas and in valley floors.

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Introduction

Ecotourism is the most compatible type of tourism with a focus on human and environmental conservation aspects (Tabibian, 2021). In the world, tourism is now expanding as a pollution-free industry (Mowforth, 2016). Ecotourism is a type of tourism based on the concept of sustainable development and characterized by communication with nature, educational incentives, and appreciation (Bellamy et al., 2015). Performing environmental activities in accordance with cultural sensitivities, directly benefiting local people, and self-sustainability in the core of natural and cultural environments are among the basic characteristics of ecotourism (Goodwin, 2009).

Tourism typically emphasizes the spatio-temporal movement of living environments (Wang et al., 2022). Human societies cannot live without the support of socioeconomic and physical factors that depend on the environment, to achieve their basic needs. Population flow on the outskirts of major cities due to migration from rural areas along with rapid population growth has disrupted the ecological potential and this process prevents the sustainable socio-economic development in each area (Srivastav & Gupta, 2003).

Currently, urban areas account for half of the world's population, and this percentage continues to increase (Cobbinah et al., 2015). It should be noted that today, people tend to touristic activities in areas around the suburbs of Tehran to escape from urban noise, among other causes. Obviously, the presence of tourists in natural areas may also have negative consequences, but many of these effects can be effectively managed, reduced, and eliminated (Moharamnejad et al., 2017). Therefore, evaluating the ecological potential of the environment as the core of land management studies can play important role in regional planning (Abdolahzadeh et al., 2016). One of the basic strategies to limit the negative effects and strengthen the positive effects of developments is to plan land use based on the region's natural potential for the intended use (Asgari & Khak Sefidi, 2021).

Ecological potential assessment is a process that seeks to provide appropriate development in harmony with nature by regulating human connections with the environment (Makhdum, 2006). According to the above definition, it is necessary to use nature in such a way that causes the least damage to the environment and the maximum productivity for humans (Anvari & Roudaki, 2020). Evaluation of ecological potential as the need for land-use planning has been raised and this is reflected in the development plans of the Islamic Republic of Iran (Ale sheikh et al., 2014).

Among the studies conducted in this field, we can mention Mohamadi Torkamani (2019). They assessed the ecological potential of ecotourism using in Mianeh, a city in West Azerbaijan Province. In the process, they used the Analysis Hierarchical Process (AHP) method for zoning the city based on ecological potential. In their study, they used 11 criteria, and the results showed that approximately 78% of the city is appropriate for ecotourism development, with the remaining 23% facing limits. Ramesht and Daneshi Maskooni (2014) conducted ecotourism site selection for Kerman, a city in the east of Iran. They investigated morphology and other factors influencing tourism in Kerman, recognized tourism attractions, and determined spatial priorities of places to build tourist attractions in the area. Their results showed that the three sites of Bam -e- Kerman, the Dis city, and Sarmayesh represent three attractive points in Kerman Province with an area of 175069 Km^2. These sites were located around Kerman in the form of satellites looking like a three-pointed star. Specially, geotourism sites in Kerman Province ramps up the merits of the areas in terms of ecotourism.

Ghorbaninia Kheibari et al. (2018) conducted a study entitled “Evaluating ecotourism potential development in Dena using Multi-Criteria Evaluation of hybrid indices”. They used five unique indicators including Wildlife Distribution Index (WDI), Ecotourism Attraction Index (EAI), Environmental Resistant Index (ERI), Infrastructure Facility Index (IFI), and the Ecotourism Diversity Index (EDI) to identify and prioritize potential ecotourism development. The results showed that the percentages allocated to suitable (S1), relatively suitable (S2), somewhat suitable (S3), and unsuitable (S4) classes of ecotourism development in their study area were 7, 85, 7 and 0.001 percent respectively. Some 12400 hectares was suitable for ecotourism development distributed evenly in the study area. Very low value for ecotourism development in the study area implies the pristine and high capacity of this area for ecotourism purposes.

Tavakoli (2018) evaluated and modeled the ecological potential of the Dehloran Natural Monuments for ecotourism development in a study entitled “Comparison of Fuzzy-AHP and ANP decision making methods to assess the ecological capability of ecotourism”. The ecological capability of the monuments was assessed for ecotourism use. The important criteria included soil, climate, physiographic, and vegetation cover. Then, Fuzzy AHP and ANP methods were used for standardization and weighting of criteria. Finally, an environmental unit map of ecological capability for ecotourism was prepared using the Makhdum model and WLC method. The results indicated that in the Fuzzy AHP method, 80 percent of the area is suitable for ecotourism, but the ANP method showed 62 percent of the area is suitable for such purpose.

Mascarenhas et al. (2015) in their study entitled “Ecosystem services in spatial planning and strategic environmental assessment-A European and Portuguese profile” stated that nature tourism has been helpful in increasing the environmental sustainability of rural areas. Akbarzadeh et al. (2011) conducted a study entitled “Environmental evaluation for ecotourism development using GIS in Arasbaran area, Iran using the ecosystem and ecological approaches through GIS and hierarchical analysis”. The results showed out of 54872.3 ha, 4985.12 ha was appropriate for ecotourism development in the study area.

Kaymaz et al. (2021) conducted a study entitled “GIS-Fuzzy DEMATEL MCDA model in the evaluation of the areas for ecotourism development (Case study: Uzundere, Erzurum-Turkey)”. The model was carried out under 4 main criteria and 16 sub-criteria. Ecotourism suitability map obtained by weighted linear combination method was classified into four categories: highly suitable, suitable, moderately suitable, and unsuitable sites. The study was useful in facilitating the planning of the sustainable structure for ecotourism and identification of the suitable areas in other areas with similar geographical conditions, as the criteria structure used was adaptable, reproducible, and modifiable.

Protecting and assessing the potential of ecotourism areas in the face of tourism damage is one of the tasks of the Environmental Protection Agency. One of the tourist areas in Tehran Province is the Kan watershed in the west of Tehran, which is very important for the residents of the capital due to its various natural endowments and is one of the important tourist destinations. The main issue is whether there is a proper balance between economic benefits and the pressures and costs imposed on the environment in the study area. The main purpose of this study is to evaluate the ecological potential of the Kan watershed to develop ecotourism, using the Analytic Hierarchy Process (AHP) with fuzzy logic and Weighted Linear Combination (WLC). The necessity of conducting research in the Kan watershed is that a specific policy is presented to the planners by quantifying and evaluating the ecological potential for ecotourism use. The Kan watershed is important in terms of tourist attraction to its geographical location and good weather conditions and can become an important tourist destination in the province and the country. Ecotourism development and tourism growth in the watershed along with environmental protection can improve the situation of villagers who face problems such as unemployment, low agricultural productivity, increasing migration to cities and marginalization. This is the first time application of the integration of fuzzy logic, AHP and WLC method for ecological potential evaluation of the Kan watershed.

Materials and methods

Description of Study Area

The Kan watershed is one of the important areas in Tehran Province, limited to Tehran in the south, Darakeh watershed in the east, Jajrud watershed in the north, and Karaj

River watershed in the west. The studied watershed is located between the latitudes 35° 46′ 28″ and 35° 57′ 14″ N and the longitudes 51° 10′ 2″ and 51° 22′ 35″ E and covers an area of 20571 ha (Fig. 1). The area includes 8 villages: Emamzadeh Aghil, Emamzadeh Davood, Taloon, Sulqan, Keshar-E Sofla, Keshar-e Olya, Sangan, Rendan, and Kigah.

The rivers in this watershed originate from high rangelands and have steep slopes. The most important waterway in the watershed is the Kan River, which originates from the altitudes overlooking Emamzadeh Davood and extends to the exit of the watershed in Kan residential areas. Laloon, Taloon, and Keshar are other important waterways of the watershed. Steep slope with high altitude variations (~2740m), erosion, and flooding are the greatest challenges in the study area.

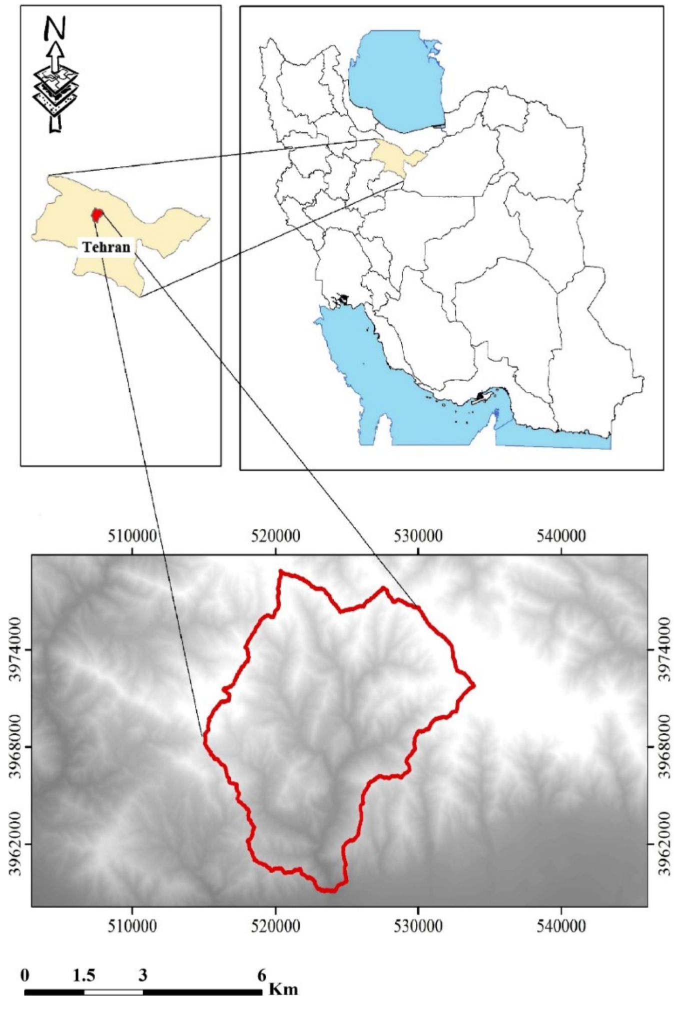

Figure 1. Location of the Kan watershed

Methodology

The present study is a survey in terms of research method, analytical-descriptive in terms of data, and applied in terms of purpose. To perform this study, library data was gathered, queries and interviews with relevant experts were conducted, and effective parameters in the field of study were identified. Then, spatial layers related to 15 effective criteria such as altitude, slope, aspect, distance from rivers, annual temperature, annual precipitation, soil erosion, land use, vegetation, distance from faults, geomorphology, pedology, petrology, and density of waterways were obtained from relevant organizations

(National Surveying Organization, Natural resources and watershed management of Tehran Province) and studied with the aim of evaluating the potential of tourism development. The major criteria and sub-criteria for each criterion were identified through a review of the literature and consultation with relevant experts. The relative priority and weight of the criteria were determined using the AHP. A Delphi panel of 17 members was constituted for this purpose. Eleven experts had master's degree in environmental science and 6 had Ph.D. in natural resources. The Delphi questionnaire was created and distributed among these experts in accordance with the purpose of the study. The experts were asked to assign values 1 to 9 to each criterion based on their view of its importance. The questionnaires were then collected and after averaging the scores assigned to each criterion, the questionnaires were returned to the experts to express their opinions. This process continued until a full consensus was reached among the experts. Then, the designed questionnaires were completed by a sufficient number of experts and specialists and the final weight of criteria and sub-criteria was calculated using Expert Choice software. After computing the weights using the AHP and preparing layers, GIS software was used to standardize the layers using fuzzy logic, and then the linear weighted combination model (WLC) was utilized to overlay the standardized weighted layers in the ArcMap environment. Each layer was multiplied by its final weight. Then, all the criteria were combined, and finally, a suitability map was prepared for zoning areas with the potential for intensive and extensive ecotourism development (Figures 2 to 13).

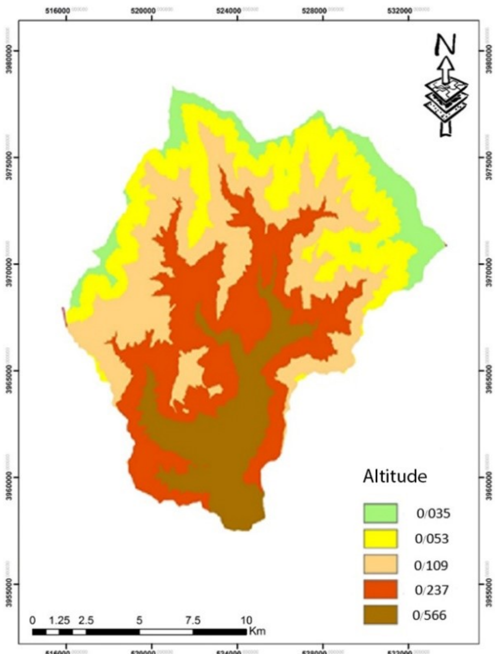

Figure 2. Fuzzy altitude map

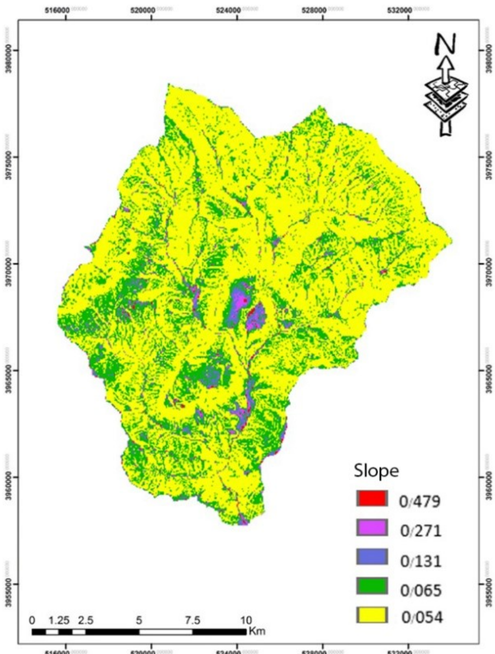

Figure 3. Fuzzy slope map

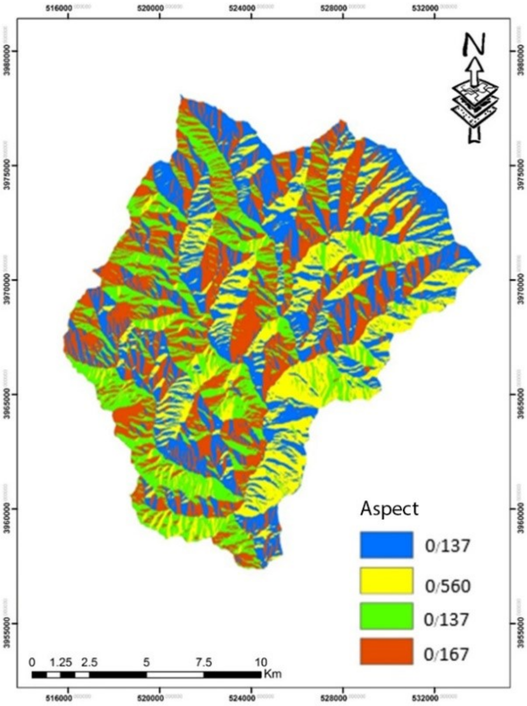

Figure 4. Fuzzy aspect map

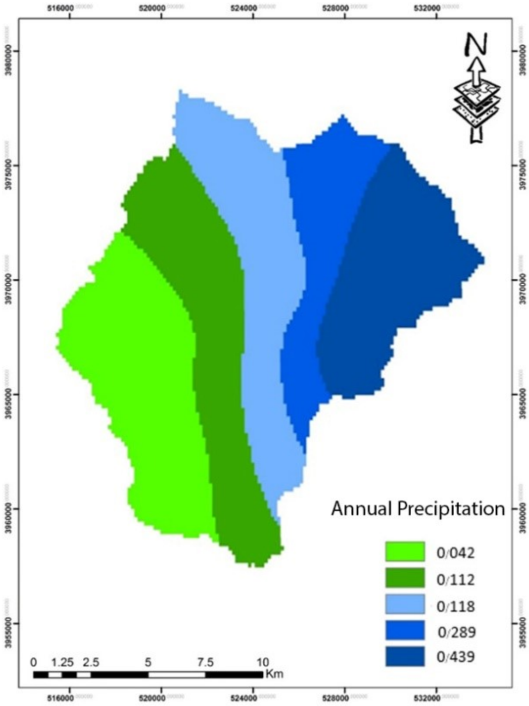

Figure 5. Fuzzy precipitation map

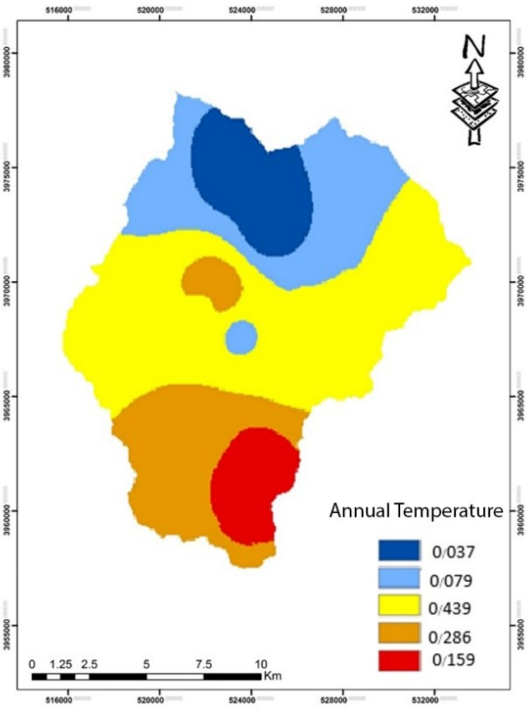

Figure 6. Fuzzy temperature map

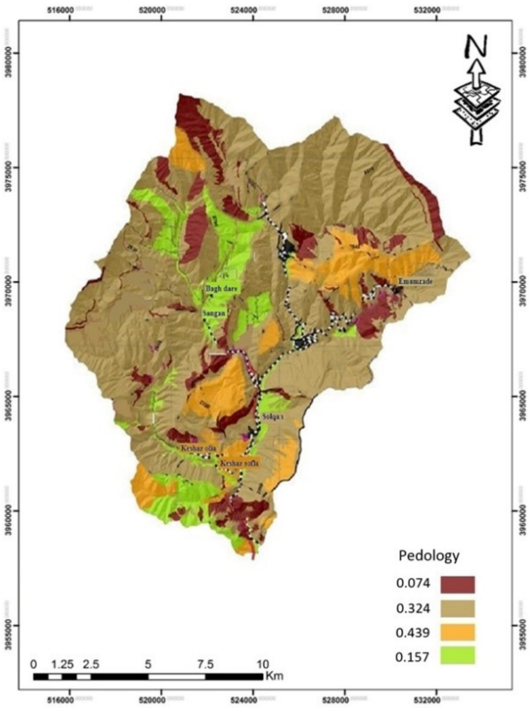

Figure 7. Fuzzy pedology map

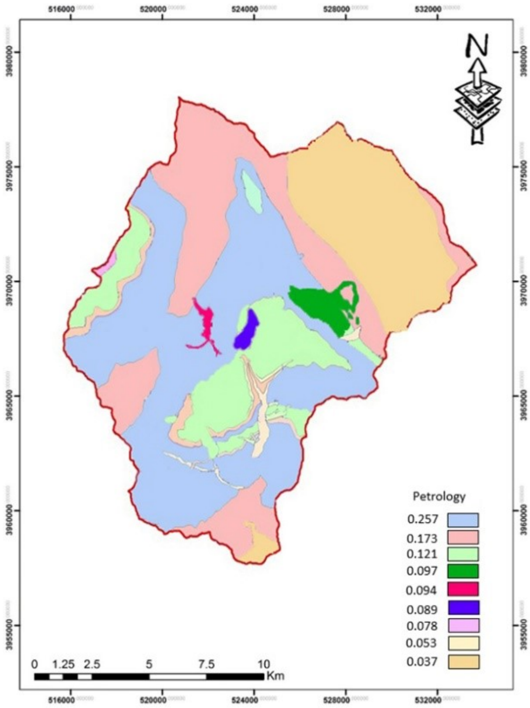

Figure 8. Fuzzy petrology map

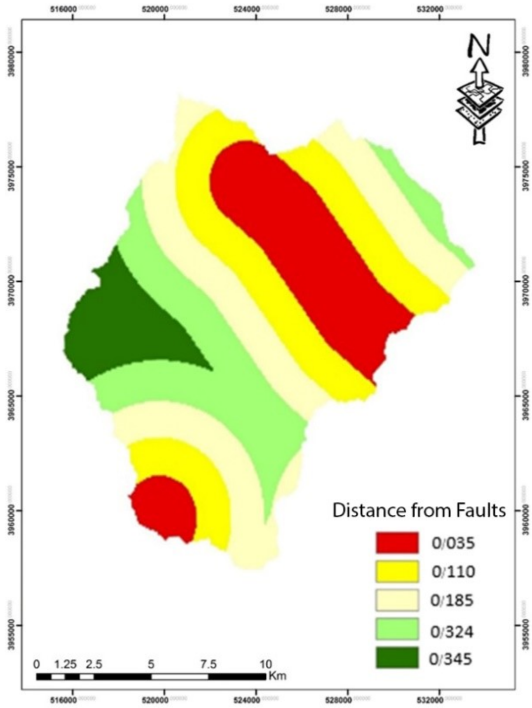

Figure 9. Fuzzy distance from faults map

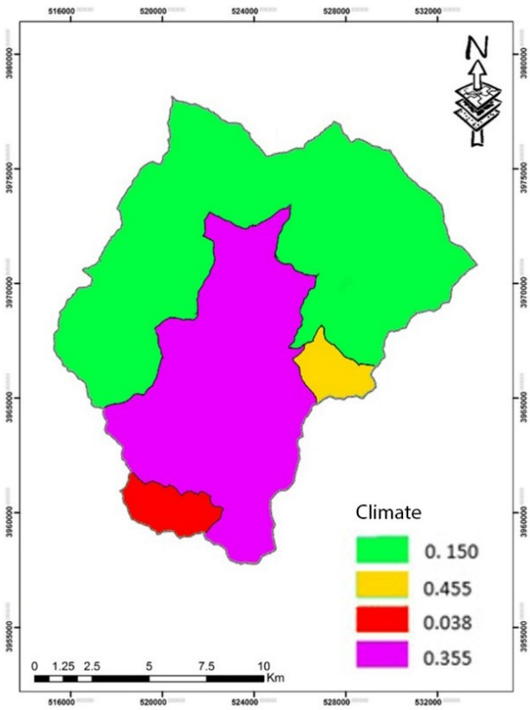

Figure 10. Fuzzy climate map

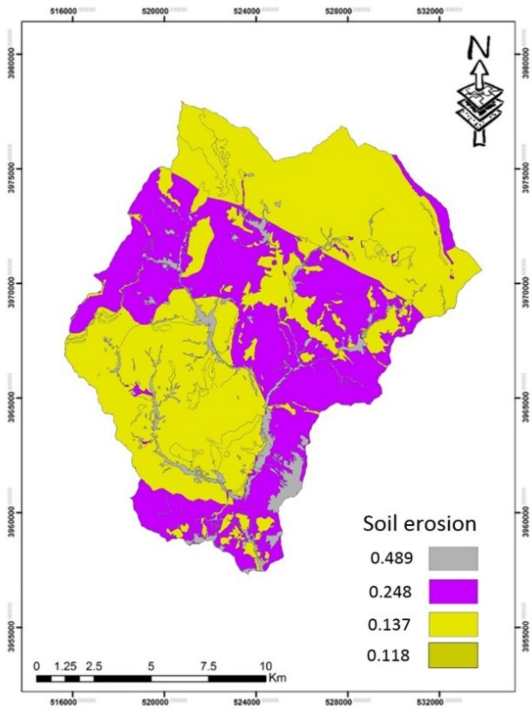

Figure 11. Fuzzy soil erosion map

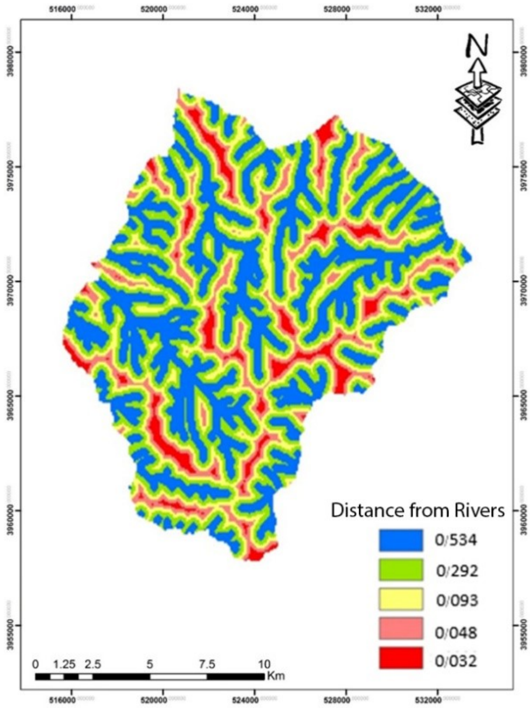

Figure 12. Fuzzy distance from rivers map

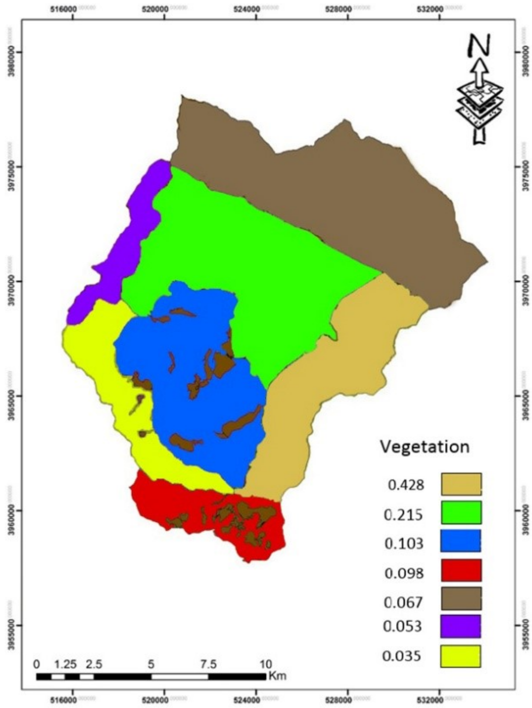

Figure 13. Fuzzy vegetation map

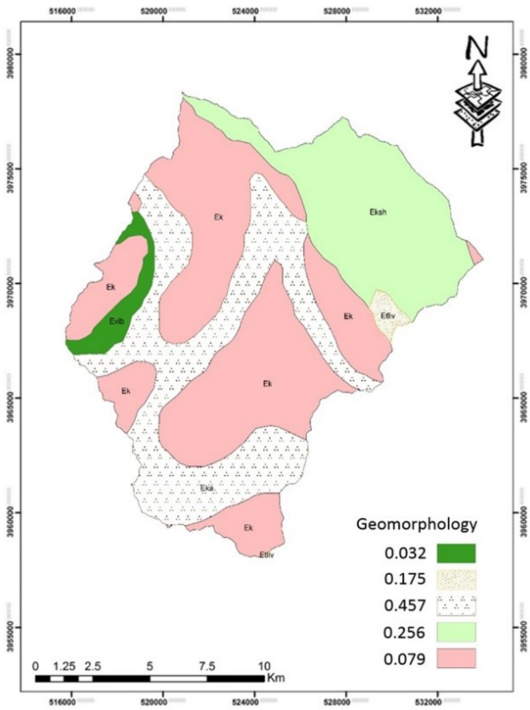

Figure 14. Fuzzy geomorphology map

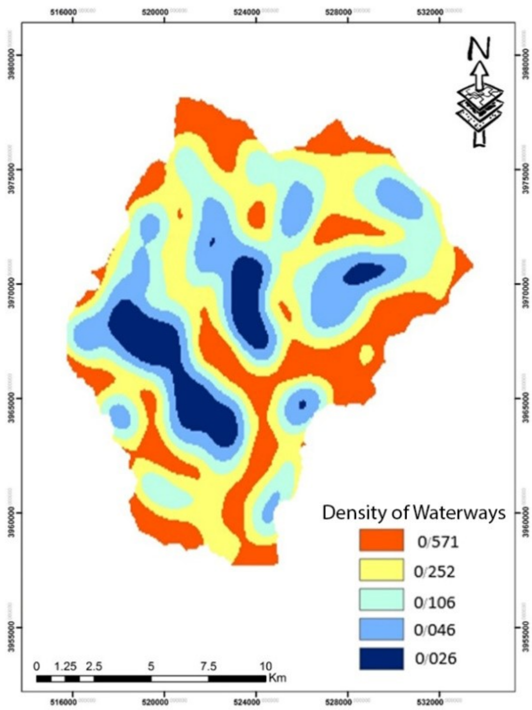

Figure 15. Fuzzy density of waterways map

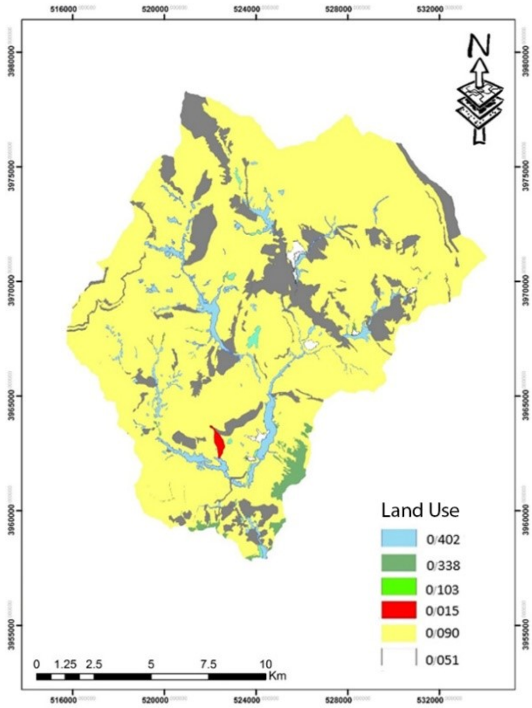

Figure 16. Fuzzy land use map

Results and Discussion

In this study, 15 criteria were used to evaluate the ecological potential of the Kan watershed for ecotourism as described formerly. Nine continuous point-scales ranging from 1 (lowest importance) to 9 (highest importance) were used for pairwise comparison (See Table 3). Consistency index (C.I) was used to determine the degree of accuracy in weighting. If C.I ≤0.1, the weighting is accurate. Otherwise, the relative weights assigned to the criteria should be changed, and the weighting should be repeated. Finally, the weights of the criteria were determined using AHP by Expert Choice software (See Table 4).

Table 3. The classification of suitable and unsuitable zones based on the Kan watershed's ecological potential

No.	Land potential	Values
1	Very unsuitable	1-2
2	Unsuitable	2-3
3	Moderate	3-5
4	Suitable	5-7
5	Very suitable	7-9

Table 4. Weighting the criteria and sub-criteria by AHP

No	Criteria	Weight	No	Criteria	Weight
1	Altitude	0.198	9	Land use	0.05
2	Slope	0.094	10	Vegetation	0.048
3	Aspect	0.086	11	Distance from faults	0.042
4	Distance from rivers	0.079	12	Geomorphology	0.036
5	Annual temperature	0.073	13	Pedology	0.036
6	Climate	0.074	14	Petrology	0.034
7	Annual precipitation	0.072	15	Density of waterways	0.029
8	Soil erosion	0.049			

Next, all of the necessary standardized maps and their calculated weights were formulated in the Raster Calculator menu in ArcGIS. Finally, the maps were classified in order to zone areas that would be suitable for intensive and extensive ecotourism development. The formula for assessment is shown below and the result is seen in Figures 17 and 18.

Ecological Potential Evaluation = (("Climate" × 0.074) + ("Temperature" × 0.073) + ("Precipitation" × 0.72) + ("Aspect" × 0.086) + ("Density of waterways" × 0.029) + ("Distance from rivers" × 0.079) + ("Distance from faults" × 0.042) + ("Slope" × 0.094) + ("Land use" × 0.05) + ("Petrology" × 0.034) + ("Pedology" × 0.036) + ("Erosion" × 0.049) + ("Vegetation" × 0.048) + ("Geomorphology" × 0.036) +("Altitude" × 0.198))

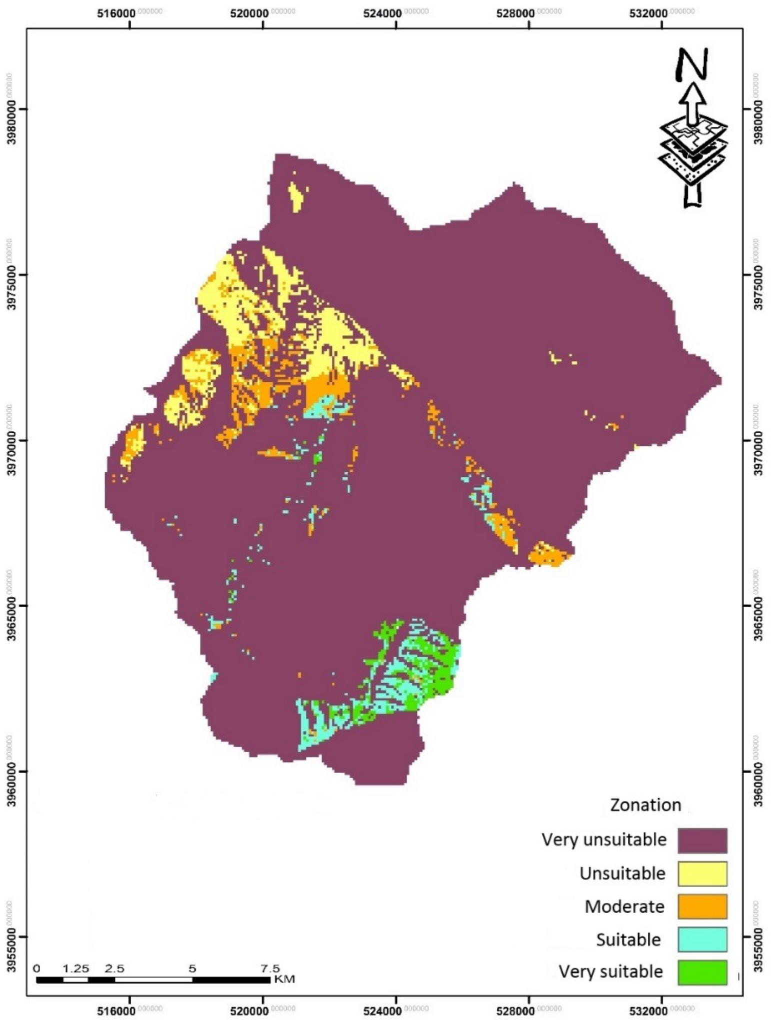

Figure 17. Zonation of suitable areas for intensive ecotourism development

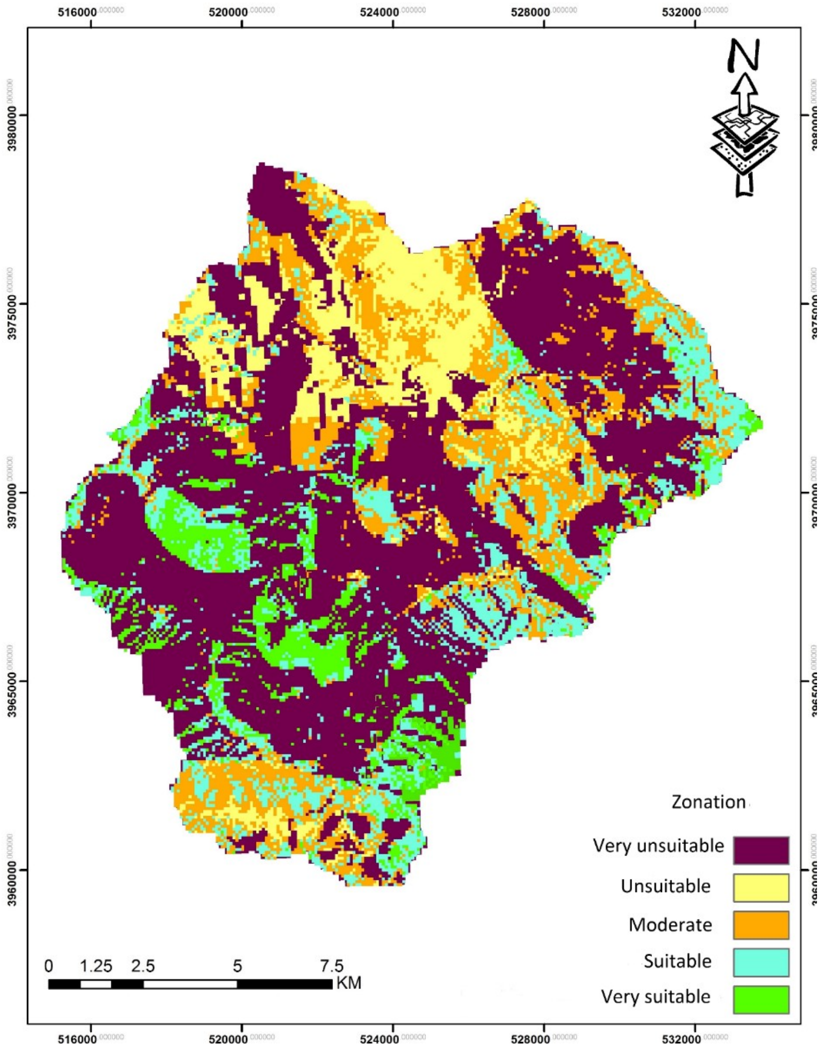

Figure 18. Zonation of suitable areas for extensive ecotourism development

Conclusions

Almost all national planners and policymakers unanimously agree that natural resources are being deteriorated and this trend will continue if over-exploitation continues at its current rate. The implementation of ecological potential evaluation allows decision-makers to identify suitable uses for areas and establish proper development and environmental preservation plans. On the other hand, the contribution of local communities in development plans improves the economic, cultural, and social conditions and prevents poverty, slum settlement, emigration, and so forth (Department of Natural Resources and Watershed Management of Tehran Province, 2019).

Table 5 shows the zonation of suitable areas for intensive ecotourism development. As seen in Table 5, out of the total 20571 ha of the Kan watershed, %1.3 (273 ha), %2.3 (475 ha), and %3.5 (707 ha) fall in very suitable, suitable, and moderately suitable categories for intensive ecotourism development, respectively. Based on Figure 17, suitable and highly suitable areas are mainly located in southeastern zones, whereas moderate areas for ecotourism development are spread in the middle altitudes from east to west. Meanwhile, %4.7 (962 ha) and %88.2 (18154 ha) are unsuitable and very unsuitable for intensive ecotourism development, respectively. Given the steep slopes and high altitude of the region (the slope percentage is mainly between %30 to %50 and the total average altitude is 2410 m), which result in heavy snowfall in winter and road closures in the upstream, the development of intensive ecotourism (except winter sports) is justifiable in downstream residential areas around Sulqan district and Keshar Sofla and Keshar-e Olya.

Table 5. Zonation of suitable areas for intensive ecotourism development

Class	Area (ha)	Percentage
Very suitable	273	1.3
Suitable	475	2.3
Moderate	707	3.5
Unsuitable	962	4.7
Very unsuitable	18154	88.2
Sum	20571	100

The result shows %11.3 (3227 ha), %14.1 (2903 ha), and %19.1 (3923 ha) of the total area of the Kan watershed is very suitable, suitable, and moderate for extensive ecotourism development, respectively (Table 6). Moreover, %14 (2872 ha) and %41.5 (8546 ha) of the Kan watershed is unsuitable and very unsuitable for extensive ecotourism development, respectively.

Table 6. Zonation of suitable areas for extensive ecotourism development

Class	Area (ha)	Percentage
Very suitable	2327	11.3
Suitable	2903	14.1
Moderate	3923	19.1
Unsuitable	2872	14
Very unsuitable	8546	41.5
Sum	20571	100

Due to the proximity of the study area to Tehran megacity, desirable climate, and natural attractions that provide ideal conditions for short journeys, extensive ecotourism development is conceivable in over %45.5 of the areas of the Kan watershed if environmental protection principles are met (Figure 18).

Comparison of the results of this study is somewhat consistent with the studies conducted by Mohamadi Torkamani (2019), Ramesht and Daneshi Maskooni (2014), Ghorbaninia Kheibari et al. (2018), Tavakoli et al. (2018), Akbarzadeh et al. (2011), and Kaymaz et al. (2021). In these studies, multi-criteria decision method in GIS. In the Kan watershed, 3.6% of the area is suitable for intensive ecotourism while 25.4% is suitable for extensive ecotourism. Similar studies conducted by Mohamadi Torkamani (2019) in Mianeh, Ghorbaninia Kheibari et al. (2018) in Dena region, and Akbarzadeh et al. (2011) in Arasbaran have shown 78%, 92%, and 9.08% as suitable for ecotourism, respectively. In the study of Tavakoli (2018), 80% of Dehloran was found suitable for ecotourism using fuzzy logic and this reached 62% using network analysis method. Kaymaz et al. (2021) concluded that a large portion of the Erzurum region in Turkey has potential for ecotourism. Due to the high slope of the Kan watershed its high weight in intensive ecotourism, a small percentage of the study area has been found suitable for intensive ecotourism. However, 25.4% of the Kan watershed has a very high potential for extensive ecotourism especially in areas close to Imamzadeh Davood pilgrimage site and recreational areas on higher slopes.

Recommendations

Tourism is a multi-faceted industry that involves economics, culture, environment, and rural services and industries. Tourism development in any region will lead to economic, social, and even cultural growth and changes. As a result of this study, the following recommendations are presented:

- It is necessary to plan for the development of recreational and sport activities in the watershed.
- Conducting tourism economic studies and investing appropriately in the industry is recommended.
- Determining the carrying capacity of the watershed is highly needed.
- Encouraging investors is suggested for the development and construction of accommodations, handicraft shopping centers and so forth in the areas that have the suitable potential for intensive ecotourism.
- Conducting studies on the determination of special pathways for tourists in the natural settings of the area using GIS is highly recommended.
- Compilation of educational programs is suggested for local people towards economic benefits for local people through the sale of handicrafts, garden and animal products, and development of ecotourism resorts.
- Landfill site selection and standardization, as well as adherence to landfill requirements are among other necessary steps to be taken in concurrent with tourisms development in the area.

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