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A hybrid GIS-OWA and DANP method for the identification and evaluation of ecotourism attractions: the case study of Abbas Abad Wildlife Refuge, Iran

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Abstract Identification of capacities for development of ecotourism is an undeniable priority in any country. The aim of this research is to identify and evaluate ecotourism attractions in the Abbas Abad Wildlife Refuge in Isfahan Province, Iran. To reach the aforementioned aim, this study uses integrated GIS-based MCDA and Decision-Making Trial and Evaluation Laboratory methods, as well as DEMA-TEL-based Analytic Network Process through ordered weighted average methods. Relevant criteria were selected, weighted and prioritized according to the extent and intensity of which they are influenced and their influencing potential, the latter of which was calculated using the DANP method. OWA was then applied to these data, resulting in the creation of five ecotourism maps with different risk levels (degrees of uncertainty). The results show that increasing risk (no trade-off) improved the ecotourism conditions for the entire study area, and decreasing risk (no trade-off) reduced the suitability of the study area for ecotourism. The results are accompanied by a map identifying areas with a high potential for ecotourism, which could assist tourism managers in identifying the conditions that can boost the appeal of ecotourism attractions.

Keywords DEMATEL · Evaluation · DANP · OWA · Abbas Abad Wildlife Refuge · Ecotourism

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Introduction

Since 1945, tourism has experienced a rapid expansion, and is now one of the top three largest industries in the world (Deng et al., 2002; Hamilton et al., 2005). Ecotourism is a new form of tourism which focuses on nature and open spaces (Bunruamkaew & Murayama, 2012; Chiu et al., 2014) and understanding the local environment and culture (Valentine, 1992; Blamey, 1997). The growth of ecotourism has provided countries all over the world with numerous economic benefits, particularly developing countries (Pyke et al., 2016). Ecotourism development is a way to make economical use of natural resources (Yekani Motlagh et al., 2020). Among the various definitions of ecotourism, the consensus among scientists and researchers is that ecotourism represents a more sustainable form of tourism for preserved nature

areas, which can help to educate visitors, protect the environment and contribute directly to the economic development and improvement in the quality of life of local populations (Gigović et al., 2016). However, research has shown that the rapid growth of eco-tourism can lead to the destruction of natural beauty and disturb the existence of both animals and plants, as well as local populations. Populations living in tourist destinations are generally aware of the positive and negative effects of tourism development within their community (Lee, 2013). Several studies have warned that the development of ecotourism can only be achieved by proper planning and the involvement of local people and communities in management systems (Ramos & Prideaux, 2014; Wishitemi et al., 2015). The purpose of this study is to develop a methodology to identify and evaluate ecotourism attractions in terms of their geographical features. It is hoped that the resulting map will be informative to stakeholders, policy makers and organizers of regional tourism development.

Evaluating ecotourism attractions, particularly in wildlife refuges, is a complex issue that requires spatial data processing and a combined analysis of numerous criteria. Furthermore, the existing relations between spatial data and tourism should be specified and analyzed through an efficient spatial context. Geoinformation technologies are suitable for this type of study because they can efficiently manage large amounts of spatial and attribute data collected from various sources (Ghorbanzadeh et al., 2019; Gigović et al., 2017). GIS is one of the main tools used in land evaluation, and in recent years, has been used GIS in a wide range of evaluation studies to highlight areas with potential for ecotourism development. Some studies have used simple analytic functions in GIS and combined the different layers (Ahmadi et al., 2015). Many researchers have also integrated GIS with Multi-Criteria Decision Analysis (MCDA) techniques to evaluate suitable land for ecotourism development, the most famous of which is the hybrid method GIS-based Analytic Hierarchy Process (AHP) (Bunruamkaew & Murayama, 2011; Dhami et al., 2014; Jeong et al., 2014). The combination of weighted linear combination (WLC)-Fuzzy and ANP techniques has also been used in land evaluations in order to develop the ecotourism industry in Taleghan, Karaj (Aliani et al., 2017). MCDA and Fuzzy Decision Making Trial and Evaluation Laboratory (FDEMATEL) was also used

to evaluate sites for developing ecotourism in the Dunavski kljuc region of Serbia (Gigović et al., 2016). For this research, 16 criteria were identified and weighted using FDEMATEL, and a map of the criteria was created and integrated with GIS using WLC.

Literature review

Combining MCDA techniques with GIS has become one of the most commonly used models in planning and managing natural resources and tourism. Recently, however, numerous researchers have begun to combine GIS with new method of DEMATEL-based Analytic Network Process (DANP). For example, Gigović et al. (2017) used the GIS-DANP-Multi-Attributive Border Approximation area Comparison (MABAC) multi-criteria model to select the location of wind farms in Vojvodina, Serbia. The results showed that the model is useful for identifying suitable locations for the development of wind farm projects, as well as for assessing the suitability of already licensed projects. Also, Ghobadi et al. (2021) used integrated GIS-DANP multi-criteria method for aquaculture site selection in lorestan province, Iran. The results showed that this method enhanced the accuracy and efficiency of the best decision for aquaculture site selection. In addition to this, Chen et al. (2019) used the DANP method to determine the relative weights of criteria—via a hybrid modified VlseKriterijuska Optimizacija I Komoromisno Resenje (VIKOR) method – in order to improve environmental management manager strategy formulation in the performance evaluation of wetlands. The DNAP method can be used to show the relations, structure, weight, dependence, and feedback of the study's criteria (Chen & Lin, 2018; Chen et al., 2019; Sufiyan et al., 2019), and is often used in combination with GIS due to its effectiveness as a tool for identifying the best locations for land use/suitability problems. The DNAP method is often complemented by the GIS-based OWA technique, which a powerful tool to generate and visualize a wide range of multi-criteria evaluation strategies, as it uses different operators and an associated set of ordered weights (Malczewski & Rinner, 2015). Over the past few decades, the GIS-based OWA approach has frequently been employed to analyze land utilization, as high-lighted by Ghorbanzadeh et al. (2019), who used

integrated GIS-MCDA and ANP through OWA when mapping the potential of nature-based tourism (NBT) areas in East Azerbaijan province, Iran. Also Mokarram et al. (2021) used the GIS-based order weight average (OWA) methods to predict suitable locations for the artificial recharge of groundwater in the Bushehr province in southern Iran. The results showed that the AHP and OWA methods have high accuracy for investigating suitable areas for groundwater recharge. Moreover, Firozjaei et al. (2019) used the GIS-Based Local Ordered Weighted Averaging in Iran to investigate the feasibility of solar energy, and found that the OWA method is very flexible having risk and compensation based on the request and priorities of investor's. In addition to this, Hajizadeh et al. (2020) used the MCE assessment and the FUZZY-OWA method integrated with GIS technique for capability evaluation of ecotourism development in the northeast of Iran. The results showed that the OWA method consistent with the many fuzzy quantifiers (Fifth scenario) had the highest accuracy and advantage of this method is that it allows the simultaneous assessment of environmental, social and economic criteria in the assessment of the land potential. This suggests that OWA is one of the best methods of evaluating ecotourism attractions, as different risk levels of ecotourism development can be determined.

In this study, the new method of DANP will be combined with the GIS-OWA technique, in order to evaluate the ecotourism attractions of Abbas Abad Wildlife Refuge in the Isfahan province of Iran. The area under study, located northeast of Naein in the Isfahan Province, presents a wide range of tourist attractions. The aforementioned methods were deemed appropriate for this research due to the rapid growth of ecotourism and the biological sensitivity of the area under study, as well as its status as a protected wildlife refuge. Based on an examination of domestic and international research and the ecological conditions of the area under study, the conceptual model used in this research will utilize three main criteria and 11 sub-criteria to evaluate the tourist attractions of Abbas Abad WR. The dependence and feedback between these criteria, as well as their weight and priority, will be calculated using the DANP technique, and GIS-based OWA will be used to conduct a risk-based analysis of decision-making factors. This is mainly due to the flexibility of the OWA method, and the fact that it is capable of preparing maps to evaluate the suitability of ecotourism in different management scenarios. This will assist the research in achieving one of its main objectives: to identify the best conservation scenario for ecotourism development in a protected wildlife refuge area.

Study area

The aim of this study is to identify and evaluate the ecotourism attractions of Abbas Abad Wildlife Refuge based on the natural, cultural, and historical values of the region. This area is more than 3000 sq. km, apprximately165 kilometers east of Naein in the Isfahan Province in Central Iran. It is considered to be one of the largest areas managed by the Iranian Department of Environment. The area contains the huge central mountain range, plains, and vast plateaus, and is a well-known hunting area. The average annual precipitation of the region is 114 mm and the average temperature is 13 °C with hot and dry climate (Fig. 1). Baziab, Khonj and Kaboudan villages with a total population of 84 people in the region and the villages of Chupanan, Bayazeh, Iraj, Haftoman and Hosseinabad with a total population of 2457 people along the border with traditional agricultural activities, carpet weaving, animal husbandry, they are one of the influential human centers in the region. There is wide variety of geomorphic conditions (mountains and hills 44%, plains 46%, sand hills and dunes 7%, and lowlands 3%) and vegetation in the area, creating a beautiful landscape. This region is one of the most important habitats for the Asiatic cheetah (*Acinonyx jubatus venaticus*), and is one of the selected habitats in the Conservation of the Asiatic Cheetah Project. The area also hosts some other rare and endangered species, including the sand cat (*Felis margarita*), sand fox (*Vulpes rueppellii*), Chinkara (*Gazella bennettii*), Persian leopard (*Panthera pardus*), and saker falcon (*Falco cherrug*). Other remarkable features of Abbas Abad region include mountainous areas in the desert, a reserve of various ungulates—such as wild sheep (Ovis orientalis) and wild goat (Capra aegagrus)— and a bridge between the current and the selected-for-conservation habitat of the Asiatic cheetah (Farhadinia et al., 2007).
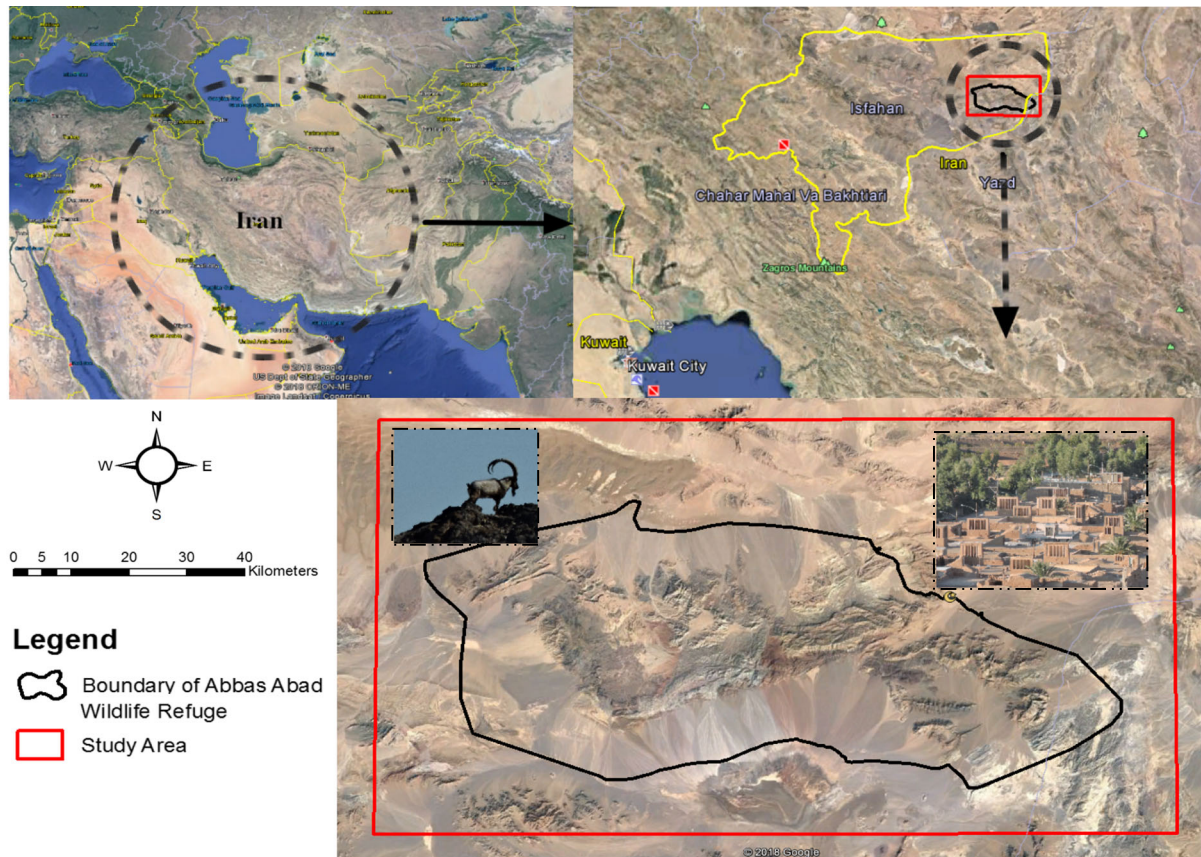
Fig. 1 The geographical position of the study area and The photos were taken by the author

Methodology and materials

The creation of a hierarchical network model is a significant step in the process of identifying and evaluating the potential attractions and suitable areas for ecotourism in the region under study, as it considers all the factors influencing this evaluation, and the interactions between these factors, in order to find a viable solution. Due to the complexity and significance of the issue, the method used in order to evaluate the ecotourism attractions is a combination of GIS and MCDA methods.

For the MCDA, the ANP method is used to overcome the problems of interdependence and feedback between criteria or alternatives. The ANP method currently deals with normalization in the super matrix by assuming that each cluster has equal weight. Although the method to normalize the super matrix is relatively straightforward, it ignores the different effects among the clusters. Therefore, we

propose a novel hybrid MCDA model combined with DEMATEL and ANP to solve the dependence and feedback problems in a way that better reflects reality. In the process of selecting optimal solutions, a large number of factors must be included in the decision, and GIS is ideal for this type of study due to its ability to manage a large number of spatial data from different sources. Furthermore, GIS-based OWA provides a tool for generating and visualizing a wide range of multi-criteria evaluation strategies by applying different operators and an associated set of ordered weights. The generality of OWA is related to its capability to implement a wide range of map combination operators by selecting appropriate order weights (Malczewski & Rinner, 2015). The process of combining GIS-OWA and DANP methods in order to evaluate ecotourism attractions in Abbas Abad Wildlife Refuge includes a number of key phases, as shown in Fig. 2.
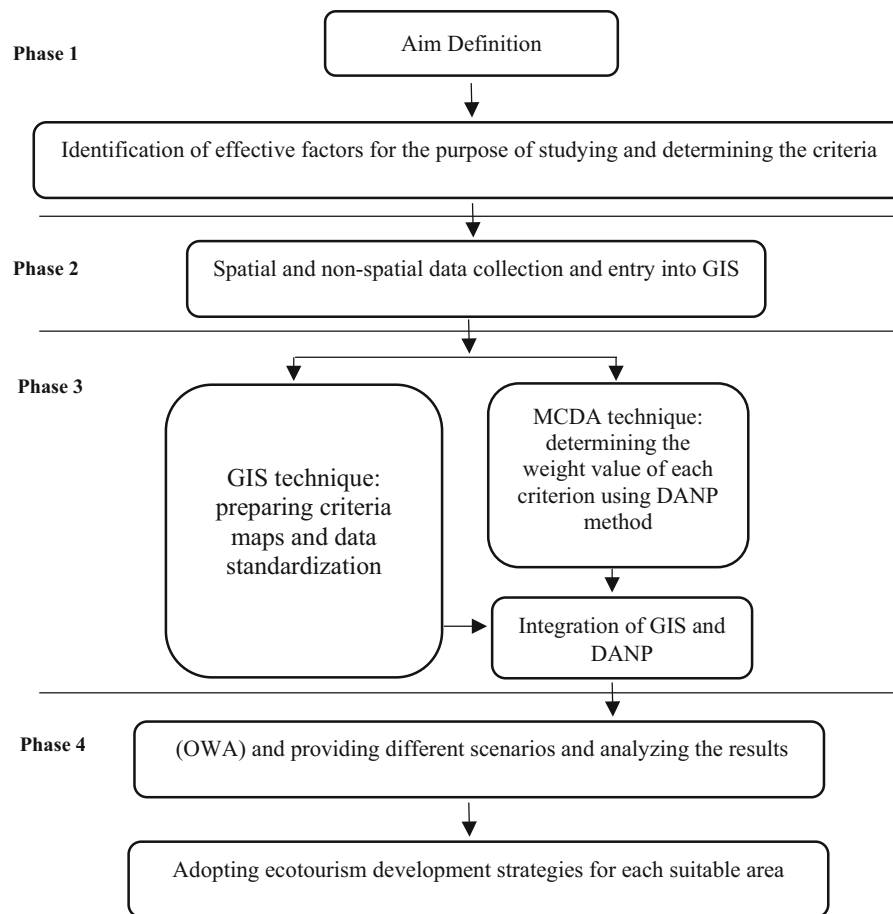
Fig. 2 Flowchart of methodology

Phase 1: Identification of effective factors for the purpose of studying and determining the criteria

The first step in a multi-criteria analysis is defining the main problem or goal, which in the case of this study is to identify and evaluate the potential attractions and suitable areas for ecotourism in the region under the study. Based on the main goal, the next step involved collecting the evaluative criteria, which were identified following a review of the relevant literature and sources. In order to select the evaluative criteria, the general rule is to determine these criteria in terms of the problem. The number of evaluative criteria depends on the characteristics of the problem to be resolved. It is worth noting that not all the ecological parameters related to the area are suitable for evaluation and decision making, so the identified criteria were distributed and grouped based on the dimensions and the ecological conditions of the area under the study. Three final criteria were selected for the evaluation of ecotourism attractions in the area under study: physical criteria with the sub-criteria of slope, landscape and water resources; ecological criteria with the sub-criteria of wildlife, vegetation and natural attractions; and socio-economic criteria with the sub-criteria of facilities, access, conflicts, population centers, and cultural and historical attractions (Table 1).

Phase 2: Data sources and entry of data into GIS

Evaluative criteria were identified to accompany the geographical phenomena and their relationships,

Table 1 Clusters and criteria for ecotourism

Criterion	Sub-criterion	Explanation
Physical (D1)	Slope (C1)	Slope is a very influential factor when considering potential attractions and suitable places for ecotourism. Areas that are too steep will have little capacity for tourism if they present a safety risk for tourists
	Landscape (C2)	The biological reserves (Fauna and Flora) and man-made structures of Abbas Abad Wildlife Refuge make it one of the most beautiful areas for the development of ecotourism in Iran
	Water sources (C3)	Since water resources account for beautiful natural scenery, they are a very important factor in attracting tourists. Water resources are considered an important factor in the selection of areas with ecotourism potential
Ecological (D2)	Wildlife (C4)	Wildlife tourism generally includes non-invasive interactions with animals such as observation and animal photography in their natural habitat
	Vegetation (C5)	Vegetation increases the ecotourism potential of Abbas Abad WR, where desert, arid, semi-arid, salt land and mountainous steppe plants are spread out
	Natural attractions (C6)	Ecotourism takes place in nature and deep in natural attractions. This area is notable for a rich variety of spectacular desert landforms e.g., Iranian golden sand dunes, and clay hills
Socio-economic (D3)	Facilities (C7)	Welfare facilities in any region are among the necessary prerequisites for attracting tourists, such as toilets and water fountains. Regions with excellent untouched nature and major historical sites but no welfare facilities are unable to maximize their potential
	Access (C8)	This sub-criterion includes main and country roads. long distances from road networks present a major challenge for ecotourism sites, as they are often located in secluded areas that are difficult for tourists to access
	Conflicts (C9)	This factor has a limiting role in attracting tourism. These areas contain regions with negative features for ecotourism development, for example the active mines of the region
	Population centers (C10)	Population centers are important due to their tourism facilities and services and various ecotourism attractions such as: Cities and villages
	Cultural and historical attractions (C11)	Cultural and historical sites increase the ecotourism value of an area. In this regard, caravanserais, historical villages and ancient castles are considered important

which were depicted in the form of GIS maps. The way these layers were combined were determined by a conceptual framework. Since various data from the area under study were analyzed together, all of them had to have conformity with each other and had to comply with the same geographical coordinate and visual system. To fulfill the research objective, required spatial, non-spatial data and available maps have been collected from Iranian Forests, Range, and Watershed Management Organization (IFRWMO), Administration of Environmental Protection in Isfahan Province (AOEPIP) and Field Survey with GPS. ArcGIS10.2 and IDRISI software were used to manage all this data and extract the relevant maps of the criteria (Table 2).

Phase 3: GIS analysis and MCDA technique

GIS analysis

The first step of this phase was to make the criteria maps and standardize the data. After defining the criteria, they were entered into GIS in order to create a map of the evaluative criteria identified in the study. This was done using different operations in the GIS environment. The data entries were obtained from sources such as digital and analog cartographic documents, field records, action plans, and statistical reports; and were organized in GIS in vector or checked formats. In the next stage, criteria maps were transformed into one format using GIS, each of which were a substitute in relation to the target.

Table 2 Data used and sources

Criteria	Geoprocessing	Scale	Sources
Slope	Georeferencing surface analysis	30 × 30 m	U.S. Geological Survey (USGS)
Landscape	Kernel density	1:50,000	land use map (IFRWMO)
Water sources	Kernel density	1:250,000	Field Survey with GPS & (AOEPIP)
Wildlife	Overlay maps of sensitive species	1:50,000	Protected Areas map (AOEPIP)
Vegetation	Focal statistics function	1:50,000	Land cover map (IFRWMO)
Natural attractions	Euclidean distance	1:50,000	Land cover map (IFRWMO)
Facilities	Euclidean distance	1:250,000	Field Survey with GPS & (AOEPIP)
Access	Euclidean distance	1:50,000	Land use map (IFRWMO)
Conflicts	Euclidean distance		
Population centers	Euclidean distance		
Cultural and historical attractions	Euclidean distance	1:250,000	Field Survey with GPS & (AOEPIP)

Before merging the maps to generate the final map, it was necessary that all the layers of data produced in the previous stages were standardized. That is, all the layers used had to be converted to a scale which has the capability to combine them using the rules of decision making. All the layers of data in this stage were entered into IRISI software so that they would be standardized using the Fuzzy Model and Membership Functions of Fuzzy Sets. The scale used in this research to determine the Membership Function was byte, which had a value range of 0–1. Higher member values implied more suitability, and lower membership value connotes lower suitability. In order to standardize the criteria maps, the values of criteria thresholds were determined following a review of the literature and of expert consultations (Eastman, 2003). The first point mark (a) indicates the location where the membership function begins to rise above 0. The second point mark (b) indicates where it reaches 1. The third point mark (c) indicates the location where the membership grade begins to drop again below 1, while the fourth point mark (d) indicates where it returns to 0. Table 3 shows the control points (a, b, c, and d) which govern the shape of the fuzzy membership function and the type of membership functions that are used to standardize the factors in IDRISI software. Figure 3 illustrates the standardized criteria maps used to identify and evaluate ecotourism attractions.

MCDA technique

The second step in this phase was the MCDA technique. In this study, a new combined multi-criteria decision analysis model called DANP was used to evaluate the ecotourism attractions (Tang, 2018). The DANP framework was established for building a visual influential relationship map among dimensions and criteria with DEMATEL (Chiu et al., 2013), and to evaluate the key determinants by considering the influential and priority weights based on the influence matrix by DEMATEL (Tsui et al., 2015). In the next section, the method needed to use the DANP technique will be outlined and broken down into a step-by-step process (Li & Tzeng, 2009; Liou et al., 2007).

Based on the DANP technique, the matrix of direct relations (paired comparisons) was formed using the average expert opinions (step 1). Considering the influence of each criteria on each other, a five-level scale rating similar to Table 4 was used in this matrix.

The next step was to normalize the matrix of direct relations, using the formula below (step 2):

$$D = S * A \tag{1}$$

In the above formula, S is calculated as the following:

$$S = \min\left[\frac{1}{\max_{1 \le i \le n} \sum_{j=1}^{n} |a_{ij}|}, \frac{1}{\max_{1 \le i \le n} \sum_{i=1}^{n} |a_{ij}|}\right] \tag{2}$$

Table 3 Fuzzy set memberships and functions with control points used

Criteria	Control point a	Control point b	Control point c	Control point d	Fuzzy function/ membership
Slope (C_1) (%)			0	50	Linear-decreasing
Landscape (C_2) (*)			0.26*	0.007*	Sigmoid-decreasing
Water sources (C_3) (m)			0	20,000	Linear-decreasing
Wildlife (C_4)	Critically Endangered 0.65, Endangered 1, Vulnerable 0.75, Near Threatened 0.40, Least Concern 0.19				Discrete categorical data
Cover (C_5)	Shrub cover 1, shrub-meadow cover 0.4, cover-less 0.2				Discrete categorical data
Natural attractions (C_6)(m)			5000	30,000	Linear-decreasing
Facilities (C_7) (m)			5000	25,000	Linear-decreasing
Access to (C_8) (m)	0	30,000	2000	10,000	Sigmoidal-Symmetric
Conflicts (C_9) (m)	2000	30,000			Linear-increasing
Population centers (C_{10}) (m)			0	10,000	Linear-decreasing
Cultural and historical attractions (C_{11}) (m)	0	30,000	500	10,000	Sigmoidal-Symmetric

*Value of the fuzzy function is determined based on the number changes of the kernel function density map

The third step was to calculate the full rank matrix for the sub-criteria using the following formula (step 3):

$$T = D + D^2 + \cdots + D^l = D(I - D)^{-1} \quad l \to \infty \tag{3}$$

Then, using this full rank matrix, the main criteria matrix was obtained by calculating the arithmetic mean of the corresponding sub-criteria.

In the fourth step, the goal was to examine how much the main and sub-criteria will influence and will be influenced by each other, using the amounts obtained from the full rank matrices in the previous step (step 4). The total amount of all elements in each row (r) for each criterion indicated its influence on other criteria in the system (variables' degree of influence). The total amount of elements in each column (c) for each criterion indicated how much that criterion has been influenced by other criteria in the system (variables' degree of being influenced).

The horizontal vector r + c indicated the influence of the criterion on the system. In other words, the higher the r + c for a criterion, the stronger the interaction between that criterion and other criteria in the system. The vertical vector r–c indicated the amount of influence for each criterion. That is, if r–c was positive, the variable would be considered a cause, and if r–c was negative, it would be considered

an effect. In the end, a Cartesian coordinate system was designed based on this matrix. In this system, the vertical axis represents the amount of r + c, and the horizontal axis is based on r–c. The position of each criterion in the system is specified as a point with coordinates of (r + c, r–c). A graphic diagram was then designed based on this system.

The next step was to form the new normalized matrix for each group of sub-criteria using the Total Normalization Method (step 5). This enabled the formation of the transpose of this matrix, also known as the unweighted super matrix (W). In a similar process, the unweighted super matrices of the main criteria were also specified.

Next, the weighted super matrix (W^α) was calculated by multiplying the unweighted super matrix of the main criteria by the matrix (W). In order to converge the amounts of the result matrix and achieve the final weight of each criterion, this matrix needed to be multiplied by itself to the limits of convergence (step 6) (Table 5).

$$\lim_{x \to \infty} (W^\alpha)^x \tag{4}$$

Phase 4: OWA Technique

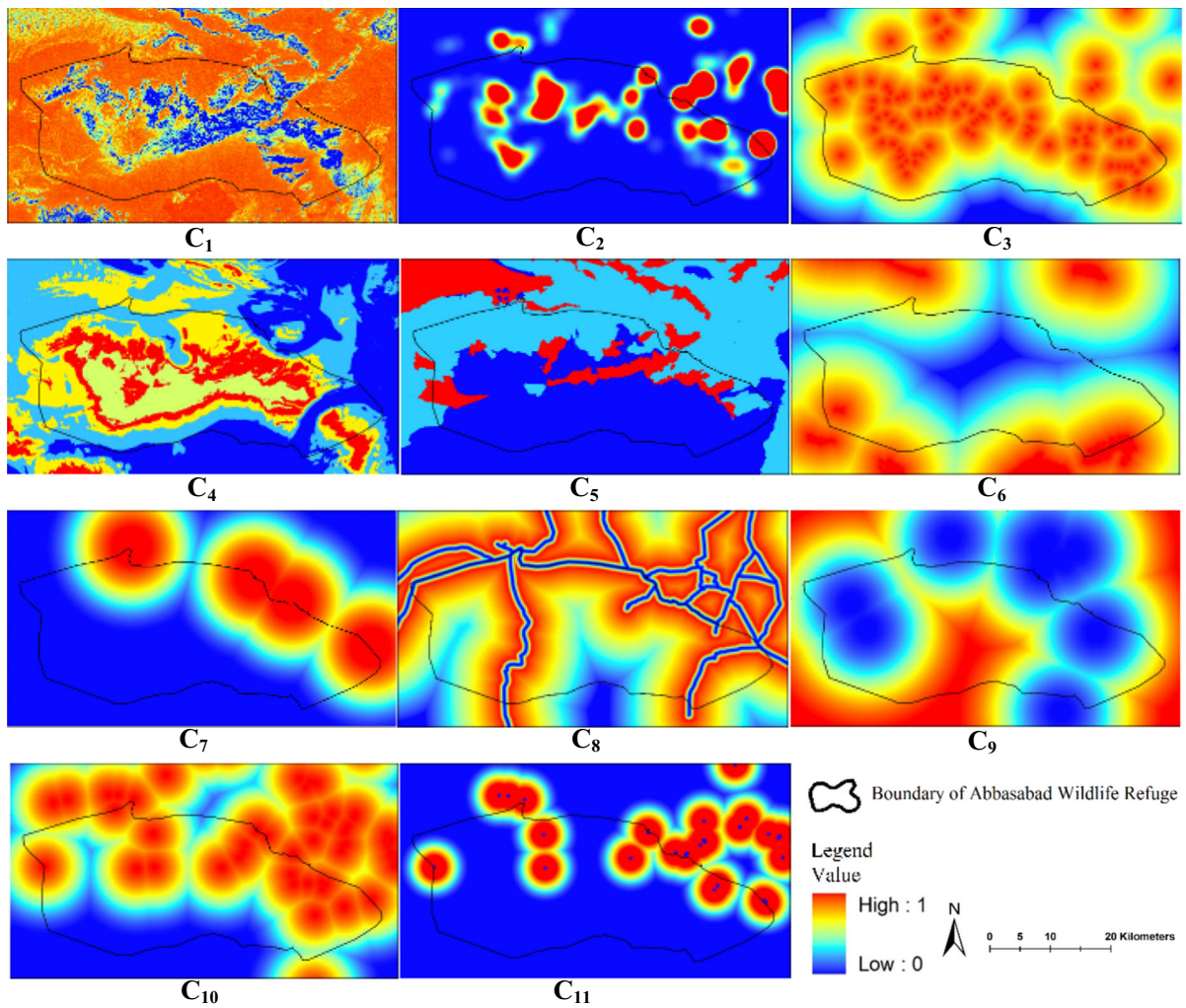After preparing the criteria maps and determining their relative weight, it was necessary to merge these maps

Fig. 3 Maps of standardized criteria of the study area

Table 4 The five-point scale continuum of DEMATEL

No influence	Very little influence	Little influence	Much influence	Very much influence
0	1	2	3	4

in order to generate a map that could evaluate ecotourism attractions. In this study, multi-criteria OWA evaluative method was used to merge the criteria maps.

OWA was one of the methods of multi-criteria evaluation. This method is suitable for MCDA analyses that are associated with uncertainty, because OWA considers the degree of optimism of the expert's

judgments. This continuous scale is completed by relative and ordered weights. Ordered weights are first determined on the basis of the decision-makers' judgments or by means of paired comparisons to control the relative compensation level of the criteria against other criteria, while ordered weights are added to or subtracted from the criteria. Ordered weights allow the decision-maker to affect the location process

Table 5 The normalized direct-influence matrix D for criteria

Sub criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
C_1	0.000	0.067	0.070	0.098	0.101	0.104	0.030	0.037	0.034	0.030	0.067
C_2	0.009	0.000	0.034	0.067	0.067	0.101	0.070	0.040	0.000	0.034	0.034
C_3	0.034	0.101	0.000	0.101	0.101	0.101	0.113	0.067	0.067	0.101	0.067
C_4	0.012	0.073	0.009	0.000	0.037	0.012	0.015	0.000	0.034	0.037	0.006
C_5	0.009	0.061	0.027	0.101	0.000	0.101	0.034	0.006	0.012	0.067	0.043
C_6	0.037	0.101	0.034	0.067	0.067	0.000	0.034	0.034	0.067	0.067	0.070
C_7	0.067	0.067	0.067	0.101	0.101	0.101	0.000	0.113	0.101	0.110	0.101
C_8	0.067	0.095	0.034	0.101	0.073	0.101	0.101	0.000	0.101	0.101	0.067
C_9	0.101	0.101	0.067	0.110	0.110	0.101	0.067	0.067	0.000	0.067	0.101
C_{10}	0.101	0.101	0.101	0.110	0.101	0.101	0.110	0.110	0.101	0.000	0.067
C_{11}	0.034	0.067	0.034	0.067	0.067	0.067	0.067	0.101	0.067	0.067	0.000

with the criteria that they deem to be more significant, keeping their level of importance. Using these weights, the general balance level of the criteria and also their risk levels can be managed effectively (Eastman, 2003).

In this research, five decision strategies have been proposed. Each strategy is associated with a given value of ⍺ and the interaction between trade-off and risk (Fig. 4). As OWA offers more control over the position of the Multi-Criteria Evaluation (MCE) along both the risk and tradeoff axes, the level of risk which we wish to assume in our MCE, and the degree to which factor weights (tradeoff weights) will influence the final suitability map, could be controlled.
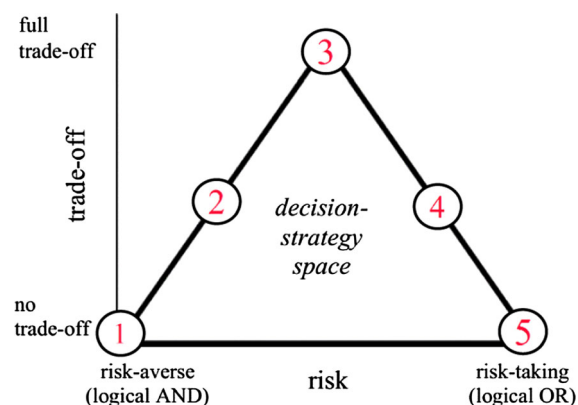
These scenarios include:

Fig. 4 Decision strategy Space in the ordered weighted average (Eastman 2003).

Scenario 1 In this scenario, full weight is given to the last rank-order (the maximum suitability score across all factors for each pixel), so that the results can more closely resemble the OR operation in MCE. The order weights that are used for OR operation is presented in Table 6. Such weighting would result in no trade-off and high risk, meaning that the decision-maker wants maximum risk in search of best places for ecotourism development in the region (Fig. 6). In this scenario, the strategy is too optimistic and alpha equals zero.

Scenario 2 In this scenario, these ordered weights specify an operation somewhere between the extreme of AND and the average risk position of WLC. In addition, these order weights set the level of trade-off to be somewhere between no trade-off position of the AND operation, and the full trade-off position of WLC (Fig. 6).

Scenario 3 In this scenario, the level of risk is exactly between AND and OR and trade-off is full; therefore, like the example in Table 6, it would specify the following order weights. This scenario resembles the WLC method (Fig. 6).

Scenario 4 This scenario may be useful for managers who are interested in a conservative or low-risk solution for the assessment of ecotourism attractions in the region, particularly those that know that their estimates for how different factors should trade off with each other are also important and should be considered. These managers may then want to develop a set of order weights that would give them some amount of trade-off but would maintain a low

Table 6 Typical sets of order weights for eleven factors*

Rank		1st order weight	2nd order weight	3rd order weight	4th order weight	5th order weight	6th order weight	7th order weight	8th order weight	9th order weight	10th order weight	11th order weight
1	High level of risk-No tradeoff	0	0	0	0	0	0	0	0	0	0	1
2	High level of risk-Some tradeoff	0.0086	0.0172	0.0202	0.0516	0.0594	0.0906	0.1073	0.1361	0.1584	0.1746	0.1760
3	Average level of risk-Full tradeoff	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909
4	Low level of risk-Some tradeoff	0.1760	0.1746	0.1584	0.1361	0.1073	0.0906	0.0594	0.0516	0.0202	0.0172	0.0086
5	Low level of risk-No tradeoff	1	0	0	0	0	0	0	0	0	0	0

*The order of elements is as following: 1st: Landscape, 2nd: Wildlife, 3rd: Natural attractions, 4th: Cover, 5th: Water sources, 6th: Slope, 7th: Population centers, 8th: Facilities, 9th: Cultural and historical attractions, 10th: Conflicts, 11th: Access

risk level in the solution. There are several sets of order weights that could be used to achieve this. For low risk, the weight should be skewed to the minimum end. For some trade-off, weights should be distributed through all ranks. The set of order weights in Table 6 and the result of this scenario are shown in Fig. 6.

Scenario 5 In this scenario, full weight is given to the first rank-order (the minimum suitability score across all factors for each pixel), so that results closely resemble the AND operation in Boolean MCE. For this strategy, the factor with the minimum value gets full weighting, resulting in no trade-off and low risk scenario (Fig. 6). The order weights that are used for AND operation are presented in Table 6.

Table 7 The amounts major criteria influenced or were influenced

Criteria	R	C	R + C	R–C
Physical (D_1)	1.7220	2.160	3.0542	0.3897
Ecological (D_2)	1.2879	4.116	3.6833	− 1.1076
Socio-economic (D_3)	2.4377	6.114	3.7993	1.0761

Results

The results produced by examining the interaction between the criteria and the sub–criteria

The criteria used in the process of evaluation are interdependent. This dependence and inter-relation between the criteria and the sub-criteria were evaluated using the DEMATEL technique. The amount that each criterion/sub-criterion influences and/or is influenced by other criteria is displayed in Tables 7 and 8, in which R shows the amount of each factor's influence on other evaluative factors, and C depicts how much that factor is influenced by other factors. Furthermore, the horizontal vector (R + C) represents the influence of that factor in the process of evaluation. In other words, the greater a factor's amount of R + C, the more it interacts with other factors in the process of evaluation. The vertical vector (R–C) shows each factor's influencing power. In general, if (R–C) is positive, the variable will be considered a cause; and if negative, it will be considered an effect. In Fig. 5, each criterion and sub-criterion's degree of influence or being influenced is displayed in a graphic chart in which the horizontal axis represents the amounts (R + C) and the vertical axis represents the amounts (R–C). The position of each factor is

Table 8 The amounts sub-criteria influenced or were influenced

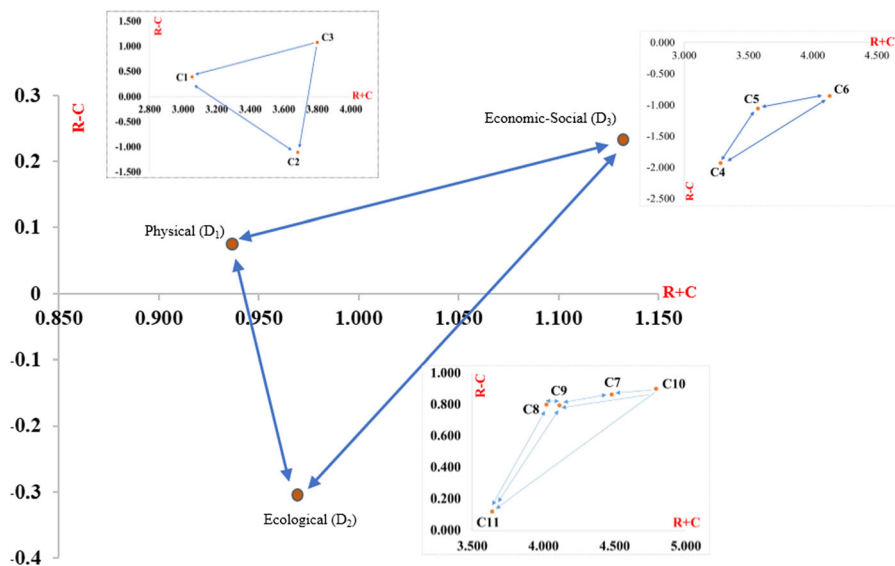| Sub criteria	R	C	R + C	R–C	Relationship
Slope (C_1)	1.7220	2.160	3.0542	0.3897	Cause
Landscape (C_2)	1.2879	4.116	3.6833	− 1.1076	Effect
Water resources (C_3)	2.4377	6.114	3.7993	1.0761	Cause
Wildlife (C_4)	0.6770	5.106	3.2830	− 1.9290	Effect
Vegetation (C_5)	1.2598	3.089	3.5729	− 1.0533	Effect
Natural attractions (C_6)	1.6382	1.081	4.1308	− 0.8543	Effect
Facilities (C_7)	2.6722	10.077	4.4805	0.8639	Cause
Access (C_8)	2.4107	7.071	4.0224	0.7989	Cause
Conflicts (C_9)	2.4549	11.066	4.1138	0.7959	Cause
Population centers (C_{10})	2.8449	9.062	4.7903	0.8995	Cause
Cultural and historical attractions (C_{11})	1.8801	8.059	3.6399	0.1203	Cause

Fig. 5 Cause and effect relationship diagram

specified by a point with the coordinate (R + C), (R–C) as outlined in the chart.

It is clear from Table 7 that ecological criteria with a higher C are influenced more than other major criteria when evaluating the ecotourism attractions of the region under study. It is also apparent that the socio-economy factor with a higher R has a high degree of influence, as this criterion has a higher R + C than the other two criteria and has more interaction with the other factors in our conceptual model. Also, considering the amount of R–C in Table 8, the sub-criteria are divided into the two groups of Cause and Effect. According to the results in this study, greater focus should be given to sub-criteria such as slope, water resources, facilities, access, conflicts, population centers, and cultural and historical attractions (Cause) more than to the landscape, wildlife, vegetation, and natural attractions (Effect). This is because the Cause group factors are difficult to move, while the Effect group factors more easily moved (Hori & Shimizu, 1999).

Weighting the criteria and sub-criteria using DANP technique

After showing the relationship, dependence and the interaction of the evaluative criteria, the final step is using the DANP technique to calculate the weight of

these criteria. The results of weighting each of the factors effective in the evaluation process of the ecotourism attractions of the area are displayed in Table 9.

It is clear that most of the weight in this study is given to the ecological criteria, while socio-economic and physical criteria hold the second and third rank respectively. Furthermore, landscape has the heaviest weight among the sub-criteria and wildlife and natural attractions come next in order. The lowest weight goes to the sub-criterion of access (Table 9). As the matrix is simply the average of the whole questionnaire, and due to the sensitivity of the DANP method, the final results have little decimal discrepancy.

The results produced by integrating the criteria using OWA and presenting different scenarios

After determining each criterion's weight and standardizing their maps, some other weights called graded weight were used using the OWA method. By defining the graded weights in various conditions, a range of results could be obtained which are different from each other in terms of the degree of risk and trade-off. Finally, ecotourism development of the region was categorized in the five distinct scenarios by considering the suitability of the area (Table 6). These scenarios show how the decision-makers' attitude toward uncertainty in the evaluative decision-making process can affect the results. It is evident from the OWA method that the goal is not to find a single optimal scenario; this method introduces places under

different decision-making strategy conditions which can be considered in relation to the area's priorities for ecotourism development by considering the level of attitudes toward risk. The suitability continuum map, which was obtained through the OWA method, was classified according to the histogram curve and the environmental conditions. This resulted in the production of the classified map of Abbas Abad Wildlife Refuge (Fig. 6), which illustrate the five indices outlined in Table 10. The area and its percentage for each index are depicted in Table 11.

In the first scenario, the graded weights are in full risk and out of balance (Fig. 6) which demonstrates an overly-optimistic strategy, and alpha equals zero. According to this strategy, the decision-maker is looking for the highest risk to identify the best places for the ecotourism development of the area. In this scenario, pixels which are good in at least one of the criteria of Table 3 gain pixel value. Therefore, it is expected that many pixels have a high general balance in this scenario, which is confirmed by the results (Fig. 6). Based on this scenario, most of the areas under study are classified as extremely suitable or very suitable. 7814.92 km2 (which equates to 99.35% of the area) are extremely suitable, 27.49 km2 (which equates to 0.36% of the area) are very suitable, and only 2.38 km2 (which equates to 0.03% of the area) are classified as unsuitable for ecotourism development (Table 11).

In the second scenario, the graded weights are in high-risk mode and balanced; the strategy is optimistic and alpha equals 2 (Fig. 6). In this scenario, the fifth

Table 9 DANP weights for the evaluation model

| Cluster	Weight	Evaluation criteria	Weight	Rank of importance
Physical (D1)	0.3298	Slope (C1)	0.0807	6
		Landscape (C2)	0.1604	1
		Water sources (C3)	0.0887	5
Ecological (D2)	0.3357	Wildlife (C4)	0.1163	2
		Cover (C5)	0.1059	4
		Natural attractions (C6)	0.1136	3
Economic-Social (D3)	0.3345	Facilities (C7)	0.0705	8
		Access to (C8)	0.0588	11
		Conflicts (C9)	0.0618	10
		Population centers (C10)	0.0769	7
		Cultural and historical attractions (C11)	0.0664	9
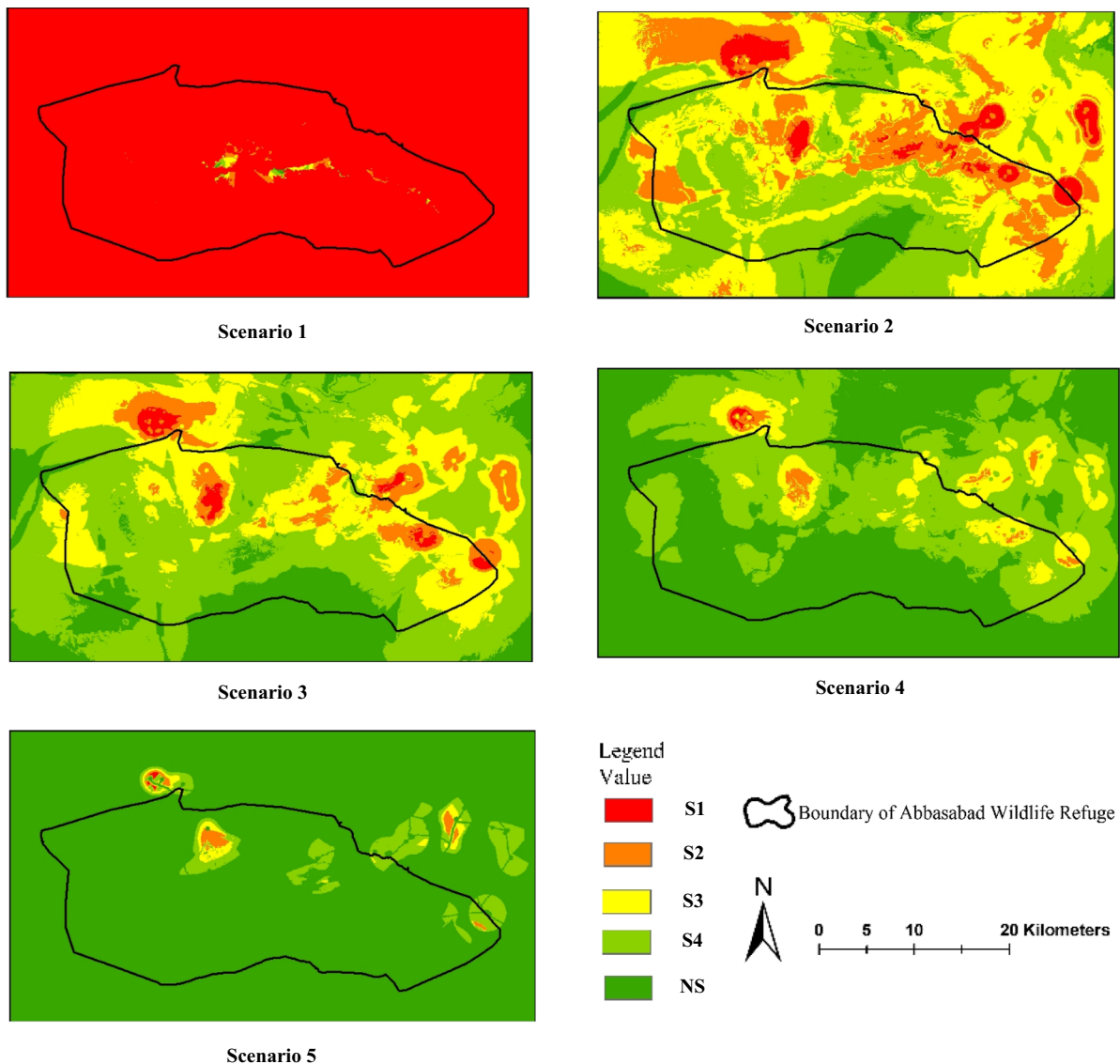
Fig. 6 The map of implementation of the five scenarios

and forth class have extreme and high suitability, and cover an area of 295.02 km^2 (equaling 3.29% of the area) and 494.34 km^2 (equaling 15.93% of the area), respectively. These areas include center, east and northwestern parts of the area under study (Table 11).

In the third scenario, the risk factor is average, balance is full, and alpha equals zero (Fig. 6). Equal weights are allocated to all the criteria of the study, resulting in a neutral factor. This strategy is the Weighted Linear Combination in which the first and second section occupy 19.36% and 49.22% of the area

under study, respectively. These areas, which are mostly located in the south and southwestern part of the region, lack historical-natural attractions and have little and unsuitable potentials for ecotourism. The third class covers 23.92% of the area which has average potentials for ecotourism. Most of the area in this section is located in the center and northeastern parts of the area under study which include ecotourism attractions such as villages with historical-traditional structures for instance the villages of Garmeh, Iraj, Beyazeh and Mehrjan, Farahzad and Abgarm. The

Table 10 Land suitability classification based on OWA values

Suitability index	OWA values	Description
S1 (Very high suitable)	0.80–1.00	Suitable capacity of locations is very high and satisfies all criteria set up
S2 (High suitable)	0.60–0.80	Suitable capacity of locations is high and satisfies almost all criteria set up
S3 (Medium suitable)	0.40–0.60	Suitable capacity of locations is medium and satisfies most of the criteria set up, but some criteria are not satisfied
S4 (Low suitable)	0.20–0.40	Suitable capacity of locations is low and satisfies some of the criteria set up, but most of the criteria are not satisfied
N (Not suitable)	0.00–0.20	Can assume that all of criteria are not satisfied

Table 11 Area (km^2 & %) of each class by using the OWA method

Scenario	Suitability index									
	S1	%	S2	%	S3	%	S4	%	NS	%
1	7814.92	99.35	27.49	0.36	13.79	0.17	6.80	0.09	2.38	0.03
2	259.02	3.29	1253.34	15.93	3314.66	42.14	2571.82	32.70	466.54	5.93
3	95.38	1.21	494.34	6.28	1881.79	23.92	3871.14	49.22	1522.73	19.36
4	8.80	0.11	83.67	1.06	556.63	7.08	2747.01	34.93	4469.26	56.82
5	2.80	0.03	38.77	0.49	58.76	0.75	383.90	4.88	7381.15	93.85

fourth and fifth section each represent 6.28% and 1.21% of the area. These areas have high and very high potentials for ecotourism which are mostly located in the northwest and eastern parts of the area under study (Table 11).

In the fourth scenario, risk is minimal, balance exists, and alpha equals 2 (Fig. 6). Considering the fact that the area under study is a wildlife refuge and a protected one, this scenario is the optimal protective scenario for ecotourism development, in which areas in the fourth and fifth section have high and very high suitability compared to the average risk scenario. Balance (WLC) reduces to 0.11% and 1.06% for each section, respectively, and includes areas in the east and north western parts of the region. The first and the second class with not and low suitability compared to the average risk scenario with balance, WLC increases to 56.82% and 34.93% each (Table 11).

In the fifth scenario, risk is also minimal in the fifth scenario, which has no balance and alpha equals zero, representing an extremely pessimistic strategy (Fig. 6). Based on this scenario, the suitable pattern for ecotourism development in the region is composed

of the worst possible result. As expected, the results show that very few areas (only 0.03% of the region under study) are classified as highly suitable. In this scenario, a large area (93.85% of the area under study) is classified as unsuitable for ecotourism (Table 11).

Discussion

This research presented a plan for the identification and evaluation of ecotourism attractions using a hybrid GIS-OWA and DANP method. The DEMA-TEL technique was used not only to construct the interaction relationship between each criterion, but also to obtain the most accurate weights of influence in real-world situations. The traditional ANP only solves problems of interdependence and feedback on clusters or factors/criteria until they are independent. Therefore, these basic ANP concepts were used in combination with the DEMATEL technique to solve these real-world issues and examine the interdependence of all criteria). Based on the results, by using the DEMATEL technique in conjunction with a DANP,

we can determine the relative influence weights of these criteria. According to the results in Table 8 & Fig. 5, natural attractions, facilities, access, conflicts and population centers have the highest amount of (R + C), and are the sub-criteria which—according to the experts who have participated in this study—have the highest degree of interaction and relationship compared to other sub-criteria in this study. Natural attractions are of great significance for their beauty and conservation of nature in the protected area and also for their potential for ecotourism development. Furthermore, access in each region is important for bringing tourists to the area and roads influence access to the ecotourism area substantially. The facilities and conflicts sub-criteria in the area under study, which evaluate the ecotourism attractions with the highest C, were influenced the most by other evaluative sub-criteria in this study.

Finally, by using the OWA method, The OWA operations make it possible to develop a variety of strategies ranging from an extremity pessimistic (the minimum-type strategy based of the logical AND combination) through all intermediate the neutral-towards-risk strategy to an extremely pessimistic strategy (the maximum-type strategy based on the logical OR combination) (Sánchez-Lozano et al., 2013; Sadeghi & Karimi, 2017). The most important advantage of the OWA method is risk control in decision-making (Firozjaei et al., 2019) which is very useful to investors in the field of ecotourism. Furthermore, the results produced by OWA show that (Fig. 6) there is balance and little risk in the fourth scenario, which makes this an optimal protective scenario for ecotourism development. Considering the fact that the area under study is a protected wildlife refuge, this scenario is an optimal protective one for ecotourism development (optimal scenario). The OWA operations have been used in several studies, some of which is outlined as follow: Hajizadeh et al. (2020) evaluate the land for ecotourism development based on WLC, and FUZZY – OWA methods in the Gorgan area is located in Golestan province (Northeast Iran). In this study, 14 criteria were determined and integrated according to OWA model and fuzzy quantifiers. The results showed that the Fifth scenario had the highest accuracy for studying the region. Bearing this in mind, we can conclude that the development of ecotourism in the region of the Abbas Abad Wildlife Refuge has strong potential due to the natural advantages of the region

and increasing needs of the urban population for short and quality stays in nature. If development strategies take these recommendations into account, this region could become a very attractive place for ecotourism, which could become a crucial factor in the economic revival of the region.

Conclusion

One of the most important features of the study area is the high capability of the ecosystem for constructing ecotourism sites and, at the same time, lack of infrastructural facilities to provide services to tourists. Considering the importance of tourism in conservation, economy, and culture of the region under study, it is of great necessity to develop infrastructure and infrastructure facilities. A Hybrid GIS-OWA and DANP Method for the Identification and Evaluation of Ecotourism Attractions and its application to the case study of the Abbas Abad Wildlife Refuge region of Iran has been shown for the first time in this paper. It is important to note that the criteria applied for selecting the areas for ecotourism development vary in different regions and depend on the current socio-economic and natural resources. Therefore, this procedure allows other criteria which have not been included in this study yet. The results of this research are useful in understanding the capability of the OWA-MCDA technique in evaluating optimal regions for the ecotourism development; and the prepared optimal regions prediction maps can be used as a basis for the decision-making process. The results of this research indicate the high potential of the OWA model in modeling complex decision-making problems in the real world. The purpose of the OWA model is not just to find a single option, but, other capabilities also have been emphasized in this model and can be used by regional authorities and could help investors, planners and engineers in supporting regional development and tourism plans.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual subjects participating in the study.

Research involving human participants and/or animals There is no humans or animals were used in this research.

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