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Evaluation of ecotourism sites: a GIS-based multi-criteria decision analysis

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Abstract

Purpose – The aim of this study is to evaluate the potential geographic locations for ecotourism activities and to select the best one among alternatives.

Design/methodology/approach – The proposed model consists of four sequential phases. In the first phase, different geographic criteria are determined based on existing literature, and data are gathered using GIS. On equal criteria weighing, alternative locations are determined using GIS in the second phase. In the third phase, the identified criteria are weighted using analytical hierarchy process (AHP) by various stakeholders of potential ecotourism sites. In the fourth phase, the PROMETHEE method is applied to determine the best alternative based on the weighted criteria.

Findings – A framework including four sequential steps is proposed. Using real data from the Black Sea region in Turkey, the authors test the applicability of the evaluation approach and compare the best alternative obtained by the proposed method for nine cities in the region. Consequently, west of Sinop, east of Artvin and south of the Black Sea region are determined as very suitable locations for ecotourism.

Research limitations/implications – The first limitation of the study is considered the number of included criteria. Another limitation is the use of deterministic parameters that do not cope with uncertainty. Further research can be conducted for determining the optimum locations for different types of tourism, e.g. religion tourism, hunting tourism and golf tourism, for effective tourism planning.

Practical implications – The proposed approach can be applied to all area that cover the considered criteria. The approach has been tested in the Black Sea region (nine cities) in Turkey.

Social implications – Using the proposed approach, decision-makers can determine locations where environmentally responsible travel to natural areas to enjoy and appreciate nature that promotes conservation have a low visitor impact and provide for beneficially active socioeconomic involvement of local individuals.

Originality/value – To the best knowledge of the authors, this is the first study which applies a GIS-based multi-criteria decision-making approach for ecotourism site selection.

Keywords AHP, PROMETHEE, Geographic information system, Black Sea, Ecotourism site selection

Paper type Research paper

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1. Introduction

Ecotourism is a sustainable form of natural resource-based tourism. It focuses primarily on experiencing and learning about nature, its landscape, flora, fauna and their habitats, as well as cultural artifacts from the locality (Fung and Wong, 2007). Ecotourism trips are separated from other tourism varieties and basically, the tourist types are different. The key difference between tourism and ecotourism lies in involvements with nature; tourism is not much concerned about the well-being of local people and conservation of nature, but ecotourism tries to create a minimal impact on the people and the environment. The groups formed by eco-tourists are usually of fewer than 25 people and the accommodation areas for ecotourism do not exceed the capacity of 100 beds. Ecotourism is also an activity that is able to promote job creation and education in local communities. Today in Turkey, the cost of farming in the agricultural sector is frequently affected by economic fluctuations; thus, many farmer families prefer to choose jobs, except agriculture (Tekin and Kasalak, 2014). This situation leads to the increase in unemployment in the country; for this reason, ecotourism entrepreneurship has to be developed in rural areas to provide jobs for young people in the ecotourism regions.

As Turkey has hosted many cultural habitats in the past and has a rich geographical structure, the country seems to be cut out from ecotourism. Turkey's tourism potential can still be expanded by investing in the changing tourism concepts serving in natural places and avoiding the prevalence of mass tourism by stopping investments in big/flashy buildings.

According to the tourism targets of Turkey determined by Ministry of Culture and Tourism for 2023, the Black Sea region is a region that aims to be developed primarily in terms of biodiversity and eco-tourism (Ministry of Culture and Tourism, 2007). The Eastern Black Sea region of Turkey is a good source of eco-tourism with its natural beauties, climatic conditions, historical sites and many other features. The Uzungöl basin, Altındere and Fırtına valley in Rize are especially important places for eco-tourism in Trabzon "within the scope of the" Yayla Tourism Project "initiated by the Ministry of Tourism in 1990, 26 highlands throughout Turkey and 20 highlands in the Eastern Black Sea region have been declared as "Tourism Centers." As a result, travel agencies have been set up to tour tourists and promote the region, and tours called "green tours" have been organized through these agencies.

At this stage; establishing national policies and investments for promoting ecotourism is very important, also this can encourage governments to use ecotourism as a tool for poverty alleviation and environmental protection (World Tourism Organization, 2017). However, finding a suitable site for an ES requires a multi-criteria approach and high levels of accuracy and reliability in the resulting maps, to be relevant for decision-making. The effectiveness of the made decision is clearly dependent on the quality of the data used to produce the considered criteria maps, as well as on the method used for decision-making analysis (Jeong *et al.*, 2016; Işık and Demir, 2017; Pantoja *et al.*, 2017). Herein, GIS-based MCDA provides a collection of powerful techniques and procedures converting spatial and non-spatial data into information within decision-maker's own judgments.

Thus, in this paper, we develop a scientific method for determining the ES for Black Sea region of Turkey. We create a map for site selection by calculating the ecotourism siting availability score of nine cities in the region. This score shows the weighted average of the city scores on 14 selection criteria which are determined by a group of experts from the Ministry of Culture and Tourism and from the tourism sector.

In the first phase of this study; topography, climate, biological and land use indicators and related data are obtained. In the second phase, the geographic information is mapped to each city using GIS software to assign an ecotourism siting availability score to each city. Lastly, indicators are prioritized and potential sites are ranked using multi-criteria decision analysis (MCDA) techniques.

The paper is organized as follows. Section 2 provides a review of the literature on GIS-based MCDA in ES selection, while Section 3 provides selection criteria. Sections 4 and 5 are the methodology and case study sections, respectively, which explain our data generation and analysis framework with a discussion of the results. Section 6 sums up our conclusion and sets future study directions.

2. Literature review

In this part of the study, we investigate the ES selection studies in the literature. Because there are not many studies about GIS-based MCDA techniques we consider all the site selection papers. It must be noted that MCDM or MCDA are well-known acronyms for multi-criteria decision-making and multi-criteria decision analysis. MCDM or MCDA explicitly evaluates multiple conflicting criteria in decision-making. Therefore, these acronyms are interchangeable. MCDA is preferred in this study.

Fung and Wong (2007) evaluated the potential for ecotourism planning in Yan Chau Tong Marine Park and the surrounding areas. They used GIS and MCDA techniques effectively to assist ecotourism planning. The application of their method successfully divided the study area into different conservation levels by considering various factors and constraints. Their results can assist in planning land resources for ecotourism to satisfy both objectives and attain sustainability in the area. Then, Kumari *et al.* (2010) identified ecotourism indicators for the identification of ESs in West district, Sikkim, by applying the hierarchical structure of AHP in the geospatial environment. They developed a method in four stages in their study that help in identifying the potential ESs based on the environmental parameters. In addition, Bunruamkaew and Murayam (2011) prioritized the potential ESs using GIS and analytical hierarchy process (AHP) in Surat Thani Province, Thailand. Their methodology was useful to identify ESs by linking the criteria deemed important with the actual resources of the Province. Zarkesh *et al.* (2011) selected a region in Dohezar Basin (northern Iran) in which the land capability was evaluated for ESs by using multi-criteria evaluation. They applied their method to different scenarios and the most suitable areas for tourism development zones belong to the first, third and second scenarios. Kaya *et al.* (2013) proposed a fuzzy multi-criteria approach for the selection of the most appropriate site(s) for promoting ecotourism activities in urban areas using a modified PROMETHEE methodology. PROMETHEE III outranking methodology is used to make a prioritization among seven different districts of Istanbul. Mobaraki *et al.* (2014) evaluated capacities and power of ecotourism as well as nature tourism in Isfahan Township using GIS and AHP. Their findings indicate that regarding the map of ecotourism capacity of Isfahan townships, resulted from combining various climatologically, geological, hydrological, topological maps and access maps, the township is not homogeneous in terms of nature ecotourism and coastal parts of the township have better condition than other parts and should be considered for ecotourism development planning. Ahmadi *et al.* (2015) used GIS to identify and study the vulnerable zones and the ecotourism status in Ilam Province. Their research procedure indicates that the GIS-based multi-criteria decision-making could be quite a capable approach to handle a variety of criteria affecting site attraction for ecotourism development. Likewise, Suryabhagavan *et al.* (2015) investigated the identification of potential ESs in Hawassa town by using multi-criteria evaluation and concluded that Hawassa town can contribute for the national development through sustainable use of ecotourism potential of this area. Bali *et al.* (2015) proposed a spatial decision support system, based on a multi-criteria evaluation, ecotourism development in the Caspian Hyrcanian mixed forests eco-region northern Iran. Their finding showed that the approach is a suitable tool for ecotourism land evaluation.

In another comprehensive study, Samanta and Baitalik (2015) tried to identify potentially suitable sites for ecotourism in the surroundings of Bankura mainly based on the natural components of ecotourism. Even factor, namely, land use-land cover, soil, elevation, slope, vegetation map, road network map, drainage map and also temperature and rainfall were considered to determine the suitability of an area for ecotourism. Fang (2017) developed a model for the identification of zone suitability for sustainable development of ecotourism. The proposed model is based on the combined application of GIS and MCDA using fuzzy decision-making trial and evaluation laboratory (DEMATEL) method to estimate and map the suitability classes of ecotourism potentials in Zhejiang Province (China). The final suitability map of ecotourism was obtained by applying weighted linear combination and the results designed in four suitability classes as follows: highly, moderately, marginally and not suitable. Gigović *et al.* (2016) proposed a model based on the combined application of GIS and MCDA using fuzzy DEMATEL method to estimate and map the suitability classes of ecotourism potentials in the study area of "Dunavski ključ" region (Serbia). The model has been developed by using 16 criteria grouped in four clusters. Wong and Fung (2016) used GIS-based MCDA approach to objectively identify potential sites for various ecotourism activities and tourism development potential in Lantau Island, Hong Kong. The considered area was classified into four zones namely sanctuary, nature conservation, outdoor recreation, and tourism development using proposed approach. Lastly, Bhaya and Chakrabarty (2016) attempted to identify potential ESs in Jungle Mahal using remote sensing and GIS techniques in forest dominated area of West Bengal. After identifying the potential sites, a demonstrative plan has been made for ecotourism development based on locally available natural resources.

As it can be seen from literature review above, although there have been some papers which apply MCDA such as AHP and PROMETHEE on ES selection individually (Gourabi and Rad, 2013; Kaya *et al.*, 2013; Zhou *et al.*, 2014; Roy *et al.*, 2018), a GIS-based AHP and PROMETHEE approach for ES selection is lacking. Because applying either MCDA techniques or GIS alone can result in undesirable results, as the success of ESs is closely related to their geographical features. Regarding this information, this paper contributes to the literature in several ways (every item is first in literature):

- application of GIS-based AHP and PROMETHEE approach to evaluate ecotourism siting availability;
- presenting an evaluation management framework using 14 different data connected with topography, land use, climate and biological indicators; and
- implementation of this study on Turkey to provide an analytic tool for tourism policymakers.

3. Ecotourism site selection criteria

As the success of MCDA studies mainly relies on the determination of criteria, we enlighten about these criteria in this section. A group of experts who are working for the Turkish Republic Ministry of Culture and Tourism in addition to the experts working for tourism sector are asked about ES selection criteria. Experts' pool consists of three people – one of them is from related Ministry and two of them are from a natural travel agency. The expert who is working for Turkish Republic Ministry of Culture and Tourism is responsible for the general directorate of cultural heritage and museums. Two experts work for the travel agency which organizes natural tourism activities in Turkey. After their and the author's investigations, mainly 4 main and 14 sub-criteria are determined. The main heading criteria are "Topography," "Climate," "Biological" and "Land Use" criteria groups. All of the main and sub-criteria are given in Figure 1.

As a comparison; Table I can be examined to see the frequently used criteria in literature and the proposed paper's criteria. In Table I, the ES selection criteria in the literature are given.

As can be seen above, the most frequently selected criteria are; "Slope, Elevation, Aspect" among topographical criteria, "Rainfall, Temperature" among climatic criteria and finally "Distance from the road" among land use criteria. We list and define the selection criteria which are used in this study in Table II.

4. Applied methodology

To evaluate the ES locations, different individual techniques are used hierarchically. While AHP is used to prioritize the weights, PROMETHEE is applied to rank the alternatives which are determined using GIS software. Although these techniques are used individually by several researchers, it is the first study which applies for ESs evaluation. For more details about AHP, PROMETHEE and GIS, the reader is referred to Saaty (1980); Mahmoudi *et al.* (2016) and Ling *et al.* (2010), respectively.

The procedure followed in the generation of the available ES locations is presented in Figure 2. As it can be seen, the methodology is applied in four basic stages which are shown in shadows.

The first step of the process was to determine the 14 criteria which are mentioned in the previous section. They are categorized under four main dimensions namely: topography, climate, biological and land use. Searching the previous ten related papers from literature, most preferred criteria are tried to be selected.

Alternative locations based on each criterion are designated using GIS in the second step. GIS data obtained from different sources is used to perform spatial analysis via ESRI ArcGIS 10.2 software. In GIS analysis part of this study, spatial analysis such as Euclidean

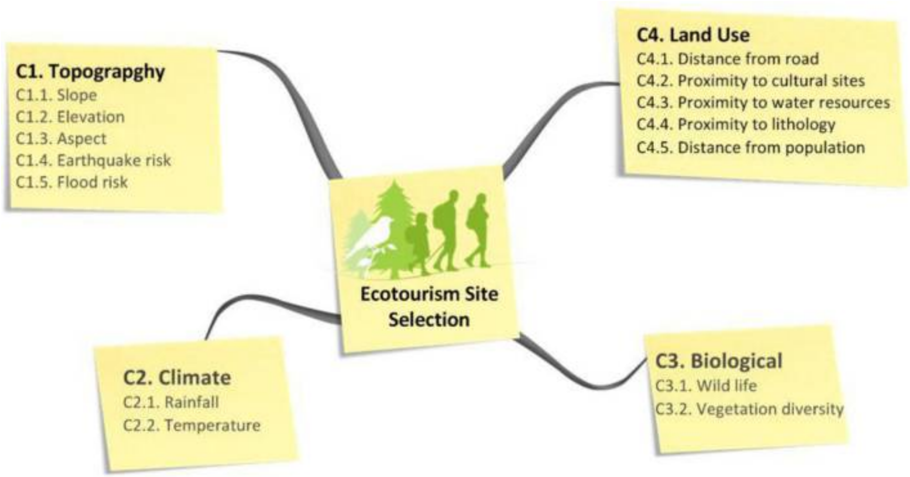


Figure 1.
ES selection criteria

Sources	Topography					Climate		Biological		Land use				
	C1.1.	C1.2.	C1.3.	C1.4.	C1.5.	C2.1.	C2.2.	C3.1.	C3.2.	C4.1.	C4.2.	C4.3.	C4.4.	C4.5.
[1]		✓						✓	✓					
[2]	✓	✓	✓					✓		✓	✓			
[3]	✓	✓	✓	✓		✓	✓	✓		✓				✓
[4]	✓	✓		✓		✓	✓		✓					
[5]	✓	✓	✓			✓	✓			✓	✓			
[6]						✓	✓		✓			✓		
[7]	✓	✓	✓			✓	✓	✓	✓	✓		✓	✓	✓
[8]	✓			✓		✓	✓			✓				✓
[9]	✓	✓	✓			✓	✓			✓				✓
[10]	✓	✓	✓						✓	✓				✓
[11]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Sources: [1] Kumari *et al.* (2010); [2] Bunruamkaew and Murayam (2011); [3] Zarkesh *et al.* (2011); [4] Mobaraki *et al.* (2014); [5] Suryabhagavan *et al.* (2015); [6] Ahmadi *et al.* (2015); [7] Rafieyan *et al.* (2015); [8] Bali *et al.* (2015); [9] Mohd and Ujang (2016); [10] Fang (2017); [11] Proposed study

Table I.
The ES selection criteria in literature

Criteria		Preferred situation
C1.1	Slope	ESs should be located at a lower slope for trekking
C1.2	Elevation	ESs should be located at high elevation
C1.3	Aspect	ESs should be located favorably south facing zones (Zarkesh *et al.*, 2011; Bali *et al.*, 2015)
C1.4	Earthquake risk	ESs should be located far away from earthquake hazard zones
C1.5	Flood risk	ESs should be located far away from flood hazard zones
C2.1	Rainfall	ESs should be located at places with lower rainfall intensity
C2.2	Temperature	ESs should be located at places with low-temperature average
C3.1	Wildlife	ESs should be located close to wildlife for better observations
C3.2	Vegetation diversity	ESs should be located close to vegetation diversity for better observations
C4.1	Distance from road	ESs should be located far away from roads for better protection of nature
C4.2	Proximity to cultural sites	ESs should be located close to "monasteries/ruins"
C4.3	Proximity to water resources	ESs should be located close to "lake, river, stream, waterfall, and lagoon"
C4.4	Proximity to lithology	ESs should be located close to "caves, natural stones"
C4.5	Distance from population centers	ESs should be located away from population centers to employ rural areas

Table II.
Description of each criterion

distance, inverse distance weighted (IDW), slope and weighted overlay are used to find out the suitable locations for ecotourism. Euclidean distance analysis calculates the straight-line distance of each point to the closest source. This analysis is used to calculate distance and proximity values of criteria. IDW technique used to calculate public land and poverty density is a type of interpolation that calculates the degree of relationship between near and distant points. Slope analysis identifies the slope in per cent of the land. Table III describes the GIS data type for each criterion.

Each pixel on the ArcGIS is equal to a minimum of 600,000 m^2. To ensure measurement integrity, the results of all are normalized after conducting the analysis. Then, all analyses

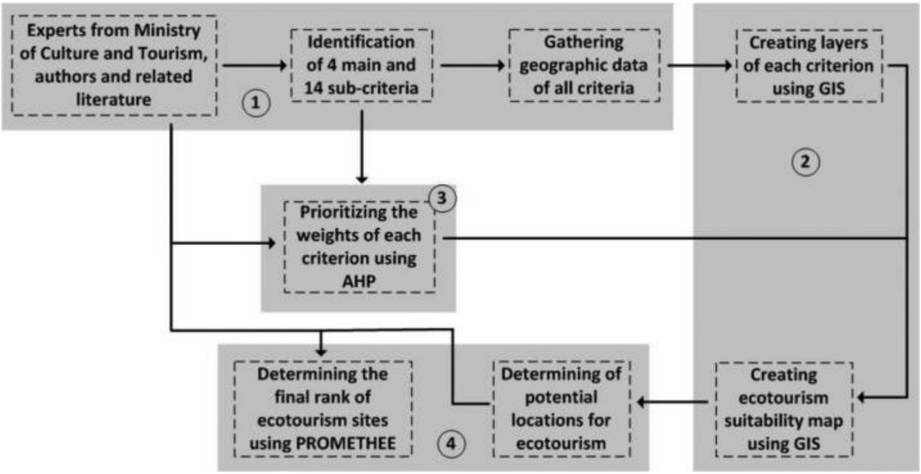


Figure 2.
Proposed and applied methodology

Criteria		Data	Data source	Analysis
C1.1.	Slope	SRTM	US Geological Survey	Slope
C1.2.	Elevation	SRTM	US Geological Survey	Normalization
C1.3.	Aspect	SRTM	US Geological Survey	Aspect
C1.4.	Earthquake risk	Active Fault Map	Miner. Res. & Explor. Gen. Directorate	Euclidean dist.
C1.5.	Flood risk	Flood risk map	Emergency Management Authority	Euclidean dist.
C2.1.	Rainfall	Rainfall statistic	Turkish State Meteorological Service	Density
C2.2.	Temperature	Temperature statistic	Turkish State Meteorological Service	Density
C3.1.	Wildlife	Wildlife areas	Republic of Turkey Ministry of Culture and Tourism	Euclidean dist.
C3.2.	Vegetation diversity	Forest	International Vector Data (VMAP0)	Euclidean dist.
C4.1.	Distance from road	Roadway	General Command of Turkey	Euclidean dist.
C4.2.	Proximity to cultural sites	Cultural sites	Republic of Turkey Ministry of Culture and Tourism	Euclidean dist.
C4.3.	Proximity to water resources	Rivers, lakes	International Vector Data (VMAP0)	Euclidean dist.
C4.4.	Proximity to lithology	Lithological areas	Republic of Turkey Ministry of Culture and Tourism	Euclidean dist.
C4.5.	Distance from population centers	Cities	General Command of Turkey, Turkish Statistical Institute	Euclidean dist.

Table III.
Spatial data and analysis list

are combined to select the alternative locations for ecotourism using the spatial analysis software, ArcGIS 10.2.

The next step was to calculate the weight values of GIS layers due to the different importance of each criterion. The calculation of the weight values was realized by the application of AHP including experts' judgments. Alternative locations for ecotourism are obtained multiplying the weights obtained by AHP and normalized spatial values obtained by GIS. To apply AHP, a software called as *Super decision* is used. Geometric means of these values are found to obtain the pairwise compassion matrix on which there is a consensus.

Finally, determined alternative locations are ranked using PROMETHEE method in the last step. Before using the PROMETHEE method to rank the alternative locations, for each criterion, a specific preference function with its thresholds is defined. Preference functions and threshold values have been defined by the experts. The preference functions and threshold values defined by the experts in this paper are special for this application, every researcher reading this paper must define his/her own values in his/her ES selection process.

5. Case study

This section presents the results of implementing the proposed system on a city-wide area for ES selection. It includes four sequential phases which are also mentioned in the previous section:

(1) study area;

(2) the data set and layers of GIS;

(3) determination of the priorities; and

(4) determination of the final rank.

In the first phase, study area with nine cities is introduced. In the second phase, spatial data and analysis list of 14 criteria are presented. In the third phase, results of AHP which show priorities of criteria are explained and finally ranking of alternative locations for ecotourism are actualized using PROMETHEE in the last phase.

5.1 Study area

The planning of tourism development should be done for different regions with specific themes. More clearly, the term "tourism development" can be different for each tourism region because every region has a different natural value. As we take ecotourism into account in this paper, we focus on the study area that suits best for ecotourism. It is stated in Turkish Tourism Strategy document that the "GAP Ecotourism Corridor," which combines provinces in the Black Sea region and the GAP corridor, is defined as a region where eco-tourism will be developed primarily in terms of their eco-tourism potential (Ministry of Culture and Tourism, 2007).

Black Sea region is very famous for its plateau tourism centers, caves, bird watching zones, mountaineering areas and river tourism (Ministry of Culture and Tourism, 2007). Although the region is very well-known for its suitability, no scientific approach is applied for determining ES selection in the region. Thus, we propose a GIS-based MCDA approach for this purpose. We focus on nine Eastern Black Sea region cities because the Western Black Sea region cities mainly deal with coalminers (Figure 3). Also, it is known that the coalminers affect the nature and water resources negatively (Tiwary, 2001).

5.2 The data set and layers of GIS

The geographic values of each criterion are obtained using ESRI ArcGIS 10.2 software as mentioned before. To ensure measurement integrity, the geographic data of each criterion are normalized (Çetinkaya *et al.*, 2016). While 1 is represented in the figure by a completely white color, a completely black color represents 0. Thus, the desired areas are illustrated in white. Figure 4 shows map layers of each criterion with normalized values. Data for each criterion is available for upon request.

After the normalization, the layers are combined and the alternative locations for ecotourism are obtained. It is assumed that the weights of each criterion are equal while GIS is determining the alternative locations (Özceylan *et al.*, 2016). Figure 5 shows both colored

Figure 3.
Study area

and normalized suitability maps for ecotourism after combination process. Suitability maps in Figure 5 indicate that the west part of Sinop and east part of Artvin have the highest rates for an ecotourism settlement. On the contrary, middle of Trabzon and Rize has the lowest rates which mean unsuitable locations.

5.3 Determination of the priorities

In the problem, there are four main criteria and fourteen sub-criteria which are determined by experts' opinions depending literature review. After determination of criteria, the weights of criteria to be used in the evaluation process are assigned by using the AHP method as mentioned before. In this phase, the experts are given the task of forming an individual pairwise comparison matrix by using the scale given in Table IV. The existing 1-9 scale in the AHP was first introduced by Saaty – the originator of the AHP decision-making theory in 1970's (Saaty, 1980). *Super decision* software is used to create the hierarchic structure of the evaluation criteria (Figure 6). It is noted that the inconsistency ratio (0.05), which means the user makes the evaluations consistently, is smaller than 0.1.

Criteria under the goal are paired, and the following question is presented to the decision-making team:

Q1. Which is considered more important by the experts selecting the ES, and how much more important is it with respect to satisfaction with the ES?

The experts select one criterion and then determine its degree of importance according to the scale in Table IV. The same process is applied for each of the other criteria. Final weights obtained by AHP are shown in Table V. According to Table V, the most important factor is "vegetation diversity" from the biological dimension. With an overall priority value of 0.1877, this aspect should be considered the most important of the criteria. Other considerable factors are ranked as follows: "slope" (0.1153), "proximity to lithology" (0.0874) and "wildlife" (0.0839). The lowest priority values belong to "temperature" (0.0250) followed by "earthquake risk" (0.0341) and "aspect" (0.0409). In the frame of dimensions, while "land use" has the highest importance rate, lowest rate belongs to "climate" dimension.

By multiplying the criteria weights in Table VI with criteria scores, a final suitability map is achieved. In other words, criteria values are weighted in the final map which is shown in Figure 7.

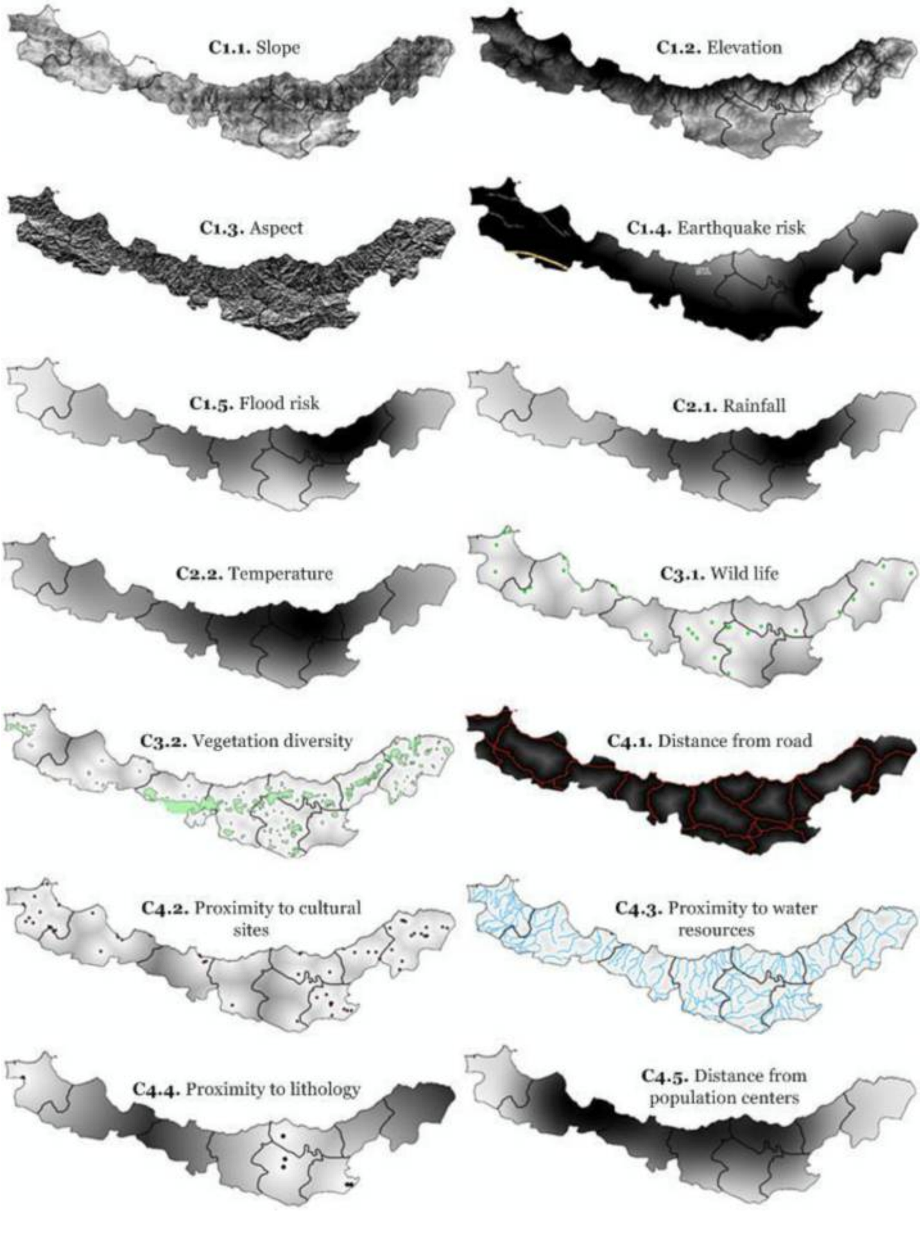


Figure 4.
Map layer of each criterion

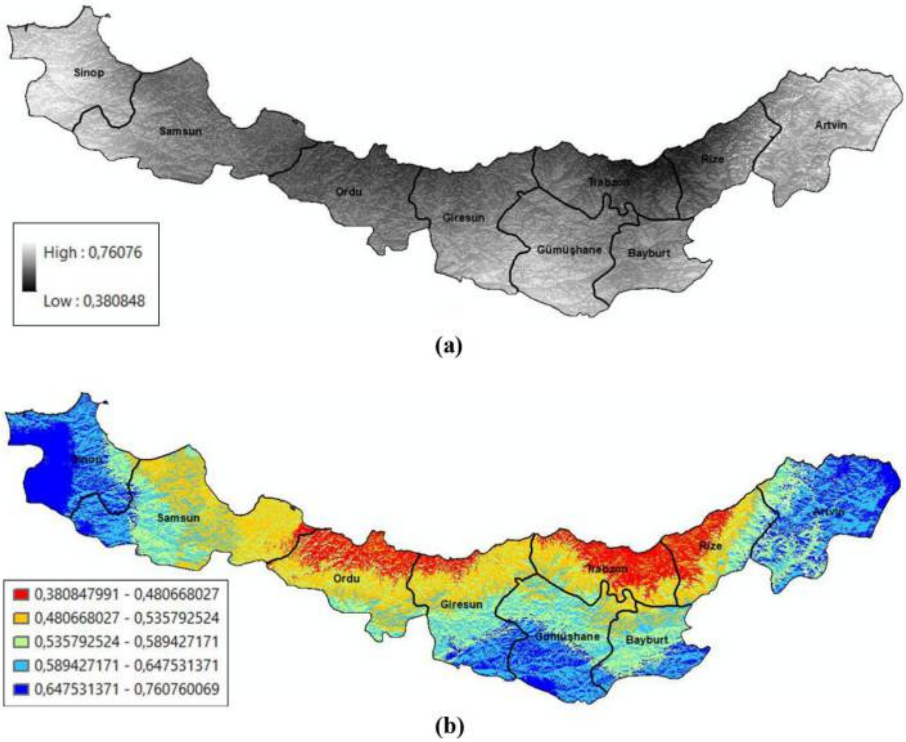


Figure 5. Clustered (a) and normalized (b) suitability maps for ESs

Table IV. 1-9 scale used for criteria comparisons

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one over another
5	Strong importance	Experience and judgment strongly favor one over another
7	Very strong importance	Activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent a compromise between the priorities listed above

Source: Saaty (1980)

Suitability map in Figure 7 indicates that the most of the part of Sinop, Gümüşhane and Artvin have the highest rates for an ecotourism settlement. On the contrary, the coastline of Black Sea region is not suitable to carry out an ecotourism activity.

After obtaining the final weighted map, alternative locations are chosen in the next step. To do so, three locations which have the highest scores in each city are determined. The

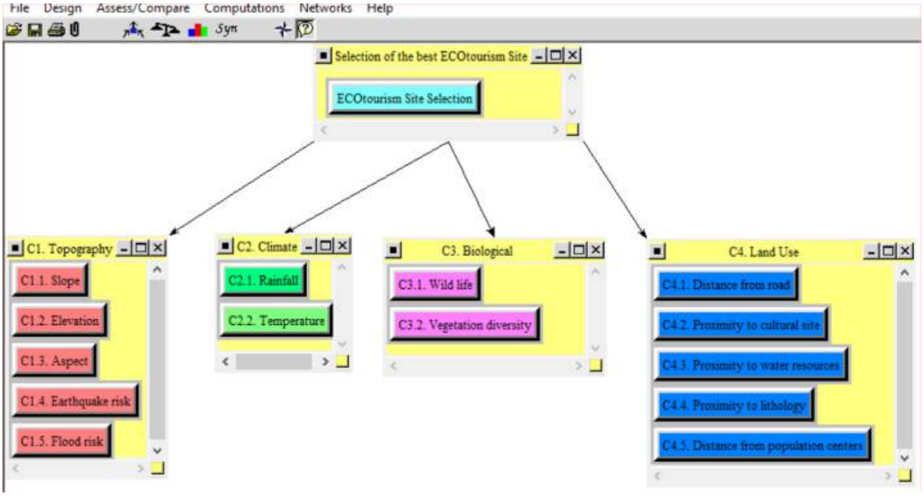


Figure 6. Hierarchic structure of the criteria evaluation for ES selection

Table V. Weights of criteria obtained by AHP

Main and sub-criteria	Weights
C1. Topography dimension	0.2908
C1.1. Slope	0.1153
C1.2. Elevation	0.0479
C1.3. Aspect	0.0409
C1.4. Earthquake risk	0.0341
C1.5. Flood risk	0.0527
C2. Climate dimension	0.0862
C2.1. Rainfall	0.0612
C2.2. Temperature	0.0250
C3. Biological dimension	0.2717
C3.1. Wildlife	0.0839
C3.2. Vegetation diversity	0.1877
C4. Land use dimension	0.3513
C4.1. Distance from road	0.0594
C4.2. Proximity to cultural sites	0.0640
C4.3. Proximity to water resources	0.0681
C4.4. Proximity to lithology	0.0874
C4.5. Distance from population centers	0.0724

main reason for this selection is to cover all region rather than focusing on a city. Obtained 27 (3 × 9 cities) alternative locations are shown in Figure 8. According to Figure 8, it is clear that potential ecotourism locations are clustered on the interior side of the area. As expected, they are located in the white area in Figure 7. Calculated scores (multiplying weights and criteria values) and other information about selected alternatives are given in Table VI. The next question is which potential ES location is the best.

Table VI. Multiplied criteria values and other information of each alternative

		Topography					Climate		Biological		Land Use						
No.	Score	C1.1.	C1.2.	C1.3.	C1.4.	C1.5.	C2.1.	C2.2.	C3.1.	C3.2.	C4.1.	C4.2.	C4.3.	C4.4.	C4.5.	City	Area (km^2)
A1	0.837	0.986	0.356	1.000	0.047	0.937	0.854	0.725	0.761	0.994	0.120	0.978	0.977	0.984	0.892	Sinop	0.01
A2	0.836	0.969	0.282	1.000	0.044	0.930	0.837	0.694	0.859	1.000	0.139	0.948	0.982	0.966	0.880	Sinop	0.02
A3	0.839	0.991	0.261	1.000	0.022	0.925	0.825	0.670	0.945	0.998	0.117	0.973	0.980	0.938	0.871	Sinop	0.01
A4	0.804	0.968	0.431	1.000	0.022	0.939	0.920	0.851	0.675	0.993	0.111	0.855	0.985	0.718	0.843	Samsun	0.03
A5	0.802	0.975	0.378	1.000	0.014	0.939	0.923	0.856	0.678	1.000	0.124	0.848	0.975	0.711	0.841	Samsun	0.01
A6	0.801	0.993	0.344	1.000	0.031	0.924	0.906	0.824	0.732	0.976	0.124	0.876	0.991	0.717	0.800	Samsun	0.01
A7	0.719	0.976	0.427	1.000	0.094	0.646	0.623	0.554	0.884	1.000	0.108	0.698	0.995	0.390	0.464	Ordu	0.01
A8	0.719	0.978	0.459	1.000	0.100	0.634	0.605	0.536	0.901	1.000	0.084	0.712	0.985	0.403	0.452	Ordu	0.03
A9	0.719	0.991	0.443	1.000	0.101	0.630	0.599	0.530	0.901	1.000	0.076	0.716	0.986	0.409	0.450	Ordu	0.02
A10	0.797	0.991	0.600	1.000	0.092	0.813	0.700	0.604	0.847	0.991	0.102	0.858	0.987	0.762	0.697	Giresun	0.01
A11	0.797	0.990	0.595	1.000	0.094	0.813	0.699	0.601	0.854	0.987	0.101	0.855	0.992	0.765	0.696	Giresun	0.02
A12	0.799	0.974	0.574	1.000	0.048	0.918	0.809	0.709	0.906	0.911	0.104	0.713	0.965	0.790	0.833	Giresun	0.34
A13	0.821	0.968	0.601	1.000	0.045	0.933	0.816	0.701	0.905	0.998	0.129	0.755	0.944	0.805	0.839	Gümüşhane	0.36
A14	0.821	0.993	0.627	1.000	0.038	0.939	0.826	0.714	0.881	0.986	0.118	0.759	0.929	0.800	0.850	Gümüşhane	0.02
A15	0.822	0.999	0.653	1.000	0.036	0.941	0.827	0.714	0.867	0.988	0.112	0.766	0.922	0.800	0.852	Gümüşhane	0.02
A16	0.731	0.976	0.621	1.000	0.352	0.387	0.220	0.044	0.957	0.996	0.086	0.982	0.948	0.909	0.202	Trabzon	0.05
A17	0.732	0.986	0.659	1.000	0.339	0.404	0.234	0.054	0.927	0.979	0.108	0.967	0.945	0.913	0.218	Trabzon	0.05
A18	0.731	0.979	0.716	1.000	0.328	0.421	0.247	0.064	0.899	0.963	0.122	0.954	0.943	0.917	0.233	Trabzon	0.02
A19	0.772	0.972	0.531	1.000	0.040	0.916	0.740	0.572	0.355	0.994	0.092	0.964	0.992	0.807	0.767	Bayburt	0.01
A20	0.776	0.983	0.546	1.000	0.031	0.925	0.752	0.588	0.355	0.995	0.086	0.965	0.990	0.801	0.781	Bayburt	0.02
A21	0.775	0.985	0.545	1.000	0.033	0.924	0.750	0.586	0.353	0.994	0.088	0.964	0.992	0.801	0.779	Bayburt	0.01
A22	0.765	0.981	0.796	1.000	0.335	0.310	0.404	0.474	0.929	0.951	0.242	0.948	0.980	0.559	0.744	Rize	0.02
A23	0.760	0.967	0.729	1.000	0.338	0.313	0.408	0.475	0.926	0.952	0.241	0.946	0.984	0.555	0.745	Rize	0.02
A24	0.765	0.986	0.820	1.000	0.340	0.329	0.424	0.482	0.923	0.940	0.243	0.944	0.970	0.544	0.752	Rize	0.01
A25	0.798	0.970	0.708	1.000	0.403	0.736	0.784	0.667	0.960	0.990	0.147	0.917	0.924	0.312	0.875	Artvin	0.01
A26	0.799	0.985	0.694	1.000	0.407	0.748	0.795	0.677	0.951	0.980	0.153	0.911	0.940	0.300	0.879	Artvin	0.01
A27	0.800	0.977	0.659	1.000	0.332	0.823	0.856	0.768	0.948	0.995	0.061	0.950	0.964	0.216	0.914	Artvin	0.15

5.4 Determination of the final rank

In this phase, firstly alternative 27 locations are evaluated based on the sub-criteria and the evaluation matrix is formed as shown in Figure 9.

Because different preference functions, number of criteria and alternatives make calculations difficult in PROMETHEE method; an open-access software program called as

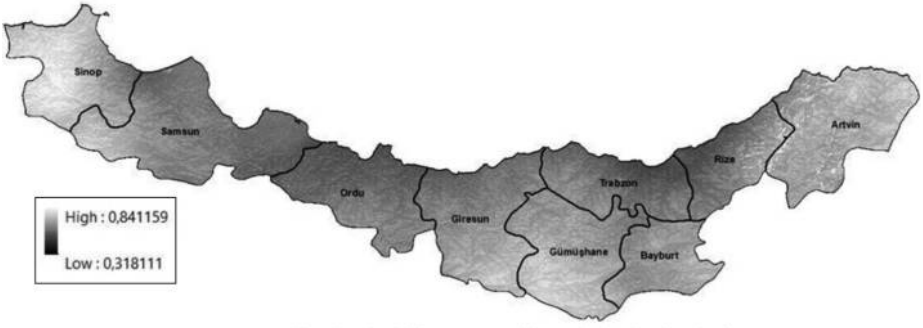


Figure 7. Normalized suitability map with weighted criteria for ESs

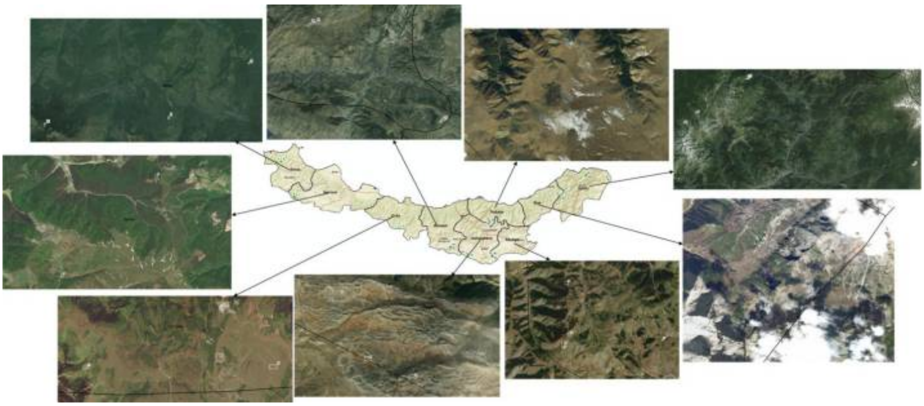
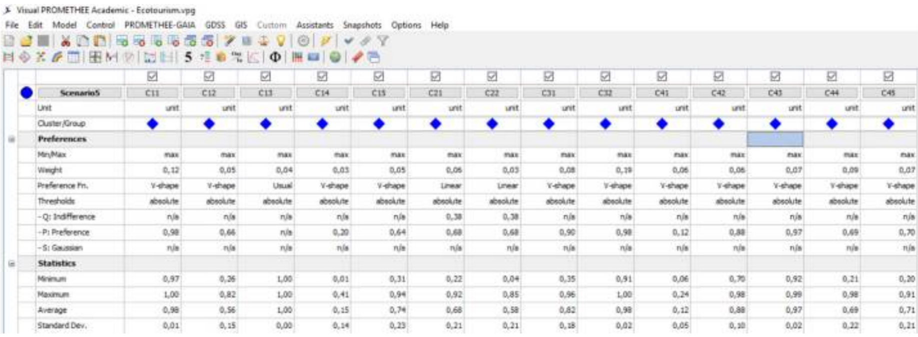


Figure 8. 27 alternative ESs in the Black Sea region



Scenario5	C11	C12	C13	C14	C15	C21	C22	C31	C32	C41	C42	C43	C44	C45
Unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit	unit
Cluster/Group	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Preferences														
Min/Max	max	max	max	max	max	max	max	max	max	max	max	max	max	max
Weight	0,12	0,05	0,04	0,03	0,05	0,06	0,03	0,08	0,19	0,06	0,06	0,07	0,09	0,07
Preference Fn.	V-shape	V-shape	Usual	V-shape	V-shape	Linear	Linear	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape	V-shape
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
- Q: Indifference	n/a	n/a	n/a	n/a	n/a	0,38	0,38	n/a	n/a	n/a	n/a	n/a	n/a	n/a
- P: Preference	0,98	0,66	n/a	0,20	0,64	0,68	0,68	0,90	0,98	0,12	0,88	0,97	0,69	0,70
- S: Gaussian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Statistics														
Minimum	0,97	0,26	1,00	0,01	0,31	0,22	0,04	0,35	0,91	0,06	0,70	0,92	0,21	0,20
Maximum	1,00	0,82	1,00	0,41	0,94	0,92	0,85	0,96	1,00	0,24	0,98	0,99	0,98	0,91
Average	0,98	0,56	1,00	0,15	0,74	0,68	0,58	0,82	0,98	0,12	0,88	0,97	0,69	0,71
Standard Dev.	0,01	0,15	0,00	0,14	0,23	0,21	0,21	0,18	0,02	0,05	0,10	0,02	0,22	0,21

Figure 9. Evaluation values for alternatives

Visual PROMETHEE Academic is used in this study. Partial ranking of alternatives is found as shown in Figure 10. PROMETHEE-I uses positive and negative flow values to find the partial ranking. At this partial ranking, it sometimes cannot be determined as the worst or best alternative and the final ranking. It is possible to find alternatives which cannot be compared to A2 and A24.

In this situation, the positive flow (*Phi*+), negative flow (*Phi*−) and net flow (*Phi*) values given in Table VII are used in PROMETHEE-II complete ranking to identify the best alternative. According to *Phi* values, while best three locations are A2, A1 and A3, worst three locations are determined as A7, A8 and A9, respectively. Obtained best, worst and mean locations are illustrated in Figure 11.

The decision problem can be also represented in the GAIA (Geometrical Analysis for Interactive Aid) plane where alternative locations are represented by points and criteria by vectors. In this way, conflicting criteria may appear clearly. Criteria vectors expressing similar preferences on the data are oriented in the same direction, while conflicting criteria are pointing in opposite directions. The length of each vector is a measure of its power in alternative ecotourism location differentiation. This plane is the result of principal component analysis (PCA), projecting the 14-dimensional space of criteria onto a two-dimensional plane, i.e. the 14 original variables are transformed to the two new variables that are obtained by two linear combinations of the original variables. In the PCA process, criteria are handled by the linear combinations to prevent double counting (Albadvi *et al.*, 2007). As it is shown in Figure 12, the Delta-parameter is 75.5 per cent; this means only 24.5 per cent of the total information gets lost by the projection.

It can be observed that C21, C22, and C45 have a high differentiation power and expresses independent preferences, different from those expressed by most of all other criteria. A cluster of conflicting criteria (C41 and C44 expressing opposite preferences) are clearly represented. It is also possible to appreciate clearly the suitability of the alternative ESs with respect to the different criteria. The alternative A2 is particularly good on C15 and C45 while it doesn't have good scores on C12 and C14. The alternative A9 is only good on C31.

Vector *pi* (decision axis) represents the direction of the compromise derived from the assignment; the decision-maker is invited to appreciate the alternative ESs located in that

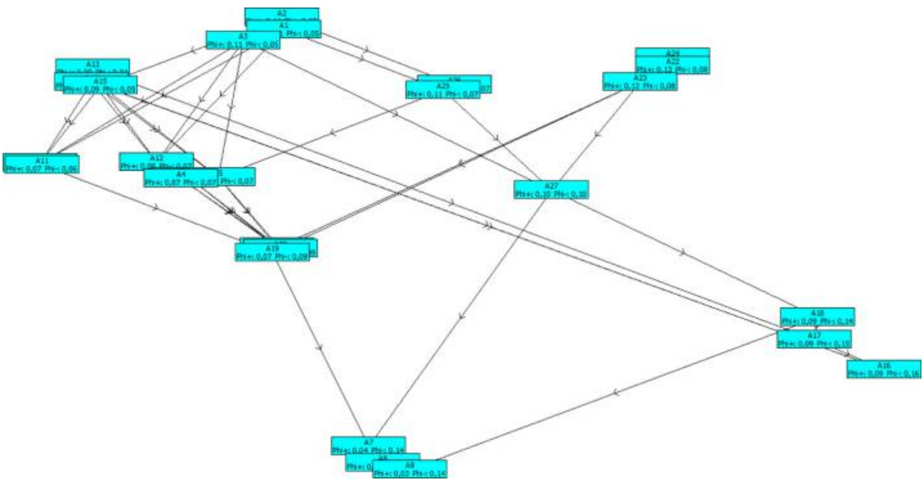


Figure 10.
PROMETHEE network of the ecotourism evaluation study

Table VII.
Ranking of alternative locations using PROMETHEE

Rank	Alternatives	*Phi*	*Phi+*	*Phi−*
1	A2	0.0655	0.1124	0.0469
2	A1	0.0606	0.1101	0.0495
3	A3	0.0567	0.1053	0.0486
4	A24	0.0500	0.1318	0.0819
5	A22	0.0470	0.1303	0.0819
6	A13	0.0460	0.0896	0.0436
7	A14	0.0406	0.0867	0.0462
8	A23	0.0406	0.1248	0.0843
9	A26	0.0397	0.115	0.0718
10	A15	0.0393	0.0868	0.0474
11	A25	0.0376	0.1097	0.0721
12	A12	0.0097	0.0759	0.0661
13	A10	0.0095	0.0676	0.0581
14	A11	0.0089	0.0675	0.0586
15	A6	0.0042	0.0753	0.0711
16	A5	0.0041	0.0773	0.0732
17	A4	0.0034	0.0744	0.0709
18	A27	−0.0010	0.0979	0.0989
19	A21	−0.0230	0.0679	0.0908
20	A20	−0.0233	0.0679	0.0913
21	A19	−0.0250	0.0665	0.0915
22	A18	−0.0497	0.0920	0.1418
23	A17	−0.0583	0.0875	0.1458
24	A16	−0.0698	0.0866	0.1564
25	A7	−0.0993	0.0360	0.1354
26	A8	−0.1057	0.0339	0.1396
27	A9	−0.1083	0.0344	0.1427

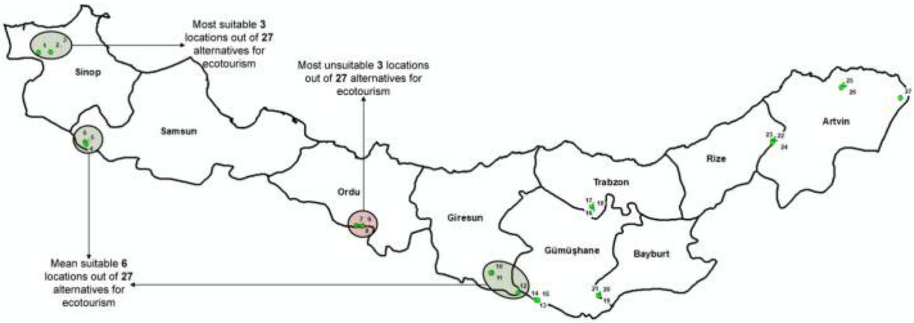


Figure 11.
Best, mean and worst alternative locations for ecotourism

direction (Wang and Yang, 2007). It can be seen from Figure 12 that *pi* vector is in the direction of criterion C15, C21, C22 and C45 and the closest alternatives to the *pi* vector are A2, A1, A3 and A12. This result is consistent with the ranking of PROMETHEE method.

5.5 Sensitivity analysis

In this section, we present the results of two different scenario analyses. The former performs sensitivity analysis to reveal the effect of changing the priority weights of criteria

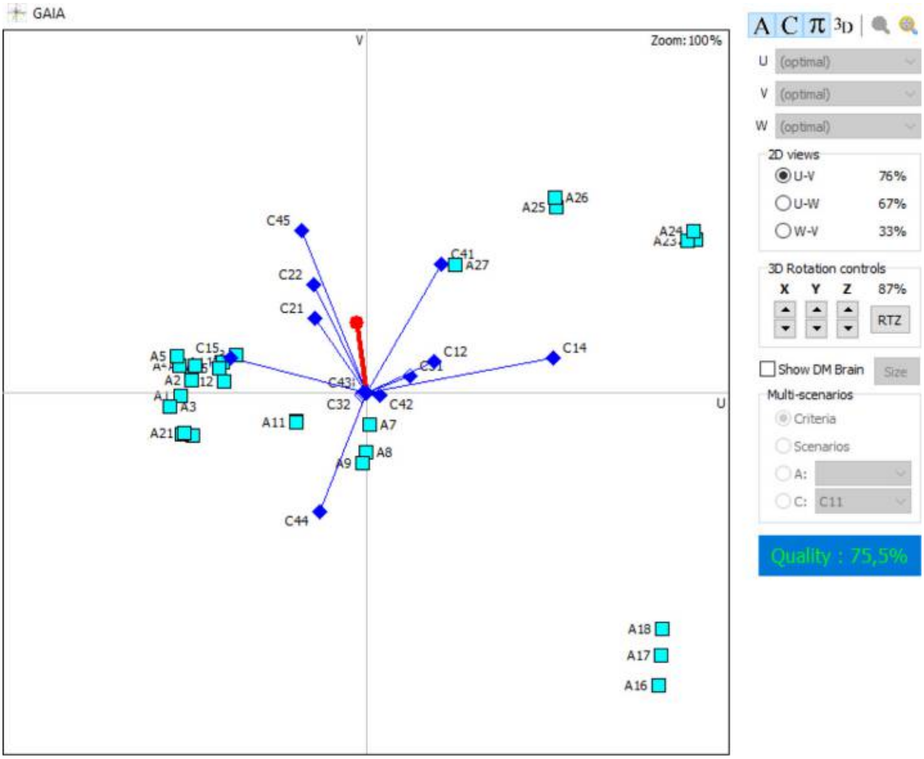


Figure 12.
GAIA plane for ES selection

on camp suitability zones. In the latter, a robustness analysis is conducted where the intervals of the weights of the fundamental alternatives are computed.

5.5.1 Effects of criteria weights on suitable ecotourism zones. In this sensitivity analysis, a common approach is to change input factors (weights of criteria) to see what effect this produces on the output. For this reason, sensitivity analysis was done where weight values of GIS layers (criteria) were changed to evaluate the differences in the ES suitability map. To assess the sensitivity, the weight of the most significant criteria, C3.2, is increased and decreased by 20, 40 and 60 per cent of the current value, giving six new weight values for C3.2. New weights of other criteria after changing the weight of criteria C3.2 are shown in Figure 13. As it can be seen from Figure 13, increasing the weight of C3.2 decreases the weights of all remained criteria.

Using the new weight values in Figure 13, six new runs are conducted. Each run generates a single new ES suitability map. Vegetation diversity criterion was selected because it has the highest weight among other criteria. The main aim of this analysis is to investigate the suitability zones for an ES under changes of criteria weights. To do so, the suitability map of the study area was subdivided into the following six categories:

(1) very unsuitable;

(2) unsuitable;

(3) slightly unsuitable;

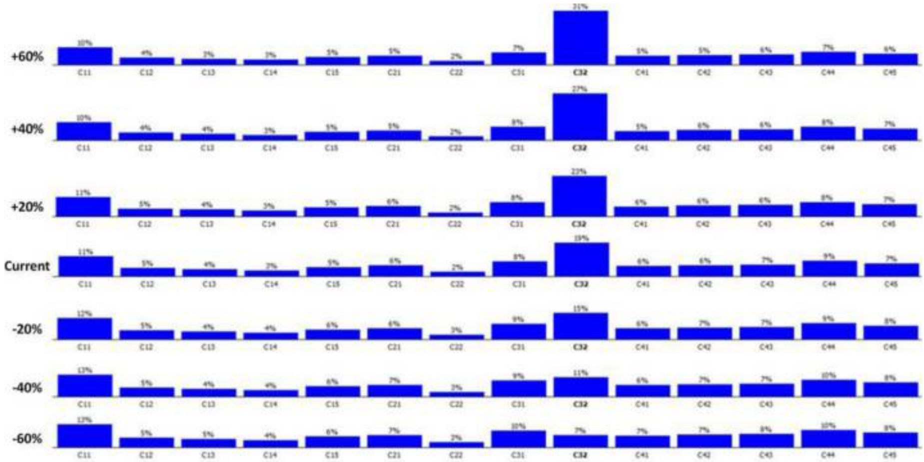


Figure 13. Effects of C3.2.'s weight on other criteria' weights

(4) slightly suitable;
(5) suitable; and
(6) very suitable.

The boundaries of the categories in the model were determined by Jenks optimization (natural breaks) for the base run (Jenks, 1967). Then, the categories in sensitivity analysis were created by manual interval as the same with a base run to make a fair comparison. The number of cells calculated in each category is shown in Figure 14.

According to Figure 14, increasing the weight of vegetation diversity (C3.2) and decreasing the weights of all remained criteria increase the suitability area for ecotourism. There are, in total, 15,990,169 cells (pixels) in the evaluation map. While the very suitable area is only 5.34 per cent of the overall map in case of 60 per cent decrement, this rate is

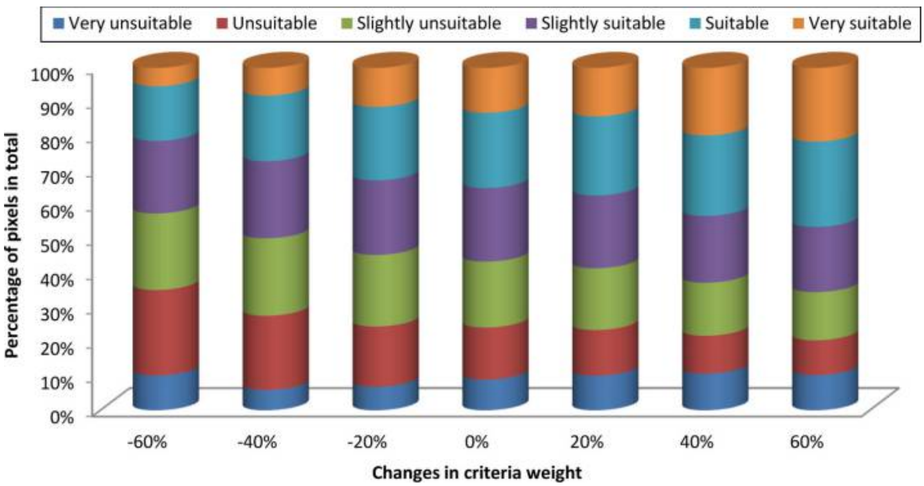


Figure 14. Number of cells (pixels) in each category

increased to 21.51 per cent in the case of 60 per cent increment in weight of vegetation diversity criterion. On the contrary, the unsuitable area which covers 24.97 per cent of the overall map in case of 60 per cent reduction is decreased to 10.19 per cent of the overall map in case of 60 per cent increment.

ES suitability maps of each sensitivity analysis regarding six categories are shown in Figure 15. It can be clearly seen that blue colored area (very suitable cells) is continuously increasing from −60 to +60 per cent changes. Figure 15 indicates that west of Sinop, east of Artvin and south part of the Black Sea region are still best locations for ecotourism.

5.5.2 Effects of weight intervals on ranking. Criteria weights are calculated based on human judgments; therefore changes in these weights may alter preference rankings. Therefore to improve the confidence in the results and to measure the model's sensitivity to weight changes, the intervals of the weights can be calculated. At these intervals, the first rank of the complete preorder among alternatives does not change. The weight stability intervals of the ES selection attributes are shown in Table VIII.

According to this analysis, for instance, modifying the weight of the slope criterion (C1.1.) in the interval [0.1143, 0.1257] will not affect the positions of alternative ESs presented in Table VII. Similarly, weight variations between 0.0248 and 0.0360 for temperature (C2.2.) will not change the ranking. On the other hand, once one or more of the criteria would have weights surpassing the upper or lower bounds of the stability intervals, the ranking would imminently change. Aspect (C1.3.) criterion has stability intervals of [0, 1]. This consequence signifies that the final ES ranking is robust to weight changes for this criterion. Another indicator from Table VIII is that elevation (C1.2.) criterion has the narrowest interval value among others. It means that changing the weight of this criterion with a number greater

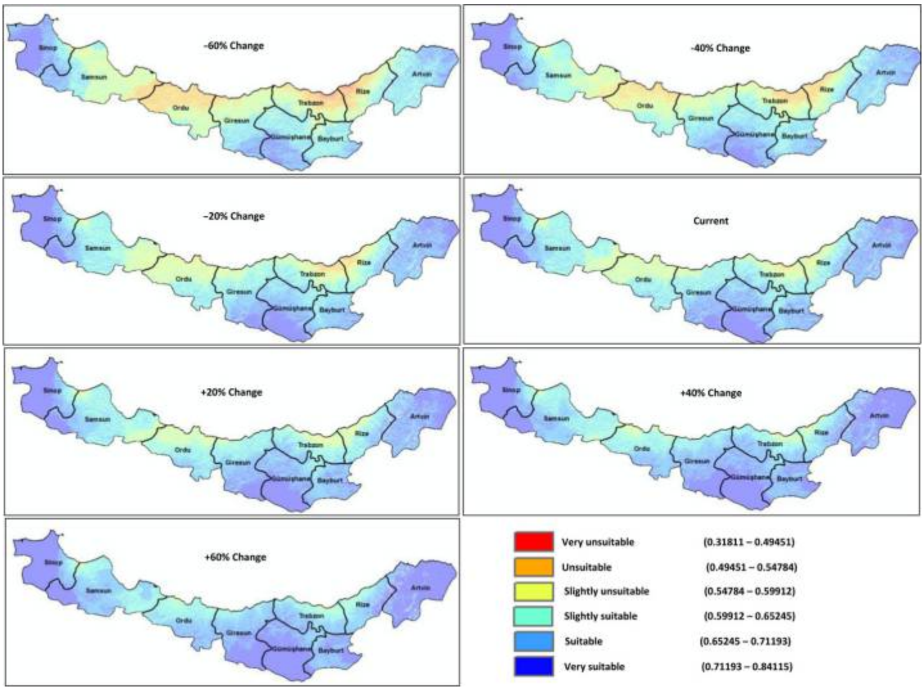


Figure 15.
ES suitability map according to different weight combinations

Table VIII.
Weight stability intervals of the ES attributes

Criterion	Weight	Lower stability bound	Upper stability bound	Interval value
C1.1.	0.1153	0.1143	0.1257	0.0114
C1.2.	0.0480	0.0480	0.0481	0.0001
C1.3.	0.0408	0.0000	1.0000	1.0000
C1.4.	0.0340	0.0337	0.0340	0.0003
C1.5.	0.0530	0.0530	0.0540	0.0010
C2.1.	0.0612	0.0609	0.0659	0.0050
C2.2.	0.0250	0.0248	0.0360	0.0112
C3.1.	0.0839	0.0823	0.0844	0.0021
C3.2.	0.1877	0.1875	0.1902	0.0027
C4.1.	0.0590	0.0581	0.0590	0.0009
C4.2.	0.0640	0.0622	0.0641	0.0019
C4.3.	0.0680	0.0611	0.0683	0.0072
C4.4.	0.0873	0.0869	0.0874	0.0005
C4.5.	0.0730	0.0729	0.0748	0.0019

than 0.0001 will change the rank. Similar to elevation criterion, the criteria of earthquake risk (C1.4.) and proximity to lithology (C4.4.) are also very sensitive (see the interval values) on ranking.

6. Conclusion

Ecotourism is now the world's fastest growing segment in terms of tourism. People want to experience the world but they should try to do it in a way that doesn't affect the natural environment negatively. Thus, many conservative programs are being followed by countries that especially beneficiary of tourism.

As we speak for Turkey, The Ministry of Culture and Tourism determined the Black Sea region to be developed primarily about biodiversity and ecotourism for 2023 tourism targets. In this regard, this paper aims to determine the most suitable ESs in Black Sea region of Turkey. Thus, a scientific four-step solution approach is developed for determining the ESs.

First, 14 indicators are determined for site selection, later these indicators are entered into GIS. Then criteria are prioritized by AHP and lastly, potential sites are ranked by using PROMETHEE. When we look at the site selection indicators it is seen that the factor having the highest priority is "vegetation diversity" and the lowest priority belongs to "temperature". This means the tourists can visit the ecotourism sites regardless of the weather temperature but they are very keen on vegetation diversity meaning that they desire to see very different kinds of vegetation. In the frame of dimensions, while "land use" has the highest importance rate, lowest rate belongs to "climate" dimension. One limitation of the study can be that; these importance rates are determined by local tourism experts and they are determined especially for this area. But any research can be done with the same technique but using close outlines. As a result of the study, west of Sinop, east of Artvin are determined as very suitable locations for ecotourism among 27 alternatives. On the contrary, the middle of Trabzon and Rize are determined as unsuitable locations. Both Sinop and Artvin are small cities that have waterfalls, natural parks, wildlife ecology and rural tourism sites etc. Although these areas have more than enough resources for ecotourism, they made no headway because of ineffective publicity or less of investment. Another important issue is the economic or ecological bearing capacity for tourism sites. If these determined areas are guided regarding their ecotourism incomes, it can make way for overcapacity which results in harming the environment-the origin of ecotourism. Thus, monitoring tourist behaviors, marketing strategies and destination management seem as suitable focus areas for city planners.

The results of this paper can be very useful for ecotourism planning because the governments invest too much on tourism although they have scarce resources. Further research can be done as determining the optimum locations for different types of tourism as "Religion tourism, hunting tourism, golf tourism etc." for effective tourism planning. Another extension can be studying the destination management in determined ESs. Finally, different MCDA techniques can be applied under uncertainty to cope with the vagueness of comparison matrixes.

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