# A GIS-Based Multi-Criteria Evaluation to Ecotourism Suitability Site Selection in Arasbaran Protected Area, Iran

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**Abstract:** Today, ecotourism is a major tourist activity around the world. Arasbaran protected area as a mountainous area in northwest of Iran has high potential for attracting eco-tourists due to its natural pristine nature and biodiversity. This study developed a spatial method for evaluation of ecotourism potential using geographic information systems (GIS). First, the effective criteria were chosen according to the previous studies. Standardization of the criteria was conducted using suitable fuzzy functions and the weights of the criteria were derived through the analytical hierarchy process (AHP). In the next step, criteria were combined using Weighted Linear Combination (WLC) method to reveal the suitability of ecotourism. Eventually, for land zoning according to ecotourism value, the module of Zonal Land Suitability (ZLS) was applied and around 37 zones were introduced for ecotourism at the study area. The result of this study showed that the most suitable ecotourism area of Arasbaran protected area is 6.45 percent (5200.62 ha) with attention to pixel with suitability more than 200. Overall, the results revealed that MCE method is capable of evaluation of Arasbaran protected area for ecotourism. Also, the geographical information system was found a useful tool, allowing combination of many criteria and Boolean layers.

**Keywords:** Ecotourism, Weighted Linear Combination Method, land planning, Multi Criteria Evaluation, ZLS

## 1. INTRODUCTION

Today, tourism as one of the most dynamic economic activities, plays an important role in the sustainable local development. It is a process that has long been associated with particular forms in order to provide psychological, cultural, social and economical needs of human communities (Salmanmahini et al., 2008; Yan et al. 2017). Ecotourism is one of the new branches of tourism that is the responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education to staff and guest (TIES, 2015). Ecotourism focuses on the resources and attractions that visitors and tourists provide through the natural environment (Nino et al. 2017; Liu 2016; Suryabhagavan et al., 2015). Today, ecotourism is a major tourist activity around the world. Ecotourism development, such as other developments has positive impacts and negative impacts on host communities (Salmanmahini et al., 2008).

Therefore, appropriate management for ecotourism development is essential inorder to maximize positive impacts and minimize negative impacts on all aspects of tourism (Courvisanos& Jaina, 2006). Unfortunately, due to inadequate environmental assessments and audits, many ecotourism destinations tend to be both hazardous and self-destructive (Tsaur& Lin, 2006). From the past few decades upwards, in lots of countries, the planning of the land based on land use planning and ecological land capability evaluation is considered as the most important tool and factor of sustainable development (Kheikhah Zarkesh et al., 2011).

Ecotourism evaluation and site selection should be regarded as an important tool for the sustainable development of tourism in protected areas. The goal of zoning and site selection exercises is to find the optimum location that satisfies a number of predefined criteria (Masoodi etal., 2016). The process of site selection typically involves two main phases: screening (identifying a limited number of candidate sites from a broad geographical area given a range of selection factors) and evaluation (Vahidnia and et al., 2009; masoodi et al., 2016).

There are a variety of analytical methods for evaluating land based its capabilies. Traditional methods of GIS site

selection and evaluation are based on the transformation of effective layers into classified maps, for example, through use of a Boolean model equal value to all suitable areas regardless (Louviere et al., 2000).

Boolean model, however, has defects such as givingof their position in reference to their factors (Hajehforooshnia et al., 2011). There are a few studies on ecotourism evaluation in Iran, that the most of them, have used Boolean logic using either the Mac-Harg or Makhdoum method (Makhdoum, 2013).

Recent developments in the Geographical Information System (GIS) have led to significant improvements in our capability for decision-making processes in land allocation and environmental management using Multi Criteria Evaluation (MCE) (Bhaya& Chakrabarty.,2016; KianiSadr et al., 2019; Asmamaw& Gidey., 2018).

The Geographical Information System (GIS)-based multi-criteria decision-making approach enables decision-makers to evaluate the relative priorities of decision-making criteria based on a set of preferences and indicators that do not have necessarily the same nature (Ahmadi et al., 2015; Mahdavi et al., 2014; Kianysalmi et al., 2016). multi criteria MCE) used to rank and achieve the priorities for the alternatives of a decision.

MCE is most commonly achieved by one of two procedures: The first involves Boolean overlay whereby all criteria are reduced to logical statements of suitability and then combined by means of one or more logical operators such as intersection (AND) and union (OR). The second is known as weighted linear combination (WLC) wherein continuous criteria (factors) are standardized to a common numeric range, and then combined by means of a weighted average (Eastman, 2012).

This paper describes a geographic information system (GIS)-based multi-criteria decision making approach for zoning ecoutourism potential of Arasbaran protected area in Iran and selecting the best zones by applying Zonal Land Suitability (ZLS) approach. This work assessed potential suitable areas for ecotourism based on physical characteristics of the land. In this process, research, applied a type of multi-criteria evaluation (MCE) method called weighted linear combination (WLC) in a GIS environment to evaluate the ecotourism suitability, the presented method evaluates overall of study area using a grading scale from 0 to 255 (Byte Scale). Where 0 defines a site without any capability for ecotourism while 255 indicates the most suitable site for ecotourism.

## 2. MATERIAL AND METHODOLOGY

### 2.1. Study Area

The study was conducted in a part of the Kaleibarchay watershed, the Arasbaran protected area, also known as "Qaradagh" or "Qaraja dagh" is a large mountainous area stretching from the Qusha Dagh, massif, south of Ahar, to the Aras River in East Azerbaijan Province of Iran.

The region is confined to Aras River in the north, Meshgin Shahr County and Moghan in the east, Sarab County in the south, and Tabriz and Marand counties in the west. This region confines to 38°40' to 39°08'N and 46°39' to 47°02'E38°40' to 39°08'N and 46°39' to 47°02'E, and covers an area about 80600 hectares. It is about160 km away from the capital city Tabriz (Fig. 1).

Biogeographically, this area is called the Hirakano-vasini region or Arasbaranian region. It is in a highly mountainous region rising from 259 to 2896 m above sea level (highest peak Keshish-Qelbisii). The average annual rainfall in this region is 400-600 mm. Average annual temperature is variable from the lowest height (the margin of the Aras River) to high mountains and from 17° C to 5° C, respectively (Darvishi et al., 2016).

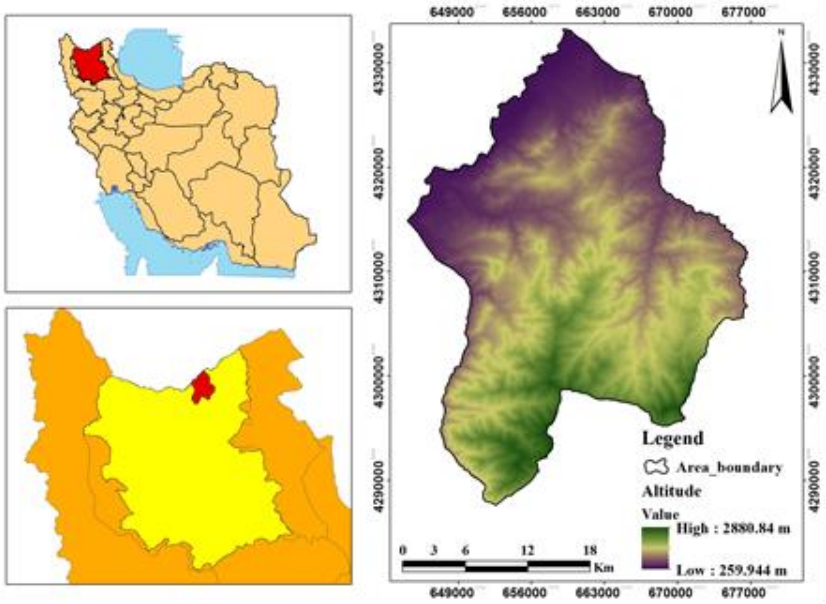


**Figure 1.** Geographical location of the study area

## 2.2. Data and Methodology

In the present study, the methodological approach to evaluate the ecotourism potential capability was divided in to seven major stages as follows:

- Identifying effective criteria on ecotourism value in the study area

- Preparing spatial and non-spatial data

- Standardizing the criteria maps

- Determining the weight value of each criterion by using AHP method

- Implementing WLC for criteria maps inorder to assign ecotourism value

- Assessing of study area using Zonal Land Suitability (ZLS) approach to ecotourism final zoning.

### *2.2.1. Identifying Effective Criteria on Ecotourism Value in the Study Area*

In this study eight criteria including, vegetation cover (Vegetation density), slope, distance from roads, distance from rivers, distance from villages, distance from natural attraction and wildlife habitats, soil erosion and geology were identified based on reviewing resources, data accessibility and expert opinions

### *2.2.2. Preparing Spatial and Non-Spatial Data*

In the present study, the data were collected from a variety of sources (Table 1). In order to prepare the vegetation cover (Vegetation density), The Normalized Difference Vegetation Index (NDVI) was drived from Landsat OLI images (acquired in July, 2018), based on this individual measurement as follows:

$$NDVI= NIR- R/ NIR+ R$$

That here NIR is Near InfraRed band or band 5 of using satellite images and R is Red band or band 4 of Landsat OLI images.

**Table 1.** List pf data and original sources (Data acquisition)

| Data | Source |
|---|---|
| Digital Elevation Model (DEM) | Department of Natural Resources and Watershed Management |
| Soil erosion, Geology map | Department of Natural Resources and Watershed Management, |
| Landsat satellite image | USGS EARTH EXPLORER website |
| Accessibility routes, Rivers, Villages | Department of Environmental Conservation |
| Natural and cultural attractions | Department of Environmental Conservation |

Slope was calculated from Digital Elevation Model of 30 m pixel with in Idrisi software and applying Surface Analysis Module. In addition, Distance Module was used to calculated distance from roads, distance from rivers, distance from villages, distance from natural attraction from related layers.

### *2.2.3. Standardizing Criteria Map*

The fuzzy majority is considered as an aggregation procedure which incorporates the opinions of the majority of decision-makers through preference. The ultimate aggregated amount characterizes the value of the majority of the most similar amounts. The similarities between pairs of preference values can be computed using a support function, Sup (a, b), which can be denoted as the support for 'a' from 'b' where:

$$\text{Sup}(a, b) \geq \text{Sup}(x, y) \text{ if } |a - b| < |x - y|, \text{ (Pasi\&Yager, 2006).}$$

Therefore, the closer argument values lead to more support from each other (Drobne& Lisec, 2009). Table 2 indicates the fuzzy function by using the criteria considered in this study.

**Table 2.** The shape of membership functions and control points of different criteria

| Criteria/factors | Shape of membership functions | Control points | |
|---|---|---|---|
| | | Starting point | End point |
| Vegetation cover | Symmetric (Linear) | a= 0 | b= 0.60 |
| distance from roads | Monotonically decreasing (Linear) | a= 0 | d= 3000 |
| distance from rivers | Monotonically decreasing (Linear) | a= 0 | d= 2500 |
| Slope | Monotonically decreasing (Linear) | a= 0 | b= 15 |
| Soil erosion | User-defined | a= 0 | d= 5 |
| distance from villages | Monotonically decreasing (Linear) | a= 0 | d= 4000 |
| Geology | User-defined | a= 0 | d= 7 |
| distance from natural attraction | Monotonically increasing (Linear) | a= 0 | d= 2000 |

*2.2.4. Determining the Weight Value of Each Criterion by Using AHP*

Weighting the defined criteria is considered as an important stage and the reliability of its consequences can guarantee the results. The weight the criteria was done by AHP method based on paired weighting. Then, the geometric mean method was used to calculate the weight of the factors and the incompatibility ratio was estimated. The probability value represents the probability of the corresponding random degrees, upon which the values of less than 0.1 are considered as good, and those are more than 0.1 are incompatible. It is worth noting that the weight the criteria should be re-established (NeisaniSamani etal, 2018).

*2.2.5. Implementing WLC to Integrate Criteria*

Weighted linear combination established by Eastman in1995 is regarded as the most common method to integrate the criteria for analyzing land suitability (SalmanMahini& Kamyab, 2010). Weighted linear combination, or simple additive weighting, is based on the concept of an average weighted in which continuous criteria are standardized to a common numeric range, and then combined by a weighted average. Regardingthe weighted linear combination, factors are combined by applying a weight to each followed by a summation of the results to yield a suitability map:

$$S=\sum (w_i\ x_i)$$

where S represents suitability, $w_i$ indicates the weight of factor i, and xi is considered as the criterion score of factor i. In those cases, where Boolean constraints are used, the procedure can be modified by multiplying the suitability calculated from the factors by the product of the constraints:

$$S=\sum (w_i\ x_i) \prod c_i$$

Where $c_j$ represents the criterion score of the constraint j. All GIS software systems provide the basic tools for evaluating such a model (Eastman, 2012).

*2.2.6. Zoning the Study Area for Ecotourism Value Using Zonal Land Suitability (ZLS) Approach*

In this research, zoning of study area based on ecotourism value was done using ZLS method. ZLS is abbreviation of Zonal Land Suitability. This method is a non-pixel, regional and polygon base approach that uses of macro properties or the same site selection at the Idrisi software and has three defaults;

- Using of Land should be based on several goals
- It selects the best pixels for the defined purpose from the pixels of maps.
- It Selects the most preferred region for each defined purpose (saeidi et al., 2014: Siroosi et al., 2019).

To execute this command, first, the macro file should be created. Macro files must have the extension. IML (for IDRISI Macro Language). This file can be created in the IDRISI Edit module. Then, the user should Choose Run Macro from the File menu. At this point, running macro mode requires the following parameters;

- Input filename (the image containing values to use in the calculation)
- The minimum suitability threshold
- The minimum area of the place
- output filename (the new image to be created) (Eastman, 2012).

According to the mentioned description, ecotourism suitability map that created using MCE method, by applying Run Macro and allocating value 200 for suitability threshold and minimum area of 20 hectares, was zoned. The zones are then ranked in descending order by the value of their zonal land suitability to facilitate the decision process.

## 3. RESULTS

In this study, at first steps, effective criteria on ecotourism were identified, mapped and standardized (fig. 2). Then, each criterion was weighted using AHP method. Weights related to criteria are presented in Table (1).

The weights indicate the relative importance of each criterion compare to their overall value in landscape. In this study, Inconsistency Ratio, calculated 0.03, since it is smaller than 0.10, then degree of consistency is acceptable.

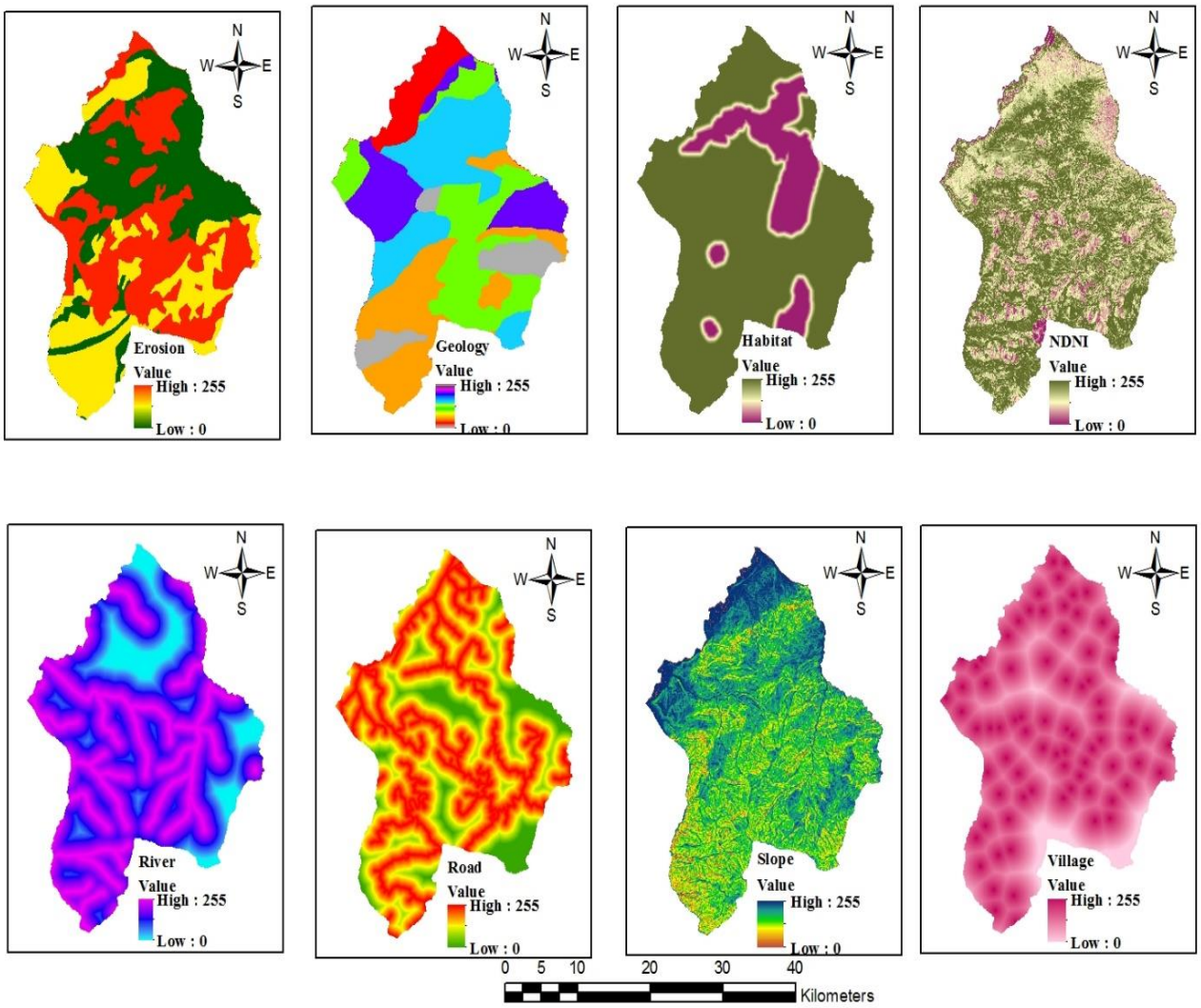


**Figure 2.** Standardized factor layers used for ecotourism suitability mapping in Arasbaran protected area, East Azerbaijan Province, Iran.

**Table 1.** The weights of criteria obtained through AHP method

| Factors | Weight |
|---|---|
| Vegetation cover | 0.2484 |
| distance from roads | 0.1727 |
| distance from rivers | 0.1359 |
| Slope | 0.1071 |
| Soil erosion | 0.0604 |
| distance from villages | 0.1727 |
| Geology | 0.0194 |
| distance from natural attraction | 0.0816 |
| Inconsistency Ratio | 0.03 |

Based on the results of the criteria weights, the effect of each criterion is determined on the final composition of the maps. The result of applying the weights and combining the maps together using the weighted linear combination method is fuzzy map (Fig. 3) which shows different degrees of suitability over the range of 0–255**.**

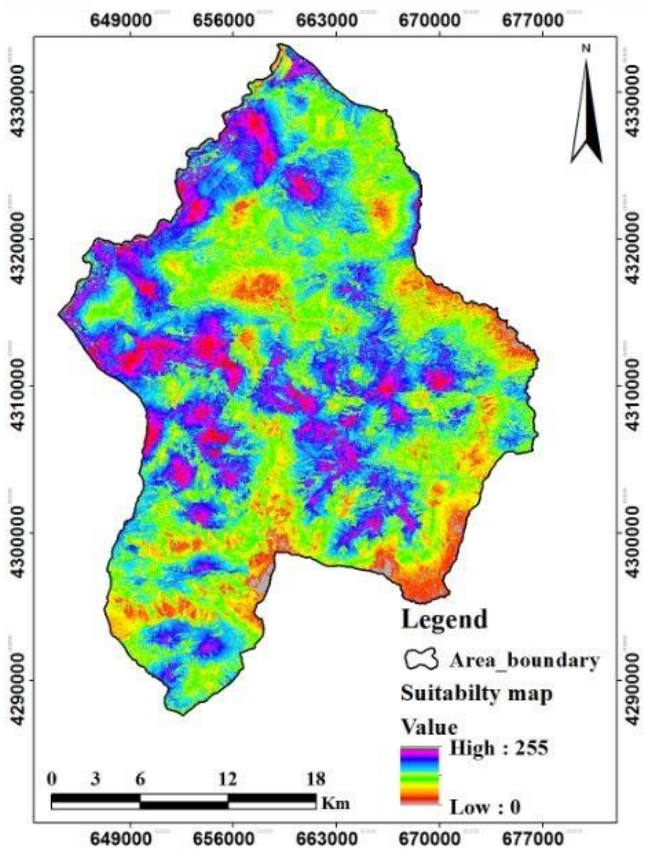


**Figure 3.** Final ecotourism suitability map

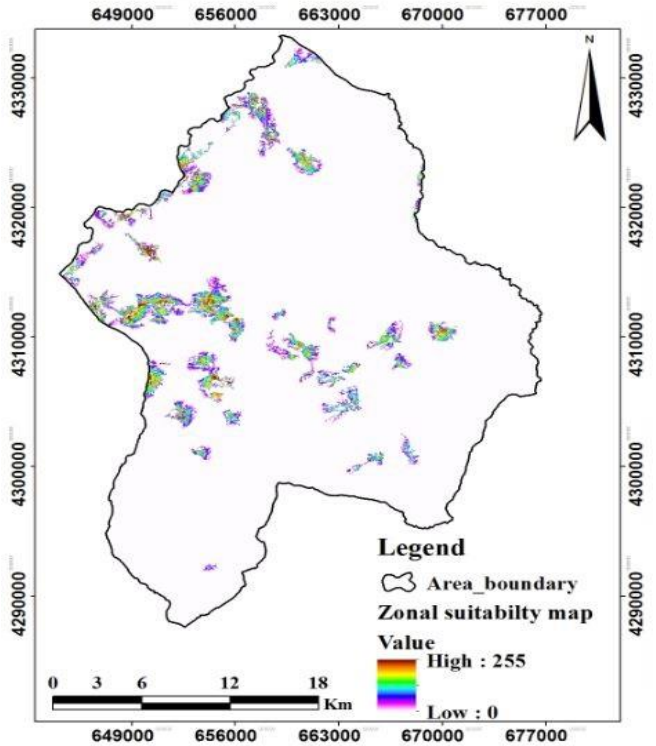


**Figure 4.** Zonal land suitability map for ecotourism

The application of the zonal land suitability on MCE map in Arasbaran protected area indicated that there are 37 zones for ecotourism that their zonal land suitability varied from 12 to 3259 (Fig. 4). Then, of these 37 zones, 13 zones were introduced as the most suitable area for the ecotourism (Fig. 5) and (Table 2).

**Table 2.** Zonal land suitability and area of 13 zones for ecotourism

| Number of zones | Minimum suitability | Maximum suitability | Area (ha) | Average land suitability |
|---|---|---|---|---|
| 96 | 201 | 251 | 1072.37 | 226 |
| 282 | 202 | 249 | 3917.46 | 225.5 |
| 888 | 201 | 217 | 34.92 | 209 |
| 1190 | 202 | 239 | 696.71 | 220.5 |
| 1213 | 208 | 232 | 925.16 | 220 |
| 1417 | 200 | 221 | 223.72 | 210.5 |
| 1549 | 207 | 234 | 300.46 | 220.5 |
| 2018 | 204 | 243 | 945.37 | 223.5 |
| 2470 | 202 | 219 | 516.13 | 210.5 |
| 2562 | 205 | 236 | 300.54 | 220.5 |
| 2833 | 204 | 220 | 256.4 | 212 |
| 2988 | 200 | 224 | 191.12 | 212 |
| 3018 | 200 | 221 | 230.53 | 210.5 |

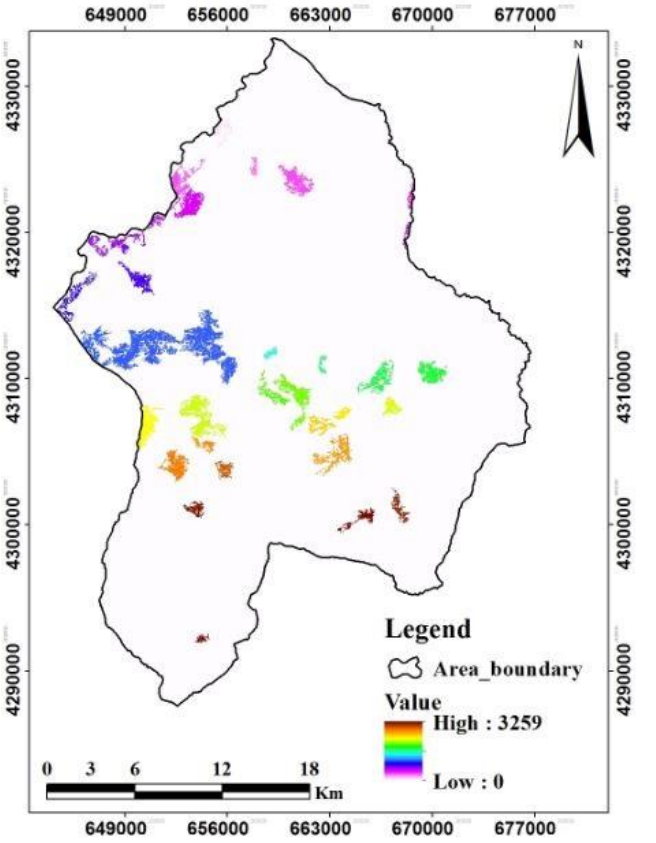


**Figure 5.** Map of the most suitable zones for ecotourism

## 4.DISCUSSION

The main purpose of this study, is to evaluate ecotourism potential in the Arasbaran protected area, Iran. Evaluation of ecotourism potential is essential when developing any region effectively. This foresight and planning will also serve to prevent wastage of financial and human resources (Masoodi et al., 2016).

The used approach in this research, integrated the evaluation abilities of MCE method and the analytical tools of GIS and showed the use of GIS as a decision support system (DSS).

At the first step, the model assessed the potential of the land for ecotourism by combining criteria, the relative importance weights of factors were estimated using the analytical hierarchy process (AHP). Initially, the land evaluation is performed on a cell by cell basis.

The Weighted linear combination (WLC) used to estimate, the suitability of each cell for ecotourism. Figure 3 illustrate the suitability map for ecotourism in the study area, which is different in the utility of the cells. More utility represented more value and lower utility indicated the lower value of the ecotourism.

Based on the weights of criteria that obtained through AHP method, Vegetation cover, distance from roads and distance from rivers were identified as the most effective criteria in transferring the values of ecotourism in the study area.

The weighted linear combination method is more flexible than the Boolean approach. It lets to criteria to be standardized consistently, and retaining important information about degree of suitability. It also lets the criteria to be differentially weighted and to trade off with each other.

While a variety of standardization technique are important to seek for any multi-criteria problem, they result in layers that indicate the suitability of location in the overall study area. The WLC method results in continuous suitability layer that makes selecting special sites for ecotourism, or any other allocation, problematic.

In the WLC approach, site suitability was clearly specified and the only problem for site selection was one of adjacency.

With a continuous result, first, there is the problem of determining what locations should be chosen from the set of all locations, each of which has some degree of suitability.

This problem was considered by adding the post-aggregation constraint that suitable sites must be at least 20 hectares in size and at least have a suitability threshold of 200. The most suitable zones cover an area around 9610.89 hectares that is 11.92 percent of the entire study area.

The model then evaluated the ecotourism suitability for each zone. This zonal suitability is acquired by calculating the average of the suitability of all cells belonging to each zone. In the final step, zones were ranked in descending order by the value of their zonal land suitability. From among the zone, planners and decision makers can choose the best in terms of availability.

## 5.CONCLUSION

This study aims to evaluate ecotourism potential of Arasbaran Protected Area, Iran. The application of Geographical information system and Multi-Criteria evaluation approach efficiently assists ecotourism management and planning. MCE is an appropriate tool for ecotourism planning, because it considers various criteria that have a significant impact on decision making. Usage MCE has prosperously identified different levels of ecotourism suitability, taking into account various factors and constraints. The results of this paper, by identification of suitable areas for ecotourism activity can help decision-makers to provide an appropriate management plan restricting ecotourism activities only in places with high potentials for ecotourism development. Applying and integrating various approaches along with different factors and using tools to quantify these factors, decrease reliance on qualitative criteria. Accordingly, it can impede, applying personal opinions in decision making and will help to attain more practical and reasonable concepts for land planning and evaluation.

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