

Identification of Potential Eco-tourism Site Suitability Using AHP and GIS, A Case of Hugumburda Forest and its Surrounding Areas, Ethiopia

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Abstract

The main objective of the study is to identify the potential ecotourism sites in Hugumburda forest reserve area, Tigray, Ethiopia by using Geographic information system (GIS) and AHP. This work was assessed the potential suitable areas for ecotourism based on land use land cover, soil, slope, elevation, scenic attractiveness, rainfall and temperature. These factors were selected according to the professional expert's opinions. First, a resource inventory and a list of ecotourism criteria were developed using the AHP method on IDRSI. At the next stage GIS techniques were used to measure the ranking of different sites according to the set criteria and thus identify those with the "best" potential. Subsequently, the ecotourism potential suitability map for ecotourism was created, based on the linear combination of the criteria and factors with their respective weights. The degree of suitability of each factor was classified as highly suitable, moderately suitable, less suitable and not suitable for ecotourism. The result showed highly suitable for ecotourism potential area accounts for 18.92% (9513.65 ha), moderately suitable accounts 17.65% (8871.82ha), less potential areas 25.54% (12841.20 ha) and 37.88% (19044.35 ha) no potential area in and around the Hugumburda forest area. In general, the study was attempted to identify the ecotourism suitability of the study area.

Keywords: Ecotourism, suitability, GIS, AHP, Factors

Introduction

In recent years, eco-tourism sector, as a subset of tourism industry, plays a great role in improving the economy of developed countries and their local people [1]. But ecotourism should be balanced in terms of a clean environment without polluting and spoiling the natural beauty and also does not harm the surrounding population. Ecotourism is a type of tourism that continues to preserve the natural and cultural resources, providing various facilities in areas with tourist attractions, either relating to attraction on the natural environment or ecology-made through the modernization of physical and social infrastructure in the region to become one of the economic activities that contribute to the national income besides to being able to improve the living standards of local communities [2]. When eco-tourism is planned well, it provides benefits for providing the sustainability of natural and cultural resources and bringing environmental, economic and social concerns together, in the contrary, it may cause as much harm as mass tourism do and it can damage the cultural structure in the touristic area due the problems that result from the interaction between the tourists and the locals [3].

Hugumburda forest has been facing many environmental problems. If these problems are not solved promptly, they will create many obstacles for the development of eco-tourism in Hugumburda and

its environment. Eco-tourism is expected to contribute in both conservation and development of environment. It has also additional appeal of promoting environmental responsibility and education by enabling local communities by creating job opportunities with enjoying the beauties of sensitive areas and provides opportunities in preservation activities. Eco-tourism is also one of the appropriate ways to achieve sustainable development.

A Strategic planning to develop ecotourism area is not measured in terms of the landscape only, but many factors should be considered such as topography, climate area, soil type and many more. This planning can be overcome by using a method in which the existence of AHP technique with the help of GIS.

With the help of GIS, ecotourism site suitability analysis was made on the study area. On the other hand, the integration of MCDM techniques with GIS has substantially advanced the conventional map overlay methods to the ecotourism site suitability analysis. GIS-based MCDM can be thought of as a process that merges and transforms spatial and a spatial data (input) into a resultant decision (output) [4]. Therefore, the present study is intended to identify site suitability for eco-tourism in case of Hugumburda natural forest.

Materials and Methods

Study site

Hugumburda natural forest is located in Tigray regional state of Ethiopia between 12°36' - 12°40' N latitude and 39°31' -39°34' E

longitude within an altitudinal range 1800 -3000 m a.s.l. [5]. The total area coverage of the study area is 502.68 square kilometers. Hugumburda Afromontane forest remnants, which are among the 58 national forest priority areas in Ethiopia bounded by different kebelles such as Shinkomajio, Meswati, Were Abaye, Kukufito, Gerjale, Menkere, Adigolo, Hashenge and Hugumburda.

Methodology

AHP and the Geographic Information System (GIS) are an integrated technique used to assess suitable land use for Ecotourism. AHP was used to evaluate the priority weight of each criteria and sub-criteria (parameters). Determination of suitable areas for Ecotourism, took place in three main steps:

Determination and Assessment of Criteria and Sub-Criteria

To evaluate and assign suitable areas for different land uses, a set of criteria must be developed [6]. Consequently, in first step, the most important criteria and sub criteria that effect on site selection ecotourism were determined. AHP was used for this purpose for making decision. AHP is a useful technique for solving multi-criteria problems. The AHP uses pair wise comparison to allocate weights to the criteria of each level, measuring their relative importance by using Saaty's (1-to-9) scale, and finally calculates global weights for elements at the bottom level. The method also calculates a consistency ratio (CR) to verify the coherence of the judgments, which must be about 0.10 or less to be accepted. Mathematical foundations of the AHP can be found in [7].

AHP method is conducted in three stages: 1) making hierarchical structure of the problem that is the most important part of AHP, 2) Calculation of the criteria and sub-criteria weight using expert's judgments and 3) survey of judgments consistency, consistency ratio (CR) of judgments should be less than 0.1 [8,9].

In this study criteria and sub criteria were selected according to similar studies, Natural conditions of the study area and expert's opinions [10]. Then, developed questionnaires were distributed among experts. Experts used pairwise comparisons and Saaty's scale to assess the importance of criteria and sub criteria. The weights of layers (sub-criteria) in each questionnaire and inconsistency rate for each judgment were calculated using Super Decision software. The inconsistency rate of each judgment should be less than 0.1 to be accepted for assessment. Then, the layer's weights of each questionnaire s were averaged and the final weight was calculated for each sub-criteria of evaluation.

Sub-Criteria Maps

In this step, map of each sub-criterion was prepared using GIS. Sub-Criteria maps form an output regarding to evaluated criteria and sub-criteria identification stage. This follows right after input of information to GIS (acquisition, reformatting, geo-referencing, compiling as well as documenting related data) saved in graphical and tabular type, manipulated and analyzed to acquire desirable info. Generally, with the help of numerous GIS techniques, a base map of the study area is created and utilized to produce a number

of sub criteria maps. Each sub-criterion is represented on a map as a layer in GIS. Every map represents one sub criterion and can be known as a thematic layer or data layer. They signify way in what the attributes are distributed in space and how they assist in achieving the objectives. In other words, a layer represents a set of alternative places for a decision. The alternatives are divided into a number of classes or are assigned values to represent the level of preference of the alternative upon given criterion, which helps an individual to visualize many less and more desirable alternatives.

Having prepared Digital Elevation Model (DEM) map of study area; slope, aspect and elevation maps with a scale of 1: 50,000 were obtained in GIS environment. Satellite image, soil and petrology maps obtained from Mekelle University Department of Land Resource management.

Maps classification was conducted based on the natural conditions of study area, previous studies and expert opinions.

Weight Assigned To Maps and Generation of Suitability Map

In this case, ever single map was combined with its own weight using weighted linear combination (WLC) technique in GIS environment (Santa-Riviera et al, 2008). In weighted linear combination (WLC) technique, parameters (V_i) are multiplied by the weight of the suitability parameters (W_i) to get composited weights and then summed. WLC is a straight forward linear method calculating composite weights. This function multiplies and sums up the layers to produce suitability maps for Ecotourism. Therefore, the weighted linear technique (Mohit and Ali, 2006) was applied to generate a suitability map by the following formula and the final map of suitable area for Ecotourism production [11].

$$E = \sum_{i=1}^n w_i * v_i$$

Where: W_i = relative importance or weight of factors/parameters i , V_i = relative weight of parameters i and n = total number of parameters related to the study.

Result

AHP was used to assess the priority of each criteria and sub criteria. AHP and GIS combined together to asses site suitability for ecotourism in Hugumburda Forest, Ethiopia. In this study, to assess the potential ecotourism site seven criteria were used including scenic attractiveness, slope, elevation, temperature, rainfall, soil and land use land cover.

Based on the result of the criteria assessment, land use land cover with a weight equal to 0.3578 was the most important in this evaluation and soil, slope, elevation, scenic attractiveness, rainfall and temperature were the much important respectively for ecotourism site development. Table 1 shows the results of the hierarchy creation, the importance of the criteria (layer) and layer classification.

Table 1: criteria and maps classification

Criteria	Sub- criteria	Weight	Layer off classification			
			Highly suitable	Moderately suitable	Less suitable	Not suitable
Environment	Land use land cover	0.3578	Lake and dense forest	Closed grassland	Open grassland and shrub land , cultivated land	Built area
Pedology	Soil	0.2938	Dystric nitisols	Eutric cambisols and vertic cambisols	eutric regosols	leptosols
Topography	Slope	0.1649	0-5 degree	5-25 degree	25-35 degree	>35 degree
	Elevation	0.0886	3200-3680m	2301-3200m	1501-2300m	1400-1500m
Recreational attractiveness	Scenic attractiveness	0.0469	7-9 (high visibility values)	4-6 (middle visibility values)	1-3 (low visibility values)	0 (invisible)
climate	Rainfall	0.0240	770-890mm	700-770mm	630-700mm	580-630mm
	Temperature	0.0240	12-15 °C	15-18 °C	18-20 °C	20-22 °C

In next step, required maps derived from reorganization of biological and ecological resources of the study area. These maps include distance from land use land cover, soil, elevation, slope, scenic attractiveness, rainfall and temperature.

The major result of this study is suitable areas map for ecotourism (Fig. 1) that classified in 4 categories. The results showed that 9513.65 ha of study area (18.92%) has potential for first class (high suitable), 8871.82 ha (17.65%), 12841.20 ha (25.54%) potential for second (moderate) and third (low) class, respectively. 19044.35 ha (37.88%) has potential for fourth class (no suitable) (table 2).

Table 2: Area coverage of ecotourism suitability

Suitability Class	Area coverage			
	Area_Sq km	%	Area_ha	%
Highly Suitable	95.14	18.92	9513.65	18.92
Moderately Suitable	88.72	17.65	8871.82	17.65
Less Suitable	128.41	25.54	12841.20	25.54
Not Suitable	190.44	37.88	19044.35	37.88
Total	502.71	100.00	50271.02	100.00

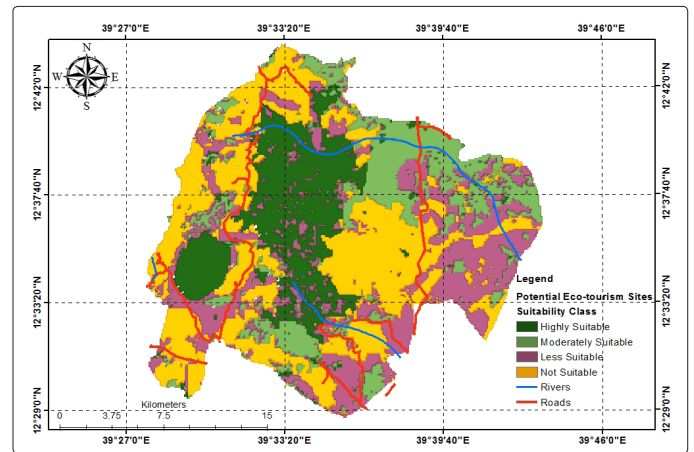


Figure 1: Ecotourism Suitability Map

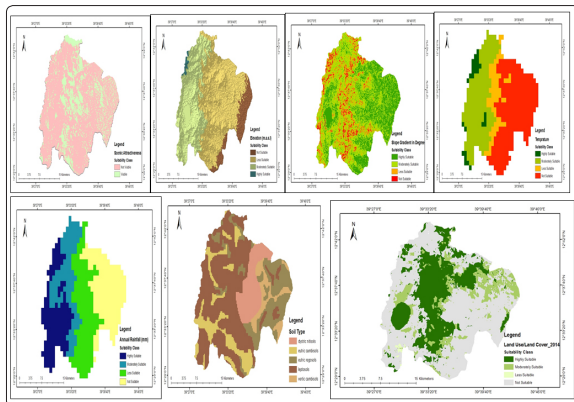
Discussion

The main contribution of this study was the identification criteria of ecotourism by applying the AHP and GIS. In this process, the research focuses to develop an integrated approach of ecotourism development by identification of ecotourism suitable sites. The final outcome of the research is based on the level of potential for ecotourism. In this case, seven criteria were used to analysis the suitability map of ecotourism. The result of the expert’s opinion showed that land use land cover is the major factor in this area to optimal site selection for ecotourism. The soil is also important factor in ecotourism on basis of vegetation growth and tolerance of disturbance. The results of the study area evaluation for ecotourism site selection showed that about 18.9% of the study area has a good potential for ecotourism, according to the suitability map of ecotourism the central region of the study area has more potential than other regions. These areas include the dense forest and the lake of the study area. Approximately 38% of the study area is not suitable for ecotourism.

Conclusions

This study used to assess the ecotourism site suitability by using GIS and AHP of the Hugumburda forest by using appropriate criteria for successful ecotourism. The research identifies and prioritizes the potential ecotourism sites in the study area based on seven criteria

Land suitability classification criteria for ecotourism



[12]. These criteria were land use land cover, slope, elevation, soil, scenic attractiveness, rainfall and temperature. Based on the findings of the research, the areas highly suitable for ecotourism 18.9%, moderately suitable 17.65%, less suitable 25.54 and not suitable for ecotourism 37.88%. Based on the findings of the study, the following recommendations are forwarded;

- The government should promote the natural resource products of the study area through mass media communication or other means of interpretation.
- Increasing the awareness of local communities in and around Hugumburda forest towards ecotourism or nature tourism is very important to brought sustainable development and nature conservation.
- Additional research is needed to refine the suitability; the ecological sensitivity and risky areas should be identified considered as one factor in site suitability which is not included in this study due to absent of data
- Both governmental and non-governmental organizations should take initiatives in bringing developmental projects like ecotourism for local communities.

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