



Ecotourism site suitability evaluation using geospatial technologies: a case of Andiracha district, Ethiopia

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Abstract This study is aimed to identify potential ecotourism sites using Geographic Information System and Multi-criteria Decision Analysis in Adiracha district of Sheka Zone, south-western Ethiopia. Landsat ETM Image and STRM data of 2016 with 30 m resolution and topographic map of Ethiopia were used in this study. Ecotourism potential site selection criteria were designed based on 26 stakeholder's opinions. The final suitability map of ecotourism has been realized by applying an integrated weighted overlay technique of Geographic Information System. The suitability map was categorized into four classes as Suitable, Moderately Suitable, Less Suitable, and Not Suitable. The study attempts to indicate the level of ecotourism suitability at different location in the study area. The outcome of this research is useful to understand the spatial information of Sheka district that can be used for policy makers. This study can be also used as a basis for assessing ecotourism site suitability in other regions.

Keywords Ecotourism · Land suitability · Multi-criteria Decision Analysis · Tourism

1 Introduction

Ecotourism is a type of tourism based on natural resources and cultural attractions. It can be defined as the combination of conservation, communities, and sustainable travel. Ecotourism is increasingly introduced in third world countries in the form of green revolution [1]. The presences of forest, wetland, grassland, a river fall, wildlife or other natural features enhance the development of ecotourism.

Numerous studies confirmed the importance of ecotourism for biodiversity conservation [2–8]. These studies highly emphasised on the contribution of ecotourism development towards biodiversity conservation and environmental protection. Conservation can be promoted through ecotourism by increasing participants' knowledge of ecology, fostering positive environmental studies, and driving in conservation behaviour [3, 9]. Ecotourism enhances the conservation of biological, hydrological and cultural diversity [10]. Study conducted by [11] in Malaysia integrates culture, nature and adventure in ecotourism. The sustainability of ecotourism depends on the relationship between tourism and environment [12].

Ecotourism is one of the fastest growing sectors of the tourism industry [6, 9] and considered as a development tool to protect the natural environment and cultural diversity. It is the source of revenue for the local people without harming nature [1, 6, 7, 13–15]. Ecotourism is considered as a way to diversify a local economy [16]. Tourism has the potential to stimulate the rural economy through producing spin-off effects in service sector [17]. This implies that ecotourism played a key role in local livelihoods through

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economic benefits. Ecotourism provides an opportunity for visiting nature and cultural heritage. Ecotourism promotes tourism activities in the natural environment and attract tourist's interest in nature and culture of places to visit [2].

Evaluating land suitability is an important use of Geographic Information System (GIS) in ecotourism [10, 12, 18]. The process of site suitability requires the identification of the appropriate locations for a particular land use activity by considering physical resources [19–22]. Previous studies used land cover types, wild animal zone, unique features, topography and distance to road as the main criteria for ecotourism suitability indicators [12, 21, 23, 24]. Geographic Information System technology has been used by various researchers to identify ecotourism potential sites [12, 24–30]. All authors considered landscape, wildlife, topography, accessibility for visit and community characteristics as the indicators of ecotourism suitability.

Geographic Information System is crucial to establish information management system, which support decision making process [21, 28, 31]. Geographic Information System and remote sensing tools are widely implemented for identification of suitable area and resource inventories [10]. Study conducted by [32] indicates that the presence of wildlife was found to be the most important criterion. Study conducted by [33] in upper Amazonian forests identifies the diversity of large mammals in a land plot that contributes for the development of ecotourism. Similar to the natural forest, plantation forest along other natural land features also contributes for the development of ecotourism [23]. The developments of ecotourism enhance sustainable development by providing job opportunities for local communities and environmental conservation through minimizing the pressure on natural resources [34]. However, because of inadequate environmental information, sustainable tourism destinations have not contributed towards conservation and nation development [35]. The study area, Andiracha district, is the home of many plant and animal diversity, which boost the development of ecotourism. Even though, the study area has rich in natural, cultural, and historical resources, little is known about the potential of the study area for ecotourism development. Above all, this research will contribute towards sustainable tourism management that can influence decision makers to promote the development of ecotourism in the region.

2 Materials and methods

The study of ecotourism site suitability evaluation was carried in Andiracha district of Sheka Zone in Southern Nation Nationalities and People's Region in south western part of Ethiopia (Fig. 1). About 47% of the total land area

of Andiracha district is covered by forest. The local people utilized the natural forest for household furniture and constructions as well as for energy consumptions. It is also a natural habitat of the wild Arabica coffee which supports the livelihoods of the local communities.

A modified method of [12] has been used for evaluation of ecotourism site suitability evaluation. In this study, multi physical land features were used to determine potential ecotourism sites; including fifteen features (topography, forest, beautiful landscape, cultural sites, rivers, open land, farmland, weather condition, mountain, wetland, lake, waterfall, cave, wildlife, and road accessibility). And then, ArcGIS and remote sensing software were employed to prepare topographic maps of the study area, which includes rivers, weather condition, road, slope, and other physical features. Thus, this study is more inclusive than those previous studies conducted by [12] in Thailand in 2011 for site suitability evaluation of ecotourism.

Data used in this study were assembled from different sources such as: Landsat ETM + image, Ethio-GIS, STRM data, GPS data, and socio-economic data (Table 1).

Satellite image processing, geometric correction, geographic processing, and image filtering of raw satellite images were performed using GIS and remote sensing technologies. Spatial enhancement such as, resolution merging was performed for image visualization. Noise and haze reduction was applied to remove the bad lines of the original landsat image. To produce suitability map, slope and elevation of the study area were extracted from DEM 30 m resolutions that can be processed by ArcGIS tool. To produce the ecotourism suitability map, slope and elevation of the study were derived from digital elevation model (DEM), and analyzed by ArcGIS software, while the spatial analysis, digital image processing, and Land Use Land Cover (LULC) classification were performed by ERDAS image software.

2.1 Multi criteria evaluation

Several criteria's has been used for potential site selection of ecotourism which includes plant density, flora, fauna, plant biodiversity, fragile habitats, water quality, wildlife species, land cover and many others [12]. Various criteria and factors were identified in consultation with key stakeholders (26 respondents), those working on tourism and agriculture office by distributing questionnaires, for identification of potential ecotourism sites of Andiracha district. The selected experts are ranks those listed ecotourism attraction features located in their local area based on their significance. To evaluate the information that generated from the expert through questionnaires are developed in the row matrix shows that list features that attracts tourists while column matrix shows the value of

Fig. 1 Location of the study area

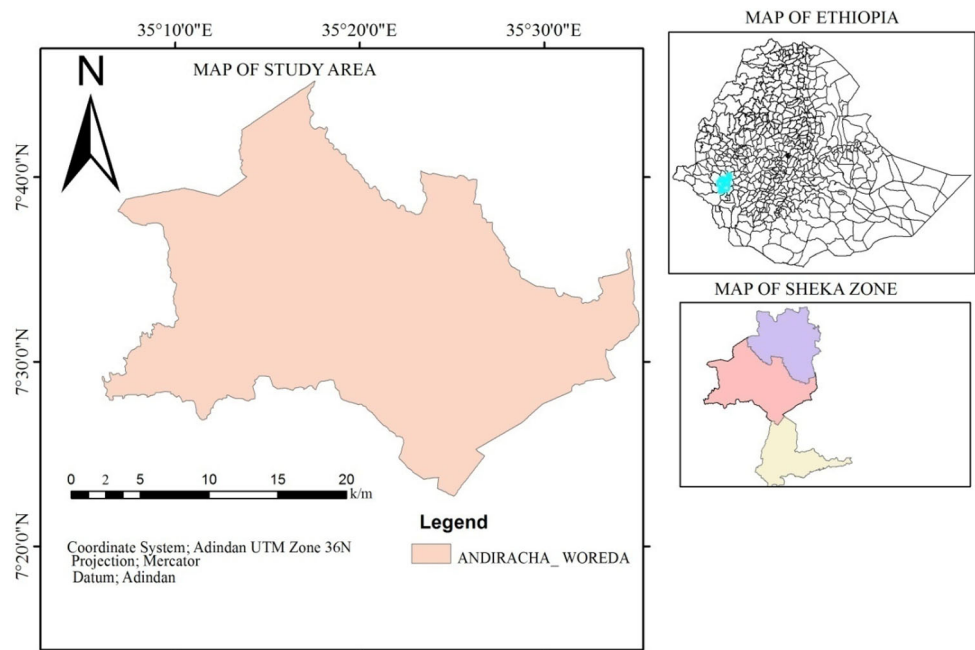


Table 1 Data sources

No	Data type	Source	Resolution
1	Landsat ETM + image	Global land cover facility	30 m
2	Ethio-GIS	Central statistics authority	
3	STRM data	Digital elevation model	30 m
4	GPS data	Field survey	
5	Topographic map of Ethiopia	Ethiopian mapping agency	1:50,000 (Scale)
6	Socio-economic data	Stakeholder's interview	

ranks. The value given to each classes of attraction sit are multiplied by total respondent and these were aggregated to for all lists of ranks. To generate the final value assigned ranks of each category, the total value of every attraction site were divided by number of respondents to a given natural, historical or cultural attraction site. Finally, by overlaying the map layers by GIS software and input of stakeholders, ecotourism potential areas were identified (Fig. 2).

3 Results and discussions

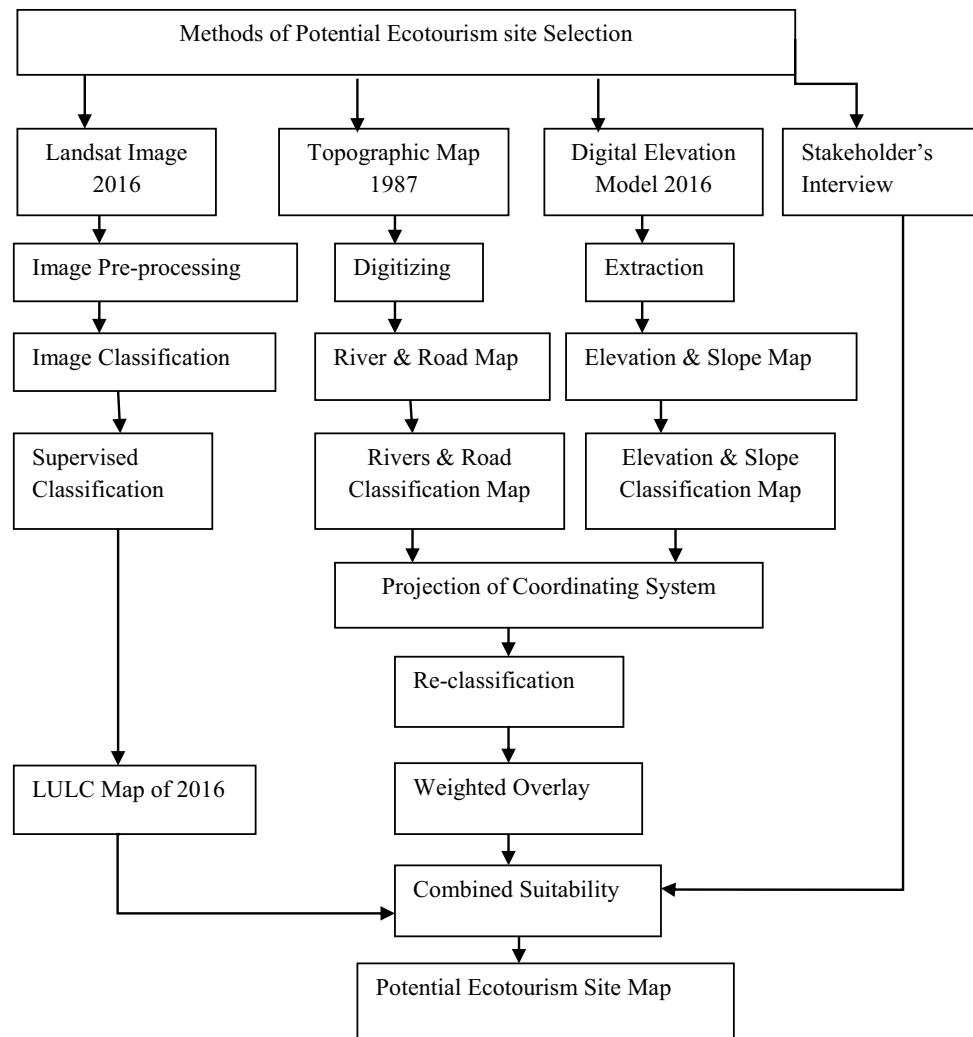
The LULC map of the study area was classified into four major classes. The classification of LULC was performed using the supervised method of image classification. Accordingly, Landsat image of 2016 was classified into four major LULC types namely forest, agriculture, settlement and wetland (Fig. 3).

The results reveals that majority of the LULC in the study area is forest. From the total area of 103,062.1 ha of the study area, about 70.8% (73,005.8 ha) was covered by

forest, while 5.4% was classified as wetlands. Both forest and wetland has been recognized as a potential land classes for ecotourism development [23]. This is mainly due to the preference of tourist's for its natural attractions like natural forest, lakes and wetlands to observe beautiful landscape, wildlife and birds for recreational purpose (Table 2). Wetland is a unique land cover and a home of various aquatic flora and fauna that attracts tourists.

Information from key stakeholders indicates that Lake is another land use suitability indicator for ecotourism in the region. Andirach district has a beautiful highland lake like Gandochi Lake. The area is also rich in waterfall such as Genji, Gemadro and Shaki. In addition to beautiful lakes and waterfall, Andiracha district is rich in caves like Abaqaqi, Shashi and Sheksheko. The existence of ever-green dense forest, lakes and waterfalls promotes the development of ecotourism [2, 12, 19, 23, 33]. In spite of the existing natural and cultural features, the area lacks basic facilities that enhance the development of ecotourism. For instance, information collected from key stakeholders indicates shortage of infra-structure facility such as road; hotel, restaurant and lack of finance are the

Fig. 2 Research methodology flow chart



major factors that affect the potential ecotourism site selection.

3.1 Ecotourism suitability indicators

3.1.1 Topography

Slope and elevation factors are one of the key indicators in selecting potential ecotourism site [12, 19, 29, 36]. Figure 4 demonstrates a slope variation; the study area varies from 0° to 80° , where there are natural caves, waterfalls, animals, and birds. The highest slope range (0–5) slope range covers 25,844 ha (25.3%) while the lowest slope ranges 340 ha (53–80) shares 0.33% of the total area. The slope is one of the most important criteria to identify potential ecotourism site. The steep slope attracts more tourists than the gentle slope endowed with hanging and cliff [26].

3.2 Elevation

The elevation class was assigned based on the degree of landscape attractiveness. Elevation is one of the primary variables used for the identifications of tourism attraction features [29, 36]. The elevation of the study area varies from 714 to 2647 m, which is an opportunity for the existences of various fauna and flora. Ecotourism involves travel to destinations where flora and fauna are the primary attractions. The presence of fauna and flora enhance the development of ecotourism.

The elevation map derived from DEM was reclassified into four classes and new values were assigned to each class based on landscape attractiveness. These classification were assigned as class 1, 2, 3, and 4. Covering about 18.47% (18,844 ha) lies between 714 and 1662 m assigned as 4; 1662–1991 m (19,204 ha), about 18.82% assigned as 3; 1991–2291 m (34,644 ha), about 33.96% assigned as 2, and 2291–2647 m (29,320 ha) accounts about 28.74% assigned as 1. For ecotourism attractiveness the highest

Fig. 3 Land use map of the study area

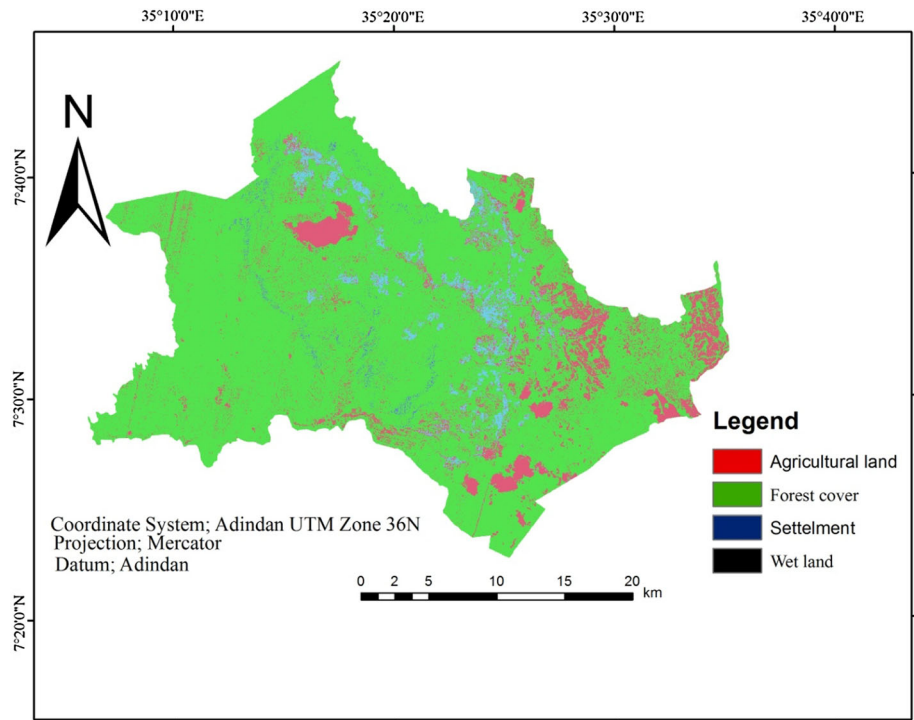


Table 2 Summary statistics of LULC for 2016 in Adiracha district

LULC classes	Area in hectare	Area in %
Forest cover	73,005.8	70.8
Wetland	5517	5.4
Agricultural land	17,552.2	17
Settlement	6987	6.8
Total	103,062.1	100

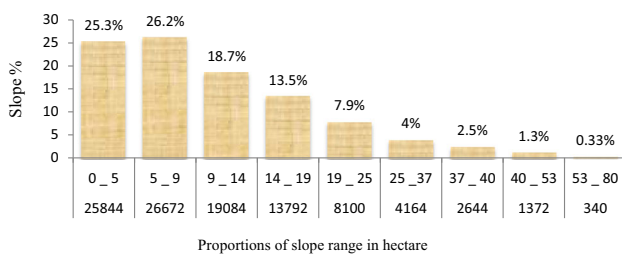


Fig. 4 Distributions of slope range

elevation which ranges between 2291 and 2647 m is assigned as (1) and considered as a more suitable area for ecotourism while the lowest elevation ranges between 1991–2291, 1662–1991 and 1048–1662 given the ranks 2, 3, and 4, respectively. The lowest elevation class (class 4) is not suitable for ecotourism because of high temperature.

3.3 Proximity to river

Water body plays a great role on ecological function and hosts a variety of fauna and flora. The availability of water body near to the ecotourism site attracts more tourists to that area. As result, river was taken into consideration as one of the factor to evaluate the suitability of the ecotourism site.

Riparian forests along rivers and stream and swampy vegetation along the river bank accommodate a variety of birds and other species, which are the major attractions of tourism. Ecotourism site near to water body such as wetland, lake, river and spring are more preferable to tourist attraction. Rivers is one of the most important resources for ecotourism development [22]. The study area accounts 20%, 23%, 28% and 29% of total area with the buffer distance of 1 km, 3 km, 6 km and > 6 km from the river, respectively. This indicates that majority of the study area is easily accessible to rivers. Based on this result, the highest rank is given to buffer distance near to river and lowest rank is for areas far away from river. Accordingly, the distance within 1 km, 3 km, 6 km and > 6 km were given a rank as (1), (2), (3), and (4), respectively.

3.3.1 Accesses to transportation

Accessibility to forest, wetlands, lakes, cultural and historical sites affects the development of ecotourism. Although, road is the only means of transport, it is not well

distributed in the study area. This situation has its own impacts on the development of ecotourism. The western and south-eastern part of the study area is not accessible for transportation (Fig. 5).

As results shows in Fig. 6, only 7045 ha are accessible to the buffer area within 1 km, this implies that the majority of road infrastructure is not well distributed. From the total land cover, about 71,302 ha are not easily accessible to road facilities.

3.3.2 Reclassification of road map

Road is the most important means of transport and basic pre-request for tourist destination. Ecotourism activities far away from the road access are not suitable for ecotourism development. The highest rank is given to the nearest areas that have low buffer distance and lowest rank is given to remote area from road access [24]. Thus, the area which is found within 1 km, 3 km, 6 km and > 6 km were assigned as 1, 2, 3, and 4, respectively. Areas accessible within 1 km to the road are ranked as Suitable for ecotourism development; the areas accessible within 3 km from roads are ranked as Moderately Suitable; and the areas within 6 km away from the road are ranked as Less Suitable; while the areas greater than 6 km away from the road are ranked as Not Suitable for ecotourism development.

The suitability class for ecotourism were classified into four classes. Accordingly, 17.49% (17,669 ha) categorized as Suitable, while 71.13 (71,862 ha) were classified as Moderately Suitable, and the Less Suitable and Not Suitable area for ecotourism development, which covers

Fig. 5 Road distribution of the study area

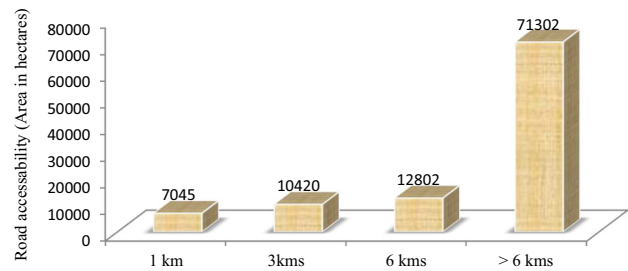
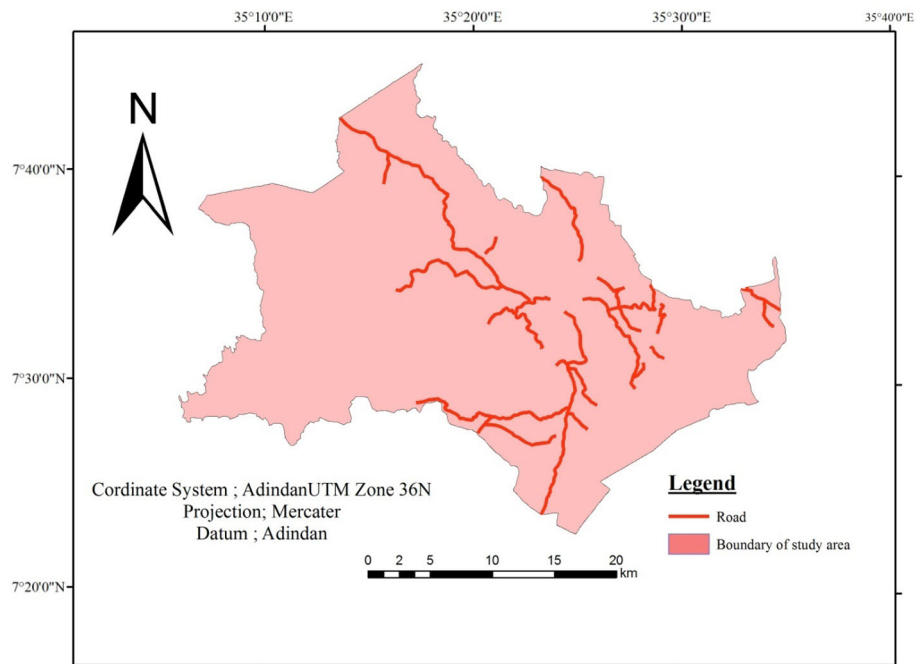


Fig. 6 Road accessibility per area in hectares at different distance

about 11,460 and 39 ha of the total area, respectively (Fig. 7).

The northern, western and southern parts of the study area, has the potential ecotourism site because of the existences of beautiful natural features such as Gandochi highland lake, waterfall (Genji, Gemadro and Shaki), caves (Abaqaqi, Shashi and Sheksheko), and mineral water (Daye, Gomri, Ganiti and Shawity). The eastern and southeastern part of the district are classified as moderately suitable for ecotourism potential because of the existences of Shishochi lake, Kechkafo water fall, Dagi water fall, Ashamashi waterfall and Kalacho caves. One of the most beautiful waterfalls in the study area is demonstrated in Fig. 8. Waterfall is one of the natural landscapes that attract tourists and considered as one of the tourist destination [37]. People are preferred to enjoy around waterfall during weekend and free time. This indicates that the existence of waterfall in the area is a key indicators potential ecotourism in the area. Such beautiful waterfall can contribute for the development of ecotourism and

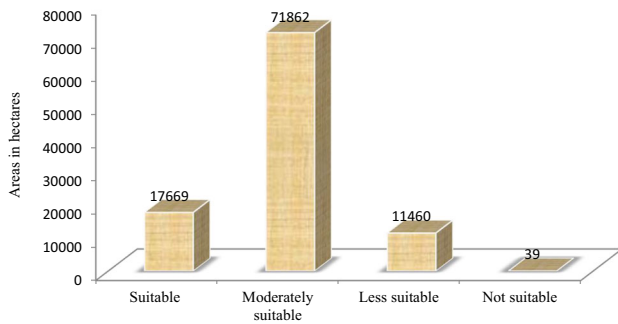


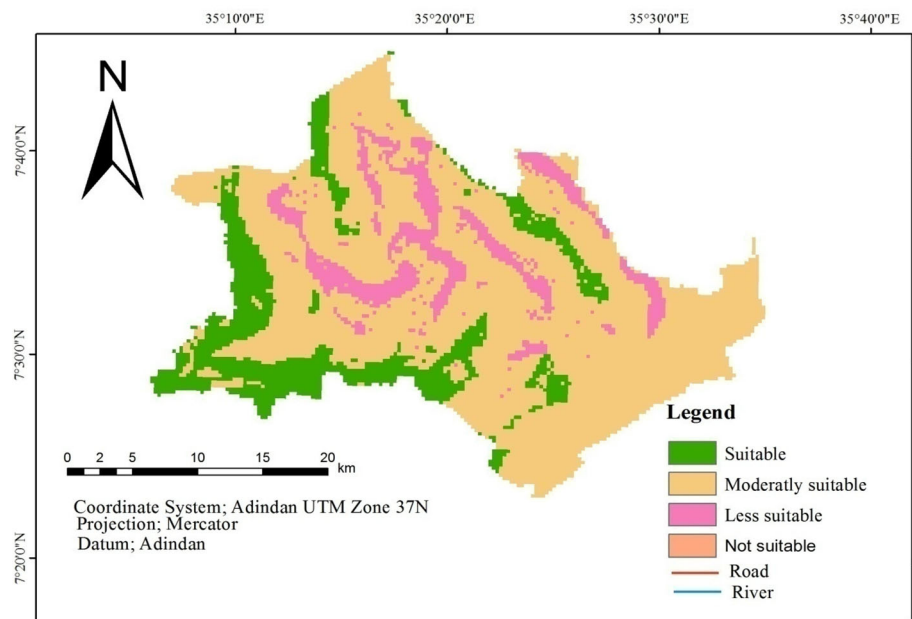
Fig. 7 Ecotourism suitable area in hectares



Fig. 8 Gey kebele waterfall (Fsurvey, 2018)

sustainable development for the region. As indicated in Fig. 9, highly suitable ecotourism sites are located in the northern, western and southern parts of the study area while

Fig. 9 Ecotourism suitability map of the study area



the northeastern and southeastern parts of the district is not suitable area for ecotourism site.

3.4 Analysis of socio economic survey

The stakeholder’s interview result indicates that the study area has a great potential for ecotourism development. Accordingly, 4% of the stakeholders confirmed the presence of historical sites while 52%, 13%, and 30% of the respondents confirmed the existence of natural, cultural, and all historical, natural, and cultural types of ecotourism in their locality respectively (Table 3).

In spite of the existing opportunities for ecotourism development, low level of community awareness, infrastructure facility such as road, hotel, restaurant and lack of finance are the major factors that affect the development of ecotourism in the area.

The stakeholders ranks those listed ecotourism attraction features located in their local area based on their significance. The row matrix showed list features that attract tourists while column matrix indicates the value of ranks. The value given to each class of attraction sites were multiplied by total respondents. To generate the final value assigned ranks of each category, the total value of every attraction site were divided by number of respondents to attraction site (Table 4). Accordingly, the existence of cave, wildlife, rivers, unique species, and waterfall stands 1st, 2nd, 3rd, 4th, and 5th ranks, respectively.

Table 3 Ecotourism potential from historical, natural, and cultural resources perspectives

Types of ecotourism	Number	Percent
Historical	1	4
Natural	12	52
Cultural	3	13
All	7	30

3.5 Weighting, evaluation and suitability analysis

The weighted site selection was done by gathering data from expert and factor maps such as land use land cover map, slope map, elevation map, road map, and river map

were prepared based on their contribution for ecotourism site selection ordering from highest to lowest importance according to information gathered from experts through questionnaires.

Table 5 showed that factor maps of pair wise comparisons are labelled with the same variable both in rows and columns. Weights are assigned based on their degree of importance and the matrix tables are arranged from highly important to less important contribution for potential ecotourism site selection. For example reclassified LULC was highly important than that of reclassified slope, elevation, road, river, rainfall and temperature. Accordingly the importance of each factor weight was orderly varying from one factor to another. The eigenvector weights contains the

Table 4 Matrix for stakeholder’s response on natural, physical and cultural features

Features	Rank																Total weight	Average weight	Rank
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16			
Forest	7	11	4	–	–	3	1	–	–	–	2	–	–	–	1	–	103	3.6	7
River	12	5	7	1	1	–	–	–	–	2	–	–	1	–	–	1	91	3.03	3
Reserves	2	10	13	1	–	–	–	3	–	–	5	–	3	1	2	–	227	5.6	12
Protection area	9	1	4	–	–	1	–	3	1	–	–	2	–	1	1	–	114	4.9	10
Wildlife	10	4	12	–	–	–	1	–	–	–	3	1	–	–	–	1	120	2.8	2
Unique species	15	6	4	1	1	–	–	–	3	2	–	–	–	–	–	–	99	3.09	4
Unique landscape	7	5	1	2	1	–	–	–	–	1	–	–	–	1	1	–	71	3.7	8
Weather condition	1	13	5	1	–	5	1	1	–	–	3	–	–	–	3	2	234	6.6	13
Wetland	3	4	–	–	–	–	2	–	–	–	1	1	–	–	–	–	48	4.3	9
Grazing land	1	15	6	–	–	–	3	–	2	–	–	–	4	–	–	–	140	3.4	6
Mountain	–	2	4	–	1	–	–	1	–	–	2	–	–	3	–	1	121	8.6	13
Open land	5	9	2	–	1	–	–	–	4	–	–	3	1	–	–	–	124	4.9	10
Farm land	8	12	4	1	–	–	–	4	–	1	3	–	–	–	1	–	138	5.3	11
Cave	13	5	7	1	–	–	–	–	–	–	–	–	–	1	–	1	78	2.7	1
Waterfall	9	6	12	–	–	–	–	4	1	1	–	–	–	–	–	–	108	3.2	5
Lake	3	7	4	3	–	2	–	–	–	–	–	–	–	–	1	1	82	3.9	8

Table 5 Pairwise comparison matrix of factor maps

Reclassified	Reclassified						
	LULC	Slope	Elevation	Road	River	Rainfall	Temperature
LULC	1						
Slope	1/2	1					
Elevation	1/3	1/2	1				
Road	1/4	1/3	1/2	1			
River	1/5	1/5	1/3	1/2	1		
Rainfall	1/7	1/7	1/5	1/3	1/2	1	
Temperature	1/9	1/9	1/7	1/7	1/3	1/2	1

Table 6 Module results for eigenvector of factor map weight

Eigenvector weights	LULC	Slope	Elevation	Road	River	Temperature	Rainfall
	0.3517	0.2550	0.1585	0.1131	0.0653	0.0347	0.0218
Consistence ratio	0.03						

factor maps such as reclassified as LULC, slope, elevation, road, river, rainfall and temperature shares 0.35, 0.25, 0.16, 0.11, 0.07, 0.03, and 0.02, respectively, with the consistency ratio of 0.03, which is acceptable (Table 6). The consistence ratio value is acceptable if the value is less than 0.1 [38]. Finally, the results are evaluated by multiplying the results of eigenvector value by each factor map and at the end suitable sites of the study area maps are produced with the support of ArcGIS software.

4 Conclusions

The study was undertaken in Andiracha district of Sheka zone, south-western Ethiopia to identify the existing potential for ecotourism development. Land suitability for ecotourism developments was classified as Suitable, Moderately Suitable, Less Suitable and Not Suitable. Andirach district has a significant ecotourism potential for its natural landscape. This study confirm that, the existences of every green forest with diverse fauna and flora, waterfall, lake, wetland, and caves as well as beautiful landscape and wildlife are some of the major potential indicators of ecotourism. The study has confirmed that 17.13% (17,669 ha) are classified as Suitable, 71.49% (71,862 ha) as Moderately Suitable, while 11.34%, and 0.04% were classified as Less Suitable, and Not Suitable, for the development of ecotourism, respectively. In spite of the existing ecotourism potential, the area is not utilized for tourism because of lack of infrastructure and advertisement. This study shows that the northern, western and southern parts Andiracha district is highly suitable for ecotourism development. Therefore, ecotourism advertisement should be created among the local people and government authorities. This type of research can be applied in other regions to identify the existing potential for ecotourism development.

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