

Using Geospatial Techniques in the Selection of Potential Ecotourism Sites in Menz-geramidir District, Ethiopia

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Abstract

Ecotourism is expressed as when tourists are attracted to a given geographic area (i.e. space) which has its own available natural, environmental, and socioeconomic resources by considering environmental sustainability, local benefit, and promotion. Space is an elementary part of ecotourism activities. Hence, the aim of this study is to identify potential ecotourism sites in Menz-geramidir district mainly by considering the natural features. Using weighting of each factor, three criteria and five-factor maps are identified, namely: landscape (land use land cover map), topography (elevation and slope map) and accessibility (road and river map). Those identified factor maps first ranked based on expert opinion, and then the weight of influence of each factor was computed by pair-wise comparison technique which is one of AHP method. The image classification was carried out in ERDAS imagine software using supervised image classification method. The image classification accuracy assessment indicates that the overall accuracy is 84% and the overall Kappa coefficient is 0.80. The final ecotourism potential sites model map was created based on the linear combination of factors with their respective weights in ArcGIS overlay extension and presented using FAO's suitability scheme into four classes. The result showed that 11% is highly suitable and lies to the eastern part of the study area. Generally, major suitable and moderately suitable area accounts for 75.6 % and marginally suitable area for 13.5 % and the not suitable area is 0.06 %. Therefore, this study shows that the district has high ecotourism potential which can contribute to the livelihood of the community through sustainable environmental development and protection.

Keywords: ecotourism, potential, criteria, geospatial, Menz-geramidir district.

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Introduction

Ecotourism is one of sub-component in the field of sustainable tourism. Ecotourism's perceived potential as an effective tool for sustainable development is the main reason why developing countries are now embracing it, and including it in their economic development and conservation strategies. It maintains development in the community by providing different alternative sources of livelihood to the local community which is more sustainable (Tuğba,2013).

According to Zegeye(2012), tourism is one of the fastest growing industries that provide services and sales of goods to visitors who come from outside of the destination area for a period of more than 24 hours and less than one year. Human beings, starting from Roman empire period have been engaging in traveling to the wilderness for the intrinsic nature of the experience (Chernet,2009). Ecotourism is defined as traveling to relatively undisturbed or uncontaminated natural areas with the particular objective of studying, admiring, and enjoying the scenery and its wild plants and fauna, as well as any existing socio-economic or socio-cultural manifestation (Zegeye, 2012). Therefore, identifying land use/land cover resource, and potential ecotourism site is a primary issue to maintain sustainable ecotourism tourism development. There is a strong relationship between land cover and ecotourism. Once we identify the land use land cover, we can easily know the potential resource, habitat for wildlife, a pleasant place where people could visit and manage the overall tourism activities and fulfill ecotourism interest. According to the Canadian Centre for Remote-Sensing 2015, land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other. Land use also defined as an economic or social benefit that we get from that actual land cover. Identifying, mapping and delineating land cover is important for global as well as regional monitoring studies, resource management, and planning activities.

As clearly stated by Rahman (2010) the integration of RS and GIS also play an important role in ecotourism planning. These technologies are considered to act as effective tools for storing, manipulating and analyzing a great variety of spatial data with huge attributes. Similarly, Chernet (2009) in his ecotourism potential site selection study stated that, GIS has been widely discussed in environmental and resource management applications and has an important role in ecotourism, though it has not been widely applied.

According to a study conducted by Zegeye (2012) and Chernet (2009), the attractions of ecotourism are primarily based on the natural environment, and ecotourism differs from nature-based tourism, in that, nature-based tourism is just to travel to natural areas, but ecotourism provides local benefits: environmentally, culturally and economically. Ecotourism is, therefore, a type of tourism that focuses on local cultures, wilderness, and adventures; travel to destinations where the scenery, flora, fauna and cultural heritage are the primary attractions. So, delineating potential ecotourism sites by considering landscape (land use land cover), topography (elevation and slope) and accessibility (distance from roads and river) as criteria and factors in Menz-geramidr district are thus helpful in tourism planning, guiding and expanding the tourism industry.

Land and its resources can be detected, mapped, and analyzed using remote sensing and geographic information system (GIS) techniques in conjunction with the secondary and ground truth data. Mapping helps to identify areas where environmental and natural resources are located and to pass appropriate decision (Simmons, 2007). Even though at world scale, the earth has ample resources at a different scale

and spatial location, our world is threatened by serious problems associated with mismanagement of natural resources and absence of spatial planning (Amessie, 2004). In several African countries including Ethiopia, there are numerous attractive sites and natural capital. In spite of the existing potential, the countries lack a number of ecological, economical and social benefits from ecotourism, which is one of the environmentally friendly activities. For example, in prioritizing tourism sector and travel, Ethiopia takes 115th and 125th rank in tourism human resource quality and labor market at worldwide respectively (World report, 2017).

As indicated by Tewodros (2014), Ethiopia's wealth in cultural and natural tourism assets gave the country strong potential as a tourism destination. In addition, Amessie (2004) in his research stated that the Ethiopian highland areas are rich in endemic species of plants, birds, and mammals. But Ageru Yilma, Reta, and Tefera (2016) established that Ethiopia's mountains are almost untouched in any ecotourism activities other than just only mountain-climbing. Chernet (2009) also stated that despite numerous amounts of natural and cultural resources Ethiopia is endowed with, in terms of tourism revenue the country is rated among the lowest in sub-Saharan Africa. The problem behind the sector's poor performance has not been studied in a comprehensive way (Muluaem, 2010). For less developed countries like Ethiopia, the fundamental challenge is maintaining sustainable development and improving the standard of living dramatically. To achieve this, promoting ecotourism is the most important part for enhancing the socio-economic development of the ecotourism sector. Despite its increasing importance in every aspect, however, ecotourism has attracted relatively little attention in the empirical literature (Getahun, 2011).

Ethiopia has the nature of ecotourism; visitors have increased to areas of major environmental interest: the Semein Mountains, the Bale Mountains, the rift valley lakes, especially to the Omo valley and other parts of the southwest (Tewodros, 2010). Previous studies had also reported the ecotourism potential of those specific areas. (Mihret & Yohannes, 2015; Tewodros, 2010). Tourism in Amhara region is highly dependent on historical heritage (Eshetu, 2014). In recent years, the Ethiopian government has formulated a series of policies for promoting national development, particularly implemented sustainable programs (Census, 2007). Ecotourism is also one of the identified environmental friendly and sustainable programs. Some researchers (Chernet, 2009; Yilma, Reta, & Tefera, 2016; Zegeye, 2012) tried to assess the ecotourism potential site in different part of Ethiopia by using a dominantly qualitative approach. However, their results and findings did not use geospatial techniques and multi-criteria methods. Therefore, this study is an attempt to identify potential ecotourism sites selection using geospatial techniques and multicriteria methods for sustainable economic development for Menz-geramidir district, North central Ethiopia.

Study Area and Research Methods

Menz is the popular name of the area and Geramidir district is one of the districts of North Shewa Zones of Amhara National Regional State. The capital of Menz-geramidir is Mehal Meda which lies about 265 Km NE of the national capital Addis Ababa. It is located between 10°15'9'' N to 10°30'15'' N and 39°24'5'' E to 39°45'37'' E. Menz- Gera is bordered on the south by Menz- Lalo- Midir, on the southwest by Menz- Keya - Gebreal, on the west by the Qechene River which separates it from the DebubWollo Zone, on the north by Geshe-Rabel, on the Northeast by Antsokiyana Gemza, and on the east by Efratana Gidim (figure 1). The administrative center of this district is Mehal Meda. Menz- Gera with a total of 21 villages (20 rural villages, and one administrative town), has a total land size of 165,671 hectares (Tadesse, 2016). The district

has an altitude range from 1500-3500 m.a.s.l. Flat areas constitute 38%, mountain constitutes 25%, rugged areas constitute 23%, whereas valleys and water covered area constitute 13% and 1% respectively of the total area of the District.

Agro-ecologically, the district is classified as wurch (Alpine), dega (temperate), woinadega (sub-tropical) and Kolla (tropical). But from these Agro-ecological zones, dega and woinadega take more share than the others. The rainfall pattern of the district is bimodal; unpredictable in nature and its distribution most of the time extends from June to August. The equatorial Westerly's and the Indian Ocean air streams are the sources of rain for the study area at different times of the year. Though showers of light rain can occur in any month of the year, informally, there are two main rainy seasons (kiremt or meher) between June to September and minor rainy season (belg) in February, March, and April. The annual rainfall at Menz-geramidir district ranges between 1200mm to 1600mm. The annual humidity ranges between 55.18% to 80.90% (Ayele, 2006).

The mean annual temperature of the area is 12.3°C. The area is characterized by mild day temperatures and cold night temperatures. During the dry season (December to January), the temperature would rise up to 21°C at day time, but falls to -7°C at night. During the wet season, temperature is 12°C at day, while 3°C at night. The area is characterized by high humidity in the wet season and low humidity in the dry season.

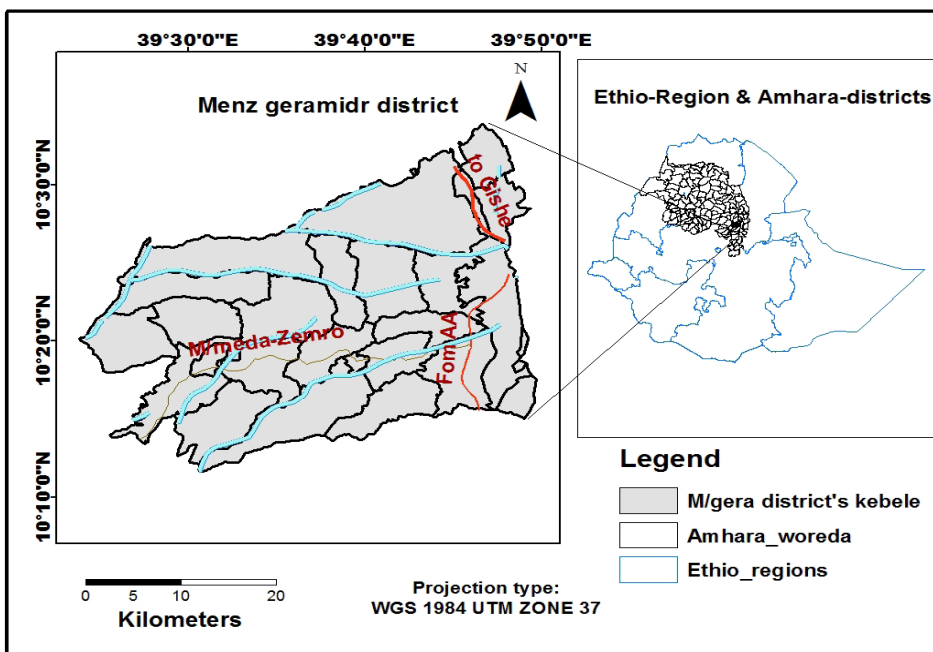


Figure 1: Map of the study area

Source: Field work, 2018

Data and Materials

The GIS-based suitability analysis method and multi-criteria evaluation techniques were used in this study. Some software were applied in this study for data acquisition, design, analysis and presentation of the final research results: ArcGIS 10.3 for map making and different analysis like mapping, reclassification, and accuracy assessment; ERDAS Imagine was employed for satellite image processing and classification; in this case Landsat8 (OLI multispectral bands) have been used. This sensor offers several enhancements over others previous Landsat sensor, including increased spectral information content, improved geodetic

accuracy, reduced noise, reliable calibration, the addition of a panchromatic band (15-meter resolution), and improved spatial resolution of the thermal band. The spectral bands of OLI (i.e. 1-7 and 9) are similar with land sat 7’s ETM+ sensor, but the data quality (signal to noise ratio) and radiometric quantization (12-bits) of the OLI and TIRS is higher than previous Landsat sensors (8-bits for TM and ETM+). Furthermore, to make the study up-to-date, the researchers also used the 2017 image of the study area (raw 53 and path 168).

Table 1: Satellite imageries of land use and land cover sources(Islam, Jashimuddin, Nath, & Nath, 2018)

Data type	Source	Use/application
Landsat 8 (OLI, 30 m)	USGS	LU/LC map
SRTM data	GLCF	Slope, elevation and drainagemap
Toposheet	ARDO	Road map
GPS data, Questionnaire and Digital Photo	Field survey	Accuracy assessment, weighing/ranking, and attractive photo

Source: Field work, 2018

Data Collection Techniques

To get the relevant information in order to meet the stated objectives of the research study. The data collection techniques used for this study were;GPS data, questionnaire, and own observation. GPS data collection has been applied to for accuracy assessment on classified land use land cover map of the study area; The land use/land cover map produced by applying supervised classification method in ERDAS imagine 2010 software. Based on the information obtained from the district Agricultural and Rural Development Bureau and experts opinion about the variety of LULC (Land use land cover change) in the study area, 97 random GPS points were taken. If the source of the image is up-to-date and acquired recently, it is possible to take GCP by executing field survey. But to perform accuracy assessment on outdated imagery, finding high-resolution images which have been acquired at the same or closer time as a reference is recommended than using GCP.To collect reference data, a random sampling technique is the best technique for the relatively small and accessible area. In this case, all feature classes have been easily selected and the collected data could be more representative for accuracy assessment. Questionnaire, on the other hand, was distributed to 12 purposefully selected key informant experts working on tourism, agriculture and land administration, and environmental issues found in the district offices of Menz-geramidir, Mehal- Meda town.Alemayehu(2011) indicated that purposive sampling is used primarily when there isa limited number of people that have expertise in the area being researched. The questionnaire were systematically compiled and analyzed to determine the rank of land use land cover classes and factor maps based on their suitability to ecotourism. The expert involvement in this process wasneeded to convert subjective relative importance of given criteria intoa linear set of weight. Field observation also applied for identifying and understanding potential ecotourism site and for recording information about different natural features and site, through simply observaing their characteristics which are located in the district. The field observations also support the researchers at the time of determining the scale of importance for factor maps using pairwise comparison technique.

Data Analysis Methods

This study was conducted using mixed approaches (qualitative and quantitative) data interpretation mechanisms. As clearly stated by Gedecho (2015), applying qualitative and quantitative research design makes the study better in quality especially for tourism-related research. In this study, the quantitative research approach was employed to measure and quantify collected data while the qualitative design approach was used for field observation and other data obtained from different sources. Mapping of land use land cover was done using a 2017 Landsat 8 image. Landsat 8 has 11 bands which are desired for different detection purposes. However, almost all of the bands from the previous Landsat missions are still incorporated—there are only a couple of new ones, such as the coastal blue band water penetration or aerosol detection, and the cirrus cloud masking and other applications (Butler, 2013). Only the multispectral bands (1-7 and 9) are layer stacked and used which are recorded by the Landsat 8 OLI sensor. The RGB combinations of different bands are also different in their areas of analysis. For example, 4, 3 and 2 is natural color; 7, 6 and 4 is false color; 5, 4 and 3 is color infrared (for vegetation); 6, 5 and 2 are for agriculture, etc. In this study, however, only bands 7, 6 and 4 (i.e. false color) were used.

Multi-criteria evaluation and selection

GIS-based multi-criteria decision making process is practiced by defining goals, determining and standardizing criteria/factors, determining a weight for each factor, aggregating the criteria and validating (Eastman, 2001). In this study, AHP (Analytic Hierarchy Process) is employed. It is one of a multiple criteria decision-making method. With regard to the factor and criteria concerned, based on the analysis of different kinds of literature and relevance to the study area, the researchers identified three criteria factors namely: land use land cover, topography (elevation and slope) and accessibility (distance from road and river). According to Kumari, Behera, and Tewari (2010), in ecotourism site selection, natural resources are higher than cultural resources. This is mainly because natural features with great uniqueness are more attractive to ecotourists. That is why the researchers mainly concerned on a natural and physical feature of the study area. As far as their suitability degree is concerned, LULC with forest and vegetation is more suitable than others; higher elevation and slope, minimum distances to river and road also highly suitable for ecotourism and vice versa. By considering this each factor map was reclassified.

According to Food and Agriculture Organization guidelines for land evaluation outlined by Bunruamkaew (2013), potential ecotourism site identification study, the identification of suitable land classes based on the different factors is presented as follows: a) Land suitability orders reflect kinds of suitability: S (Suitable) and N (Non-suitable). b) Land suitability classes that reflect the degrees of suitability: S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), N (not suitable). Therefore, these degrees of suitability classes have been applied in this study for analyzing land evaluation for the ecotourism potentiality of the study area. As to be able to create realistic model binary classification into “S” and “N” is not only enough, so more precise break is needed which into the degree of suitability (Helmut, Patrick, and Stephanie, 2013).

Weighted overly analysis

In several previous studies conducted on potential ecotourism site selection studies, key informant experts

views are involved in attractive site determination and factor map ranking (Bunruamkaew, 2013; Chernet, 2009; Gedecho, 2015; Mihret & Yohannes, 2015; Suryabhadgavan, 2015). That is why the expert participation is needed in this section.

With regard to factor maps, weight for each factor maps are assigned based on their relevance by the researchers. For this, the researchers used a pair-wise comparison of the AHP method. Then, prioritizing of factor maps (or simply factors or criterion) from highest to lowest was arranged according to their suitability value for ecotourism. The value was derived from pairwise comparison matrix which has been computed in excel. The process of converting data to such numeric scales is most commonly called standardization. Standardized factors are combined by means of weighted linear combination method; that is each factor is multiplied by a weight, with results being summed to arrive at a multi-criteria solution (i.e. ecotourism potential site map).

Finally, the ecotourism potential map is produced by using this logical formula given by Ronald (2001) in Arc GIS weighted overlay extension tool. The logical work flow of the research is presented in (figure 2).

$$S = \sum W_i X_i; \dots\dots\dots\text{equation (1)}$$

Where; S is suitability, \sum is sum. Wiis weight of factor and Xi is Criterion score factor.

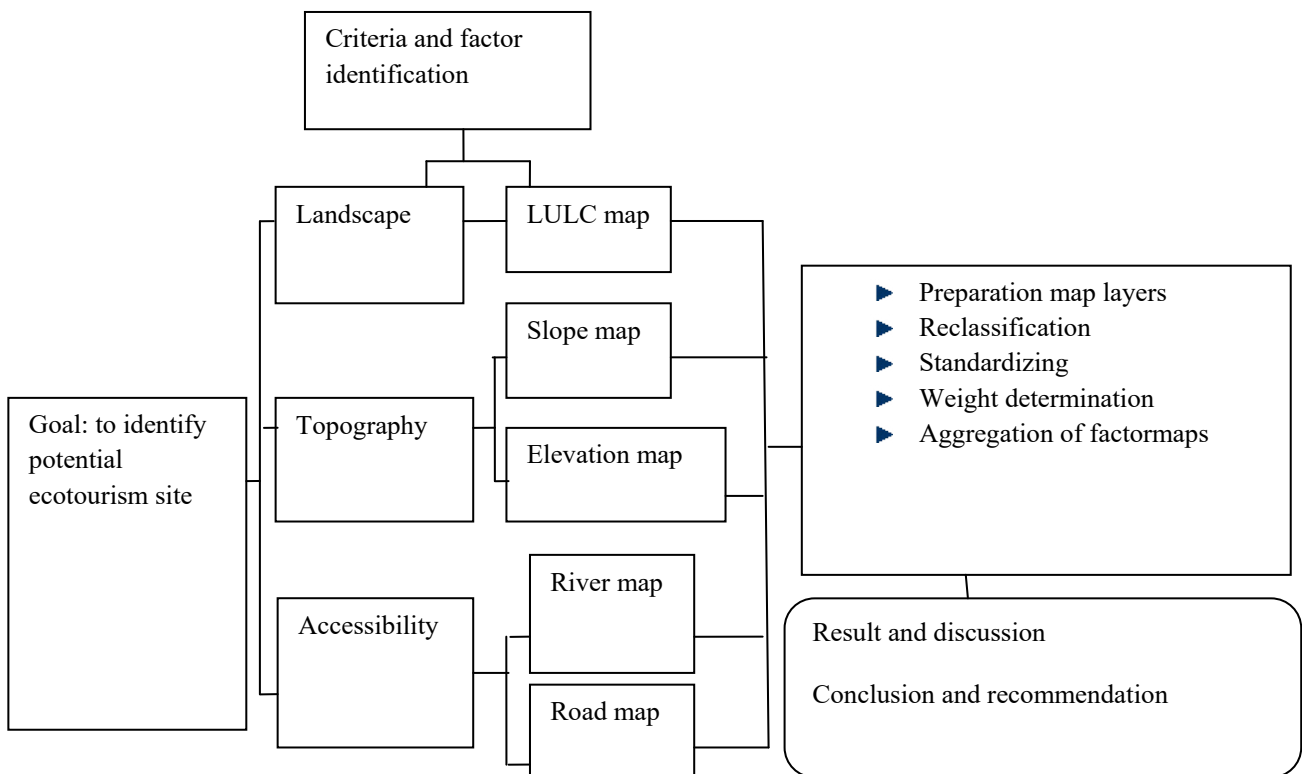


Figure 2: Frame work of the study

Source: Field work, 2018

Selected Factors for Ecotourism Suitability Criteria

Landscape/land use and Land cover

Landscape represents the distribution and variation of features in a given geographic area (Suryabagavan, 2015). The land cover is taken as one major parameter that affects the suitability modeling. Land use is the way in which, and the purpose for which, human beings employ the land and its resources. Examples include farming, mining, and logging. Land cover is also the physical state a surface. The term, originating, referred to the type of vegetation that covered the land surface, but has broadened subsequently to include human structures, such as buildings or pavement, and other aspects of the physical environment, such as soils, biodiversity, surface and groundwater. Land use Land cover map is useful for resources assessment, land use planning, land evaluation, and land use/ land cover change detection, etc. Likewise, (Figure 3) depicts the land use/land cover map of the study area (Ayele, 2006).

In order to make sample collection and classification process easily, land use/land cover nomenclatures (identification) are required to create and define the possible land use/land cover classes first (Alebachew, 2011). In this study, five major land use/land cover nomenclatures: farmlands, forest, bushland grassland, grazing land, and bare lands were used to produce the final land use/land cover map of the study area.

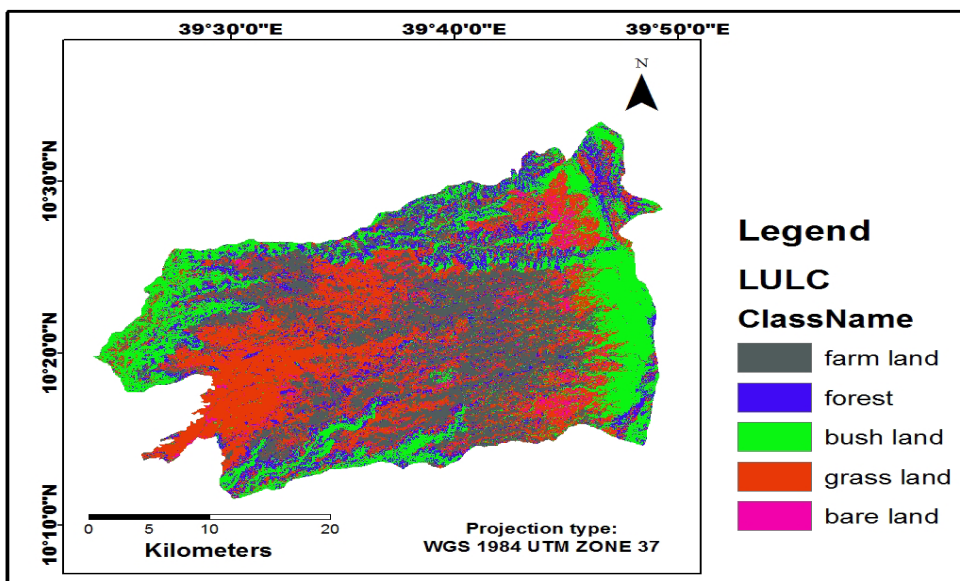


Figure 3: Land use land cover map of the study area

Source: Field work, 2018

Land use land cover map represent the spatial distribution of the land use manner in a study area. As it is indicated in the above LU/LC map of the study area (figure 3), 32.7 % (53900 ha) of the study area is covered by grassland, followed by bushland and farmland 25% (27289.8 ha) and 24.2 percent (26573.13ha) respectively. Forest also covers 15 percent (16861.6 ha). The last share is bare land, which accounts 2.7 percent (3013.65 ha) from the total area of the study area. This result indicates large size of land use/land cover is highly important for ecotourism suitability. For example, forests and bushland even grasslands are highly important for ecotourism and environmental sustainability. Altogether, those features take the lion's share in the case of the study area. Another feature (bare land) is less or not important for ecotourism.

Accuracy Assessment

In order to determine classification accuracy, it is necessary to determine if the output map meets, exceeds, or does not meet certain predetermined classification accuracy criteria. One of the most common methods used to assess classification accuracy is the use of an error matrix (sometimes called a confusion matrix). Currently, accuracy assessment is considered as an integral part of any image classification. This is because image classification using different classification algorithms may classify pixels or group of pixels to wrong classes. The most obvious types of error that occur in image classifications are errors of omission (producer accuracy) or (user accuracy) commission (Alebachew, 2011).

Therefore, in this study, the overall, user’s and producer’s accuracies, and the Kappa coefficient were calculated (Table 2). The error matrix was obtained from reference data [ground control point (GCP)] with the help of Arc GIS 10.3 software accuracy assessment operations data management extensions. The researchers executed field observation and random ground truth data collection using GPS from well-known sample sites to arrive at reasonable validation statistics. The study assessed the image classification accuracy by using 97 random GCP for all land use classes (22, 17, 22, 14 and 22 for farmland, forest, bushland, grassland, and bare land respectively).

Table 2: Error matrix table

Class category	Reference (GCP) data						Producer accuracy %	user accuracy %
	1	2	3	4	5	Total		
Farm land (1)	19	0	1	0	1	21	86.36	90.47
Forest (2)	0	15	1	0	1	17	88.25	88.23
Bush land (3)	1	0	19	0	1	21	86.36	90.47
Grass and pasture land (4)	1	1	1	12	2	17	85.71	70.58
Bare land (5)	1	1	0	2	17	21	77.27	80.95
Total	22	17	22	14	22	97		

Source: Field work, 2018

Overall accuracy

This is computed by dividing the total correct number of pixels [i.e. summation of the diagonal (19+15+19+12+17= 82)] to the total number of pixels in the matrix [grand total (97)]. It can be expressed by X_{ii} and N as:

$$\text{Overall Accuracy} = \sum X_{ii}/N \dots \dots \dots \text{equation (2)}$$

Where, X_{ii} = Number of correctly classified pixels, or the diagonal value and

N= entire number of pixels in the matrix.

Therefore, the overall accuracy under this classification is, 84 %; which is (82/97)*100

Producer’s accuracy

This refers to the probability of a reference pixel being classified correctly. It is also known as omission error because it only gives the proportion of the correctly classified pixels. It is obtained by dividing the number of correctly classified pixels in the class category by the total number of pixels of the category in the

reference data. As clearly indicated in (Table 2), lower producer’s accuracy exists for bare land class (77.27 %). The remaining 22.73 % percent is omission error. This is probably due to the similar spectral properties of pixels in this land use/land cover classes with some of the other features example, like bare land similar to grassland and pasture land in dry season and from land under crop harvesting season, and fallowing time may have a relative similar spectral property and might make the researcher to identify at pixels level.

User accuracy

This presents the probability that the pixels in the classified image of the study area represent that class on the ground. It is obtained by dividing the total number of correctly classified pixels in the category by the total number of pixels on the classified data. As in the case of this study, from the user’s accuracy point of view, grassland and pasture land presented low accuracy (70.58 %). This implies that, to some extent, it is misclassified. This is probably caused by the presence of grassland and pasture land associated with other land use class in the study area, and due to the GPS device low accuracy.

There is also another term for classification accuracy assessment which is kappa coefficient though it lacks practical applications in reality discussed by (Robert, and Marco, 2011), calculating the kappa coefficient is commonly used in different studies (Alebachew, 2011; Biresa, 2012; Chernet, 2009).

Kappa coefficient

The Kappa coefficient, which measures a classification agreement, can also be used to assess the classification accuracy. It expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification (ENVI, 2013; Congalton, 1999). The Kappa coefficient (K) is calculated using the information in the error matrix table (Table 3) and using equation given by (Congalton, 1999).

$$K = \frac{N \sum_{i=1}^r X_{ii} - \sum_{i=1}^r (X_{i+} \times X_{+i})}{N^2 - \sum_{i=1}^r (X_{i+} \times X_{+i})} \dots\dots\dots\text{equation (3)}$$

Where: r = is the number of rows in the matrix; X_{ii} = is the number of observations in rows i and column i (along the major diagonal); X_{i+} = the marginal total of row i (right of the matrix); X_{+i} are the marginal totals of column i (bottom of the matrix); N is the total number of observations.

Therefore, to get the kappa coefficient of the classification process, the Congalto formula applied.

$$K = \frac{(\text{total} \times \text{sum of correct}) - \text{sum of the all the (Row total} \times \text{column total)}}{\text{total squared} - \text{sum of the (Row total} \times \text{column total)}} \dots\dots\text{equation (4)}$$

$$\frac{(97 \times (19 + 15 + 19 + 12 + 17)) - ((21 \times 22) + (17 \times 17) + (21 \times 22) + (17 \times 14) + (21 \times 22))}{(97)(97) - ((21 \times 22) + (17 \times 17) + (21 \times 22) + (17 \times 14) + (21 \times 22))}$$

K = 0.80

Therefore, K= 0.80 implies that the classification was relatively good. It is reasonable to employ the generated map for further analysis and studies of potential ecotourism site selections.

Topography

Topography is recognition of physical properties and morphological status of a study area, by considering different physical criteria. It also shows the differences in altitude and surface structure of any part of the earth. Again, it refers to various landforms (physical features) which represent the external shape of a place. For this study among different topographic criteria, elevation and slope were considered.

Elevation

Elevation, also called altitude, is the height of a place above (or below) a reference level, such as mean sea level. Altitude, like latitude, acts through climatic conditions to exert a major influence upon the distribution and abundance of living things (Zegeye, 2012). Topography influences the distribution of different natural resources; fauna and flora distribution. This in turn has a direct relationship in ecotourism activities. For example, some ecotourist prefers to have a journey to high land area and to enjoy and appreciate. Others may also prefer to go to low land and to show the available interesting resources and features. Therefore, using elevations map as a factor, when preparing the ecotourism suitability model for a certain area to become viable. There are different types of DEMs; such as TIN, contour, and GRIDDED. For this study, the Elevation of the study area was generated from a DEM which is one of the scaled models of topography.

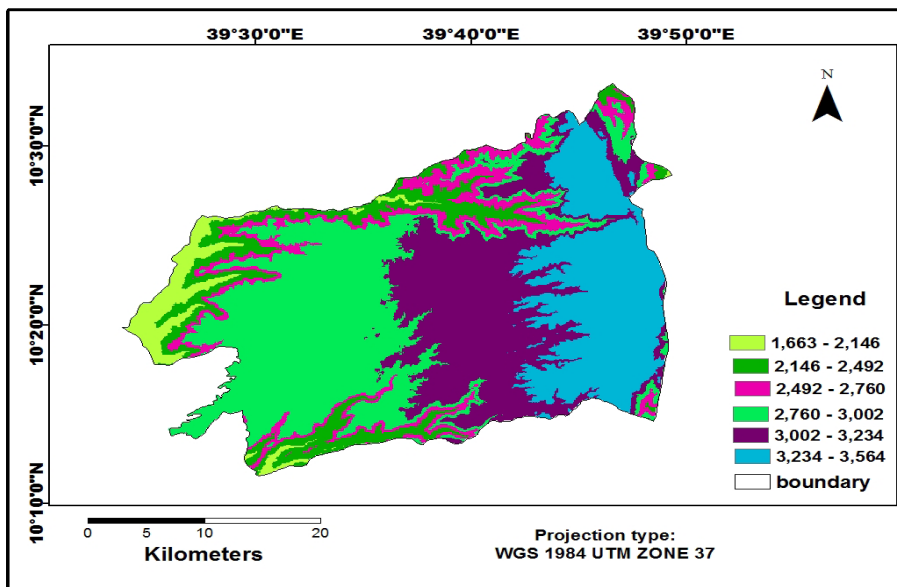


Figure 4: Elevation map of the study area

Source: Field work, 2018

Table 3: Percentage share of the elevation map

Elevation range (m) a.s.ls	Area (ha)	Percent (%)
1663-2146	499.41	4
2146-2492	1127.52	10
2492-2760	1105.02	9
2760-3002	38255.99	33
3002-3234	2815.47	24
3234-3564	2352.06	20

Source: Field work, 2018

Slope

Slope represents the gradient of an area expressed either in percent or in degree. It is computed as the vertical increase divided by the horizontal increase. Slope can also be classified as gentle and steep slopes. Those experiencing little variation are gentle slopes while those experiencing extreme variations are steep slopes (Mihret and Yohannes, 2015).

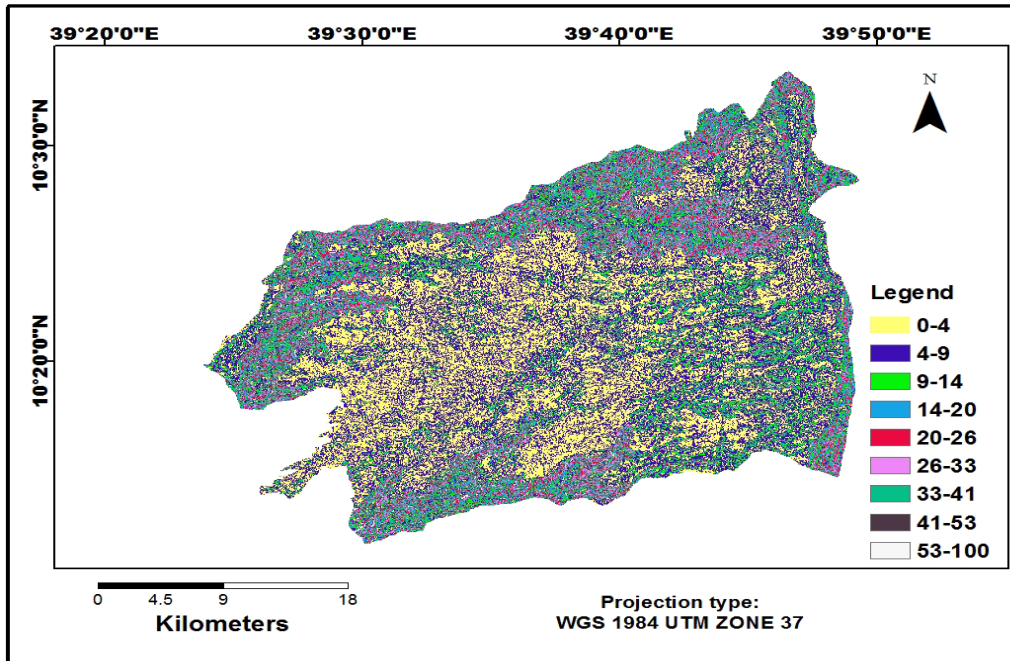


Figure 5: Slope map

Source: Field work, 2018

Table 4: Percentage share of the slope map

Slope range (percent)	Area (ha)	Percent (%)
0-4	33178.5	30.3
4-9	36605.07	33.4
9-14	14310.54	13
14-20	9991.44	9
20-26	6662.61	6
26-33	4486	4
33-41	2495.79	2.3
41-53	1882.22	1.3
>53	425.7	0.4

Source: Field work, 2018

Accessibility

Accessibility simply refers to the relative ease by which the location of activities can be reached from a certain area. According to a study conducted by Kudeep (2013), accessibility is the prerequisite for ecotourism development. Ecotourism needs fair connectivity over land. One travels from point of origin to the destination in pursuit of tourism-related activities. This is possible by road connectivity: good road network connectivity with proximity or nearness to scenic beauty (Like River and other natural resources)

depicts high suitability. It provides a facility for easy and faster movement. In a terrain where another mode of transport is not available, road provides the most convinces means of transport.

Road

Roads are considered as the tourism industry arteries. This system makes a communication line between destination, accommodation and natural attractions. The existence of roads in nature leads to rupture in the landscape and reduce the apparent values for tourists.

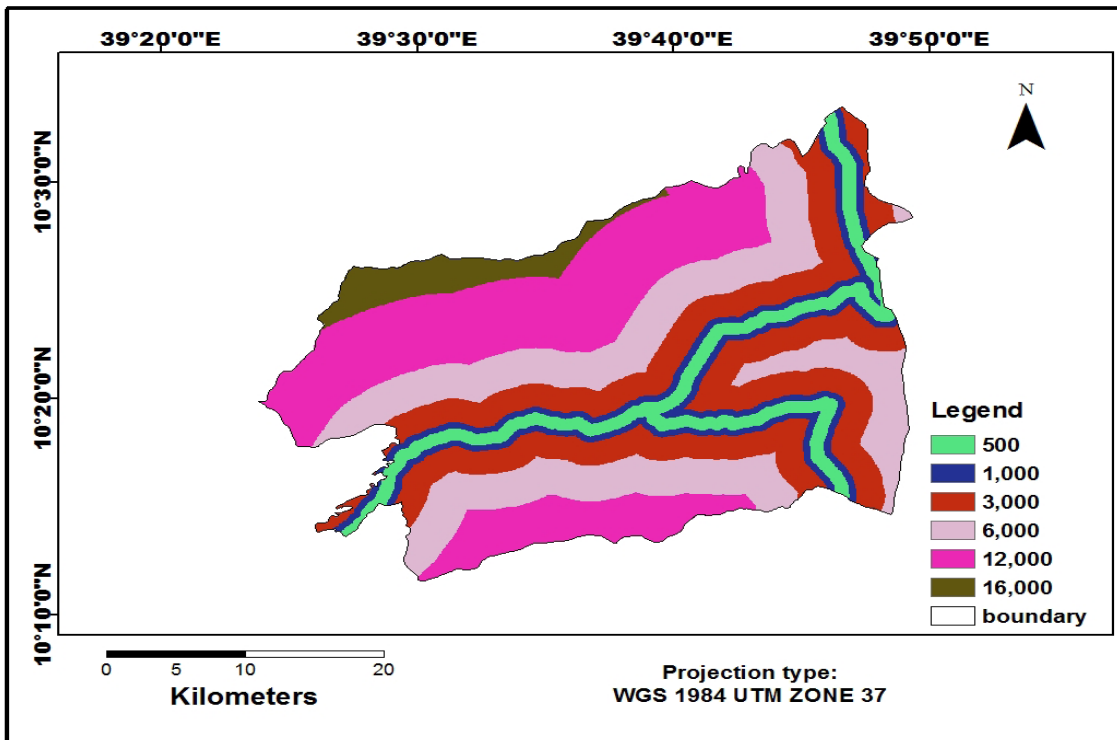


Figure 6: Road buffer map

Source: Field work, 2018

Table 5: Percentage share of the road map

Distance (m)	Area (ha)	Percent (%)
500	8750.43	7.988
1000	8078.76	7.37
3000	26652.78	24.3
6000	29190	26.6
12000	31704	28.9
16000	5167	4.7

Source: Field work, 2018

As clearly indicated in the road buffer map (Figure 6) of the study area and as shown in Table 5, most part of the area is found out of road accessibility. For example, 28.9 % and 4.7 % of the study area is far from 12 km and 16 km from the available road respectively. Whereas 7.98%, 7.3% and 24 % of the area is located near to the road access, which is far away by 0.5km, 1km and 3 km respectively.

River

Water bodies are ideal for ecotourism as they provide recreational spaces. It can be developed for tourism-related activities. For example, river and riverfronts can be developed into the active sport and water-based recreational site like white water rafting, fishing, swimming and for different bird watching activities.

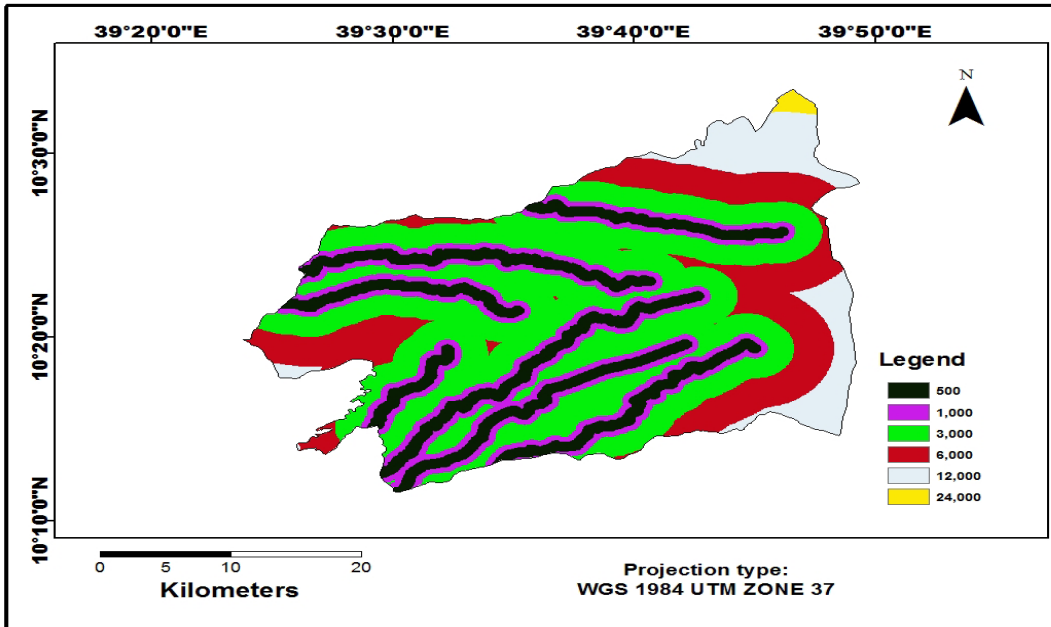


Figure 7: River buffer map

Source: Field work, 2018

Table 6: Percentage share of the river map

Distance (m)	Area(ha)	Percent (%)
500	17649	16.11
1000	17070.7	15.58
3000	44250	40
6000	19783	18
12000	10259	9.36
24000	528.48	0.48

Source: Field work, 2018

As indicated in Figure 7 and Table 6, the areas nearest to the river account more share than the outlying areas. For example 16%, 15% and 40 % of the area is far away by 0.5km, 1km and 3 km from the river. Therefore, the area accounts for a total of 60%. This shows that most part of the study area is located nearby a river. This also makes the area to have a high ecotourism potential. On the other hand, the proportional share of remote areas is relatively low. For example, the area distant up to 12km and 24km from river accounts 9.3% (10256.4 ha) and 0.4% (528.4 ha) respectively.

Multi-criteria Decision Making (MCDM)

A decision can be defined as a choice between alternatives, where the alternatives may be different actions, locations, objects, and the like. For example, one might need to choose which area is the best location, or perhaps identify which areas will be best suited for certain activities. According to research conducted by (Eastman, 2001), MCDM provides a number of techniques and procedures for structuring decision problem

and evaluating, and prioritizing alternative decisions. Multi-criteria decision making (MCDM) problems typically involve criteria of varying importance to decision makers. The derivation of weights is a primary step in clearing the decision maker’s performance preferences. Weight is a critical step in eliciting to an evaluation criterion that indicates its importance relative to other criteria under consideration (Ayele, 2006).

Multi-criteria Evaluation

To evaluate ecotourism suitability, five-factor maps namely; land use land cover map, elevation map, slope map, road map, and river map were considered. These factor maps were selected based on their relevance to the study area. These factors had been used for ecotourism site mapping by many researchers (Suryabhadgavan, 2015; Tewari, 2010). These factors were first ranked and reclassified based on questionnaires prepared for this purpose. The questionnaire was distributed to experts working on Tourism and Land and Agricultural office of the district. The ranking for those land use land cover class and factor maps were computed based on the statistics derived from the results of the questionnaire (Table 7).

A total of 12 questionnaire (6 agricultural experts and 6 tourism office members) were distributed, and the experts ranked those LULC classes and factors based on their significance for ecotourism suitability found in the study area. Most suitable classes and factor maps were given the least value (1st rank), whereas the least attractive sites were given the highest value (5th rank). To evaluate the questionnaire, a matrix was developed in which the column matrix indicates the value of rank while the row matrix indicates a list of LULC classes and factor maps. Values given to each category were then multiplied by the total number of respondents to that class or factor map, and these were aggregated for all lists of ranks. To determine the final value of rank, the aggregate value (total weight) of each attraction was divided by the number of respondents to that attraction category. Average weight with the minimum number takes the first rank order and the maximum average weight takes the last rank.

Table 7: Questionnaire matrix

Possible Attractions categories	Rank					Total weight	Average weight	Class rank	Factor rank
	1 st	2 nd	3 th	4 th	5 th				
LulcMap	6	4	2			20	1		1
Forest	5	5	2			21	1.05	1	
Bush Land	4	5	3			23	1.15	2	
Farm Land	1	2	3	3	3	41	2.05	4	
Grass Land	4	3	4	1		26	1.3	3	
Bare Land				1	11	59	2.95	5	
River Map	2	3	4	4		36	1.8		4
Road Map	4	4	2	3		29	1.45		3
Slope Map		1	3	4	4	47	2.35		5
Elevation Map	4	4	3	1		25	1.25		2

Source: Field work, 2018

As the above questionnaire’ matrix (Table 7) shows, the average weight, and rank of Forest, Bush Land, Farm Land, Grass Land, and Bare Land are 1.05, 1.15, 2.05, 1.3 and 1, 2, 4, 3 and 5 respectively. Similarly, the weight and rank of the identified factor map are 1, 1.8, 1.45, 2.35 and 1.25 while 1, 4, 3, 5 and 2 are for land use land cover map, river map, road map, slope map and elevation map respectively.

Reclassified land use land cover map

The first stage in multi-criteria evaluation is preparing a land use data to classify the land use and land cover according to their importance. As clearly stated by TEWODROS (2010), landscape attractiveness increases with vegetation cover. Diversity and density in vegetative communities in the landscape can produce spatial patterns that may carry higher scenic values for a visitor. Land use types would be in conflict or in line with ecotourism activities in the case of certain geographic area. Therefore, reclassifying based on the situations is necessary. Reclassification of land use land cover types was done based upon the relevance to the study area, experts’ opinion and literature reviews. Accordingly, bushland and forest land get the first rank (i.e. highly suitable); grassland, 2; farmland, 3; and bare land, 4. Figure 8 shows the reclassified LULC map of the study area. This is because in the case of the study area, most ecotourism potential resources are included in the first two classes (i.e. forest and bushlands). Whatever be the case, forest land is one of appealing land use for ecotourism development. Since grassland is found associated with forest and bushland, there are a number of endemic species. In the case of farmland, it is not commensurable with ecotourism. Soil features can greatly affect tourist activities in tourist destinations in that marsh soils severely limit recreational activities, or walking on loosely structured soils can cause severe erosion. So, farmland may not be significant. Hence, the intention of this study is to generate ecotourism suitability model map, the rank of farmland is appropriate.

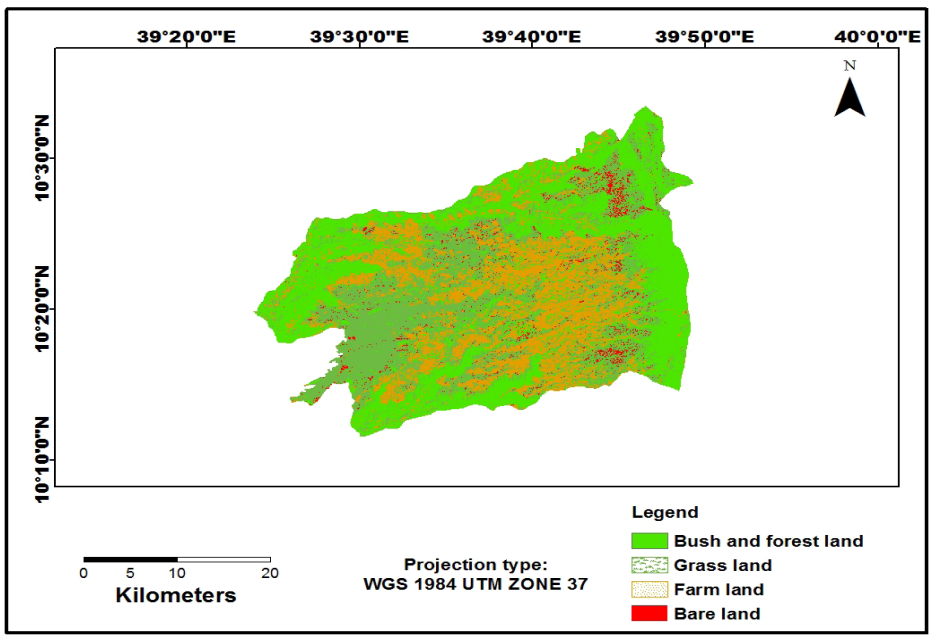


Figure 8: Reclassified LULC map

Source: Field work, 2018

Reclassified elevation map

Some of earlier studies suggested that topography/elevation is one of the most important dimensions of

attractiveness in the landscape (Chernet, 2009; Rahman, 2010). The higher elevation range has higher suitability value for scenic attraction because such land feature is usually not found everywhere, and it is attractive to human visual (Chernet, 2009; Kebede, 2010). Elevation value of the study area ranges from 1663m to 3564m. For ecotourism suitability, highest elevation is preferable. Accordingly, the highest rank was assigned to the highest elevation, and vice versa. Elevation range between 3098 and 3564 is reclassified as 1st rank (i.e. suitable); between 2698 and 3098, 2; between 2240 and 2698, 3; and, between 1663 and 2240, 4. Figure 9 depicts reclassified elevation map of the study area.

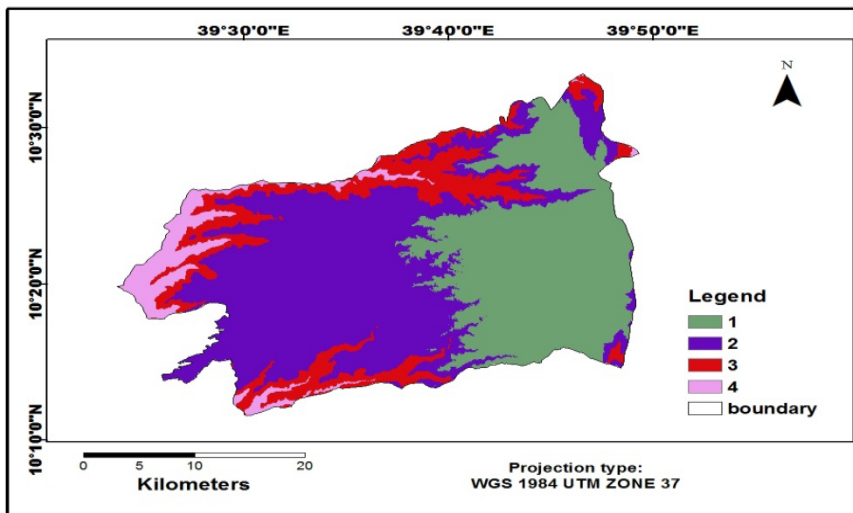


Figure 9: Reclassified elevation map

Source: Field work, 2018

Reclassified slope map

The slope of the terrain surface can be expressed either in degree or in percentage. The slope change of the study area determined and expressed in percentage and reclassified (Figure 10). A slope is important for ecotourism because all terrain features are derived from complex landmasses. As indicated in research conducted by TEWODROS (2010) and Sridam (2015), terrain properties such as convexity and concavity generate undulation in slope profile, which appears visually attractive to observers across a wider geographical area. Since cliff and hanging wall landscape is the result of steep slopes that create good scenic beauty, it is more suitable for ecotourism than a gentle slope. As a result, the highest rank is assigned to the highest slope values while the lowest rank is given to the lowest slope value. A slope value between 0 % and 7 % is ranked as 4; between 7 % and 18 % as 3; between 18 % and 32 % as 2; and above 32 % as 1.

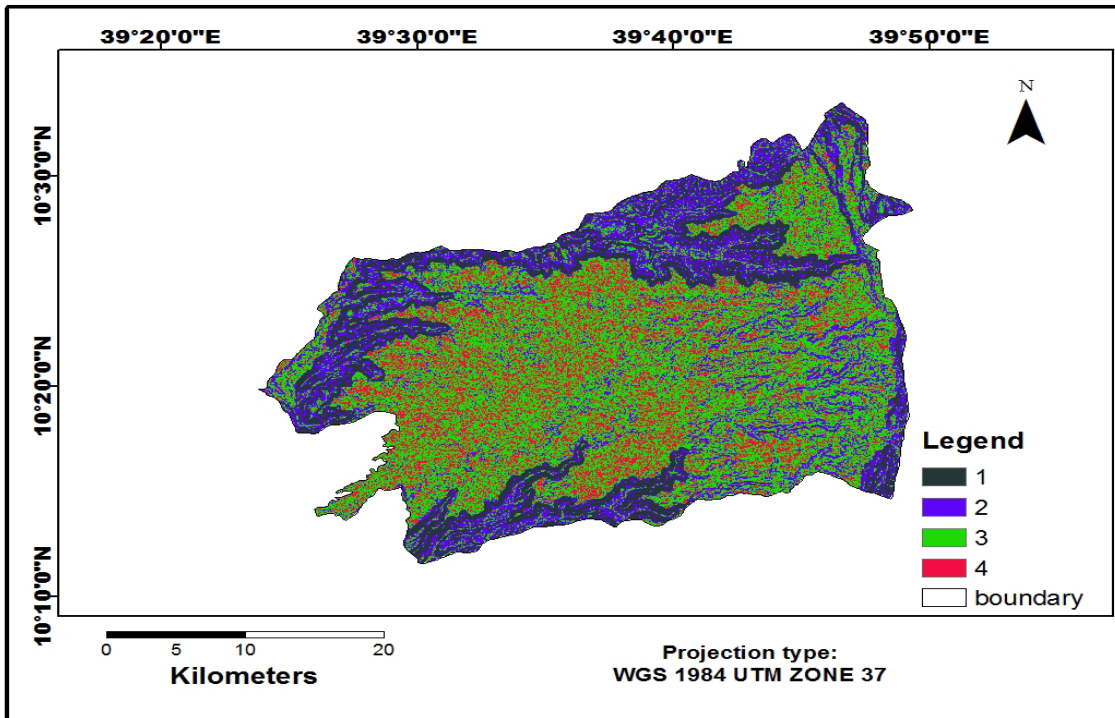


Figure 10: Reclassified slope map

Source: Field work, 2018

Reclassified river map

Water resources play a determining role in tourist destinations. Tourists prefer to spend their leisure time somewhere; possibly a place which has the closest distance from water sources such as springs, rivers, wetlands, lakes, etc. Tourists are very attracted to water sources. Since, it would have a greater potential for ecotourism development. River map is represented by line feature and it is not compatible with MCE. Firstly, the line feature should group into the buffer zone and convert into raster feature, then reclassified based on their suitability (Tewodros, 2010). As a result, the highest rank is assigned to the lowest buffer distance, and lowest rank is given to the highest buffer distance. Thus, the areas which are found below 1 km buffer zone are reclassified as 1; between 1km and 3km as 2; between 3km and 6km as 3 and above 6km as 4 (Figure 11).

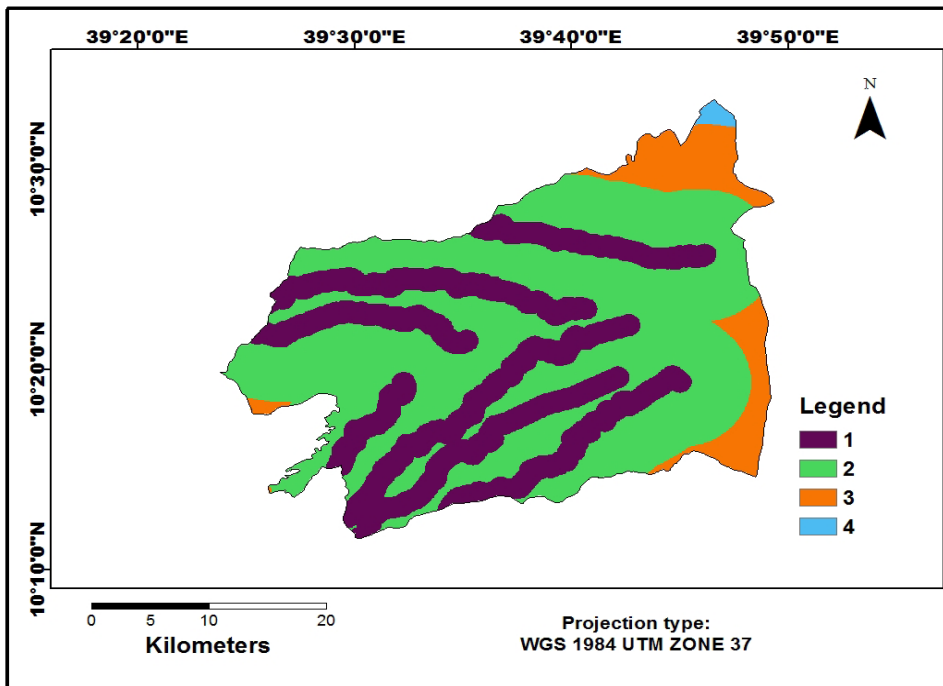


Figure 11: Reclassified river map

Source: Field work, 2018

Reclassified road map

Road accessibility is essential for ecotourism development. Whatever the unique natural resources and features a given area has, if it is extremely out of access, its value to ecotourism development is meaningless (Mihret and Yohannes, 2015). Since the source of the road map for this study is topo sheet, it was first digitized in Arc GIS environment and changed to line feature. Then after multiple rings buffering operation, it was changed to raster to make it more compatible with multi-criteria evaluation. Finally, it is reclassified based on their suitability. Ecotourism activities are not recommended in those extremely remote areas. As a result, highest rank (first rank) is assigned to nearest areas which have low buffer zone distance, while lowest rank is given to remote area from road access. Thus, the areas which are found below 1km buffer zone are reclassified as 1; between 1km and 3km as 2; between 3km and 6km as 3; and above 6km as 4 (Figure 12).

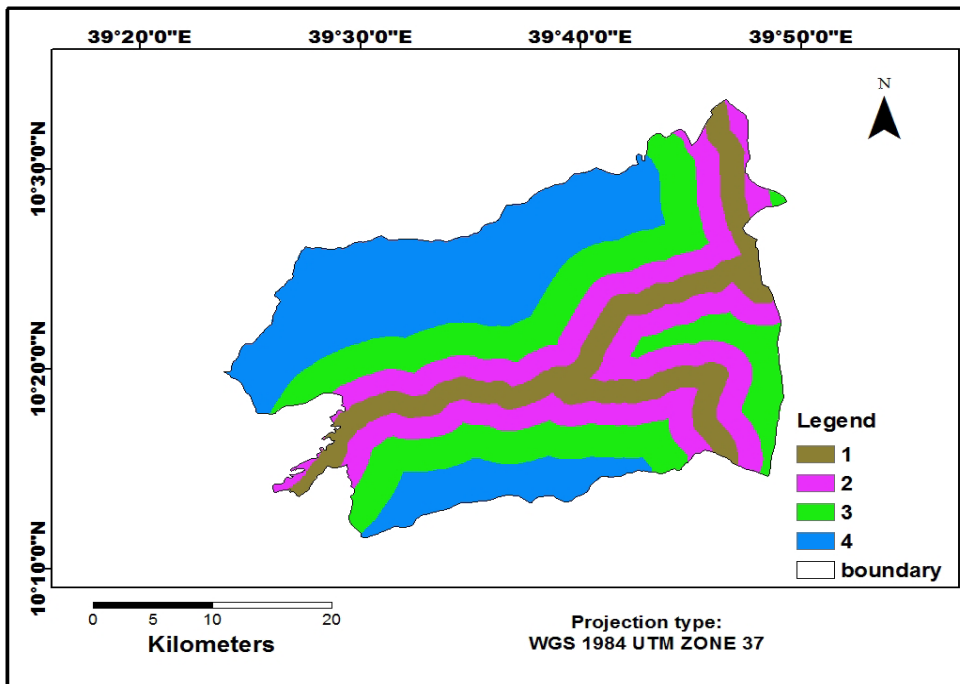


Figure 12: Reclassified Road map

Source: Field work, 2018

Weighted Overlay, Evaluation and Suitability Analysis

Assigning a weight to each reclassified raster factor map in the overlay process allows controlling the influence of different criteria in the suitability model. The weighted overlay is one method of modeling suitability. Arc GIS uses the following process for this analysis.

- Each reclassified raster layer is assigned a weight in the suitability analysis.
- Values in the rasters are reclassified to a common suitability scale.
- Raster layers are overlaid ,and each raster cell`s suitability value is multiplied by its layer weight then finally total value of each multiplication derive the suitability value.

Weight for each factor maps was assigned based on the relevancy to the study, by considering the situation in the study area as well as using a pairwise comparison method. As stated by Kolios, Mytilinou, Lozano-Minguez, and Salonitis (2016), in quick binary approach (Boolean analysis) all influencing factors have equal importance. However, most often, criteria or factors do not equally influence the decision.

Table 8: Pairwise comparison matrix

	Lulc	Elevation	slope	Road	River
Lulc	1	2	7	3	3
Elevation	1/2	1	5	3	3
Slope	1/7	1/5	1	1/3	1/3
Road	1/3	1/3	3	1	1
River	1/3	1/3	3	1	1
sum	2.309524	3.866667	19	8.333333	8.333333

Source: Field work, 2018

As it is indicated in the pairwise comparison matrix (Table 8), LULC is equal to moderate important than elevation, very strongly important than slope, and moderately important than road and river for ecotourism.

The elevation factor is strongly important than the slope, and moderately important than road and river. On the other hand, the slope is moderately less important than road and river, very strongly less important than land use land cover, and strongly less important elevation map. Road and river are moderately less important than land use land cover and elevation respectively. Finally, Road and river have equal importance to each other.

To determine the weight of each factor map, normalization process is needed. To normalize the above pairwise matrix value (Table 9), each cell value is divided by its column total (sum). To get the weight of each class, the mean value of the row calculated.

Table 9: Normalization result

	Lulc	Elevation	slope	Road	River	weight
Lulc	0.43	0.51	0.36	0.36	0.36	41
Elevation	0.2	0.23	0.36	0.36	0.36	30
Slope	0.06	0.05	0.04	0.04	0.04	5
Road	0.14	0.08	0.12	0.12	0.12	12
River	0.14	0.08	0.12	0.12	0.12	12

Consistency ratio=0.021 < 0.1 (acceptable)

Source: Field work, 2018

Therefore, the weights of land use land cover map, elevation map, slope map, road map, and river map are 41%, 30%, 5%, 12% and 12% respectively. Accordingly, the prioritizing of factor maps from highest to lowest is as follows: land use land cover map, elevation map, road map, river map, and slope map. The final ecotourism suitability map was then computed by multiplying each factor map layer by their respective weight in Arc GIS software extension, weighted overlay.

$$\text{Finally, the ecotourism Suitability map} = 40 (\text{land use-land cover map}) + 30 (\text{elevation map}) \\ + 5 (\text{slope map}) + 12(\text{road map}) + 12 (\text{river map})$$

Weighted Overlay is a technique for applying a common measurement scale of values to create an integrated analysis. It is common with such Geographic problems, which often require the analysis of many different factors.

While running the suitability model using a weighted overlay, the cell values of each input factor maps are multiplied by the estimated weight (percent of influence). The resulting cell values are added to produce the final output raster model. The value “1” indicates the highly suitable site whereas the value “4” indicates not a suitable site. Finally, a raster of overall suitability model is created with four suitability classes; highly suitable, moderately suitable, marginally suitable and not suitable.

Results and Discussions

Ecotourism suitability map developed for Menz-geramidir District

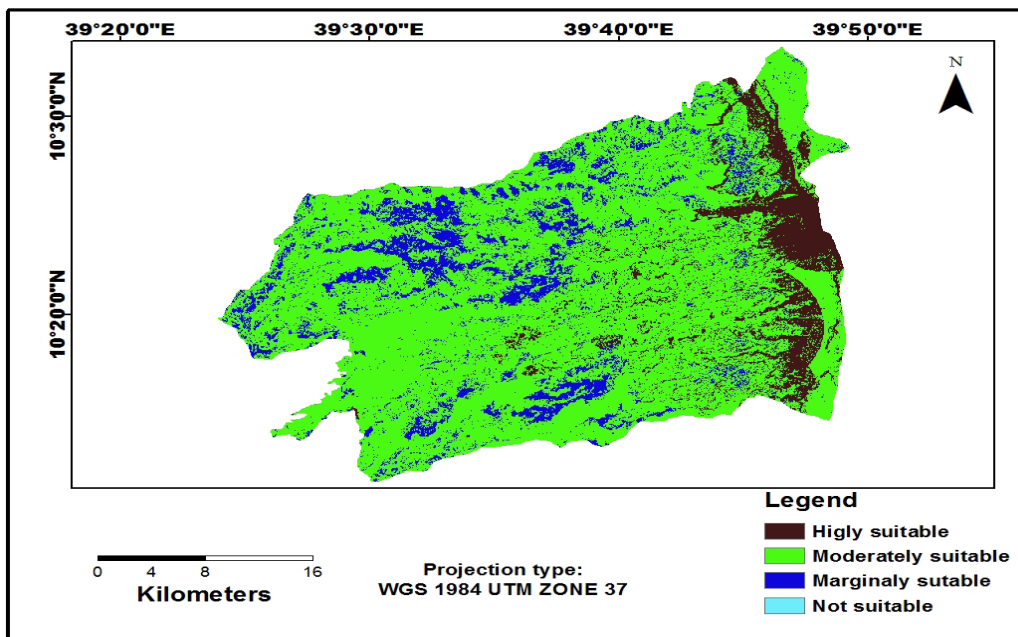


Figure 13: Ecotourism suitability map

Source: Field work, 2018

As indicated in Figure 13, the ecotourism suitability model map was generated by using FAO’s four suitability classes; highly suitable, moderately suitable, marginally suitable and not suitable. This suitability class scheme, also applied by different researchers on their ecotourism potential site identification studies (Chernet, 2009; Mihret & Yohannes, 2015; Sridam, 2015). According to previous studies (Biresa, 2012; Giday, 2014), areas which satisfy almost all criteria are grouped under the highly suitable class. Therefore, the result of this study shows that a large part of the highly suitable area lies in the eastern part of the study area. On the other hand, the map shows that, even though their proportion is relatively insignificant, the suitable sites lie in the central part of the study area. Specifically, Anazsted and Guassa community-based conservation area, wojed (fertile) forest and ridge topography, Siregedel plateau, attractive land features and upper gorges of Shay, Wizar River, and around Mehalmeda are among the highly suitable sites in the study area. In the case of the second class, moderately suitable is the suitable capacity of sites with medium, and satisfies most of the criteria set up, but some criteria are not satisfied. It is surprising to see that most parts of the study areas are incorporated under a moderately suitable category. Almost all southwestern and central part of the district has moderate potential for ecotourism and related activities. Those grass and open communal land areas like Amedguya, some part of Guassa areas and Quangue area are grouped under the moderately suitable areas. The marginally suitable site is an area with low suitability and satisfies some of the criteria set up, but most of the criteria are not satisfied (Sridam, 2015). Thus, in this study, the marginal suitable sites are found dispersedly in the northern and southern part of the study area. However, the proportion of non-suitable site is almost insignificant in all parts of the study area. In this case, we can understand that all of the criteria are not satisfied. The share of these suitability classes is summarized in Table 10.

Table 10: Ecotourism sites percentage share

Suitability class	Area (ha)	Percent (%)
Highly suitable	11908.44	11
Moderately suitable	82613.79	75.6
Marginally suitable	14742.54	13.5
Not suitable	6.84	0.00626

Source: Field work, 2018

As shown in Figure 12, out of the total study area, 11% percent (11908.44 hectares) is a highly suitable area for ecotourism and environmental sustainability under the current situation. As explained by Suryabhadgavan (2015), the ecotourism processes are highly maintained by natural species and features diversification. Therefore, based on the identified factors and criteria, this site contains most ecotourism potentials, and considered as the first ecotourism related recreational and developmental site. The moderately suitable sites also account around 75.6 % (82613.79 hectares). This implies that if there is comprehensive and participatory ecotourism planning within a short period of time, most part of the study area can be suitable. The rest, marginally suitable areas account 13.5% percent (14742.54 hectares) of the district, which mainly laid on most part of farmland; this is the area where almost all local communities are found. Such areas have great potentials, if they get the required attention from any concerned bodies, to maintain sustainable ecotourism development and to make the local community more beneficiary. Nahid et al. (2011), suggested active participation of local communities to ecotourism activities have significant power to maintain sustainable development. Several previous research studies conducted (Julie Dasenbrock, 2002; Lowmen, 2004; Ngece, African, & Development, 2002; Weggoro, 2008) revealed that, due to low living standard in villages, the presence of ecotourists and ecotourism activities can contribute to economic and livelihood diversification for local communities by creating new jobs, employment opportunities, development of infrastructures, etc. The other 0.006% or 6.84 hectares of the study area was considered as a ‘not suitable’ site. It is insignificant in its share, but this indicates the area is less important for environmental sustainability and ecotourism activities. Thus, it requires an impact assessment and environmental management. Moreover, the area can serve as a source of raw material for infrastructure development.

Discussion

One of the most important applications of the geospatial technique is the display and analysis of data to support the process of spatial and environmental decision-making. The application of GIS and RS in so many spatiotemporal analysis and studies are common at a different scale. However, in ecotourism, it is at a minimum stage. It has been mentioned in (Chernet, 2009). In Ethiopia, the application is uncommon, though its roles in different spatial modeling are expressed literally. The researchers believed that this study is one of few that have been done concerning ecotourism in Ethiopia. For ecotourism site selections, there is no uniform standard in the overall procedure of the operations; rather, it is applied based on nature, situation and available resource in a given geographic area. For example, according to a study conducted by Chernet (2009), urban area may be concerned with the available socio-economic infrastructures. In another area, the center of discussion may be the availability of natural and cultural aspects. In ecotourism, suitability mapping, considering natural factor and criteria should come first. Other socioeconomic variables become better for further study with regard to the impact of ecotourism in a certain area (Alemayehu, 2011).

Therefore in the case of this study, considering the nature of the study area and the available information, time and resource, the researchers tried to include three criteria and five-factor maps. Namely: landscape (land use land cover map); topography (elevation and slope map); and accessibility (road and river map). MCE is done based on those factor maps to produce the site suitability for ecotourism.

The results of this research findings and analysis were performed based on geospatial techniques and multi-criteria evaluation methods. The AHP method was applied to determine the relative importance of all selected factors. Analytic Hierarchy Process (AHP) is one of multi-criteria decision-making method that was originally developed by Saaty (1980). In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurements such as price, weight, etc., or from subjective opinions such as satisfaction, feelings, and preference. AHP allows some small inconsistency in judgment because human is not always consistent.

The influence of identified factors for the analysis is not equally important to select potential ecotourism sites. This difference can be managed by multi-criteria evaluation. With this study, pairwise comparison technique was applied for weight calculation of each factor based on their relative importance. Some writers also used this procedure in their ecotourism site selection studies (Chernet, 2009; Kifle, 2015; Mihret & Yohannes, 2015). Therefore, an important factor has a greater impact on the outcome than other factors. Hence, the weight LULC map is 41% and the remaining elevation map, slope map, road and river map is 30%, 5%, 12% ,and 12% respectively. This research revealed that, the calculated consistency ratio (CR) from pairwise comparison matrix is 0.021 (less than 0.1), which indicates that a reasonable level of consistency in the pairwise comparisons and weights is acceptable.

After the factor maps were developed and their respective weights assigned to each input layer (factor maps), an aggregation process was undertaken to combine them. Each factor map was reclassified and standardized to a common numeric range based on their importance ranging from 1 to 4, indicating a variation from least suitable to a most suitable site. Factors are measured on different scales. It is necessary that factors have to be standardized before combination as outlined by Samo and Anka (2009) so that all factor maps are positively correlated with suitability. GIS overlay process for the combination of factors uses a weighted overlay process (Shenavr & Hosseini, 2011). Weighted Linear Combination (WLC) technique was used to aggregate the factor maps applied in this study. According to a study conducted by Attua and Fisher (2010), the map overlay approach has been applied in the form of WLC in different suitability analysis. This is because, this method is easy to implement using a GIS system with overlay capabilities and allows the evaluation of factor map layers to be combined in order to determine the composite map layer which is the ecotourism suitability map. The WLC of MCE techniques for potential ecotourism site selection has been reported by a number of studies (Bunruamkaew, 2013; Sridam, 2015). Finally, the ecotourism suitability model map is then presented based on FAO's suitability scheme in four classes. The result indicated that 11% of the study area is highly suitable for ecotourism and environmental sustainability under the current situation. This finding is also in line with other research findings (Chernet, 2009; Gedecho, 2015; Mihret & Yohannes, 2015). The geospatial techniques are a great tool to analyze, generate and identify potential ecotourism sites for the study area.

Conclusion

This study attempted to develop ecotourism suitability model that further support decision-making process in Menz-geramidir district; one of the districts of North Shewa Zones of Amhara National Regional State. In order to produce potential ecotourism sites, multi-criteria evaluation is done based on three criterion and five-factor maps. These are, landscape (LULC map), topography (elevation map and slope map), and accessibility (road map and river map). Geospatial (GIS and RS) techniques were applied predominantly.

Even though ecotourism is still in its infancy as a global and national phenomena, there are a variety of definitions for ecotourism forwarded by different individuals and organizations, each with a different perspective. However, there is considerable agreement that ecotourism must be beneficial to local communities and have a positive effect on protecting the environment and maintaining sustainability. Therefore, since ecotourism is contextual, it is defined in this study as a travel to a given geographic area by considering the issue of environmental sustainability, promotion, and local community benefit.

The land use land cover map of the study area which is one of the factor maps was derived from Landsat 8 satellite imagery, and classified into five classes by using supervised maximum likelihood image classification method. Namely, farmland, forest land, grassland, bushland, and bare land, which account 24.23%, 15.37%, 32.7%, 24.89% and 2.7% respectively of the study area. It was then reclassified based on the relevance to the ecotourism suitability model map. This process is also used for other factor maps.

The study has demonstrated the application of geospatial techniques and multi-criteria decision-making role in solving and identifying suitable sites for ecotourism development, and to efficiently use the available resources for economic development of the district. The advantage of applying MCE (Multi-criteria evaluation) and geospatial techniques helped us to analyze ecotourism suitability at the district level for a better understanding, and to employ graphical user interface. This provides an easy way for decision-makers to manage and develop ecotourism through sustainable environmental protection, and management of Menz-geramidir district. In the future, further studies should be conducted to include other socio-cultural criteria factors.

Acknowledgment

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