



Application of geospatial technology for potential ecotourism site selection in Masha district, Southwest Ethiopia

A. Andemo¹ · K. Getahun² · A. Melese² · T. Melese³

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Abstract

Ecotourism is one of the fastest growing sectors in the tourism industry nowadays. Ethiopia is not effectively using its rich and endemic wildlife species for ecotourism due to various physical and socioeconomic factors. Masha district has also abundant and valuable natural and cultural resources that can be developed into ecotourism, but the district was not used its attractive resources for ecotourism. The current study was initiated to select potential sites for ecotourism using Geographic Information System and Remote Sensing as a decision support tool in Masha district, Southwest Ethiopia. This study employed Geographic Information System-based Multi-Criteria Evaluation Method because it was commonly used technique in suitable site selection. To achieve the objective of this study, about even physical and socioeconomic parameters were selected through the literature review. Then, weights for each factor were assigned based on Analytical Hierarchy Process using pairwise comparison matrices. Based on the overlay result, a thematic map of potential ecotourism sites was produced. The final results reveal that about 21.2% of the study area was classified as highly suitable potential ecotourism sites whereas about 59 and 19.5% of the district were under moderately and marginally suitable classes. But, only the small portion of the district (0.4%) was considered as not currently suitable site for ecotourism. Therefore, decision-makers should give a due attention to advertise the selected suitable site for both local and foreign tourists in order to develop the district as one of the ecotourism destination areas in the country.

Keywords Geospatial · Multi-criteria evaluation · Satellite images · Suitability

Introduction

Tourism is a rapidly growing industry and a powerful tool for sustainable development (Kiper, 2013; Mondino and Beery 2019; Salman et al. 2020). In recent times, ecotourism has gained recognition as a strategy for sustainable development, aligning tourism with environmental preservation

(Kelly and Williams 2007; Tiberghien 2019). The fundamental purpose of ecotourism is to protect natural and cultural resources, generate income for local communities, support educational research centers, and facilitate capacity building (Liu and Wang 2017; Shiaty et al. 2016). In Africa, countries such as Ethiopia, Kenya, Tanzania, and Uganda are renowned for their endemic species (Tefera, 2011). However, the economic significance of tourism in Africa remains comparatively modest, accounting for only 5 and 3% of global international arrivals and global intercontinental receipts, respectively. In 2013, Africa generated a total of US\$ 34.2 billion in international tourism revenue, and these numbers are expected to more than double by 2030, reaching 134 million international arrivals (UNWTO 2014).

Ethiopia stands out as a captivating tourist destination in Africa, blessed with breathtaking natural resources and unique cultural heritage. Its diverse range of natural and cultural attractions, combined with a pleasant climate, makes it a potential hub for ecotourism (Geremew, 2019; Woldu 2018). However, Ethiopia has not effectively utilized its rich

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✉ T. Melese
tadelemelese21m@gmail.com

¹ Department of Geography and Environmental Studies, College of Social Science, Dilla University, Dilla, Ethiopia

² Department of Geography and Environmental Studies, College of Social Science, Jimma University, Jimma, Ethiopia

³ Department of Natural Resource Management, College of Agriculture and Environmental Sciences, Bahir Dar University, Bahir Dar, Ethiopia



and endemic wildlife species for ecotourism due to inadequate infrastructure, unsustainable resource utilization, low community awareness about ecotourism, and weaknesses in advertising and promoting its attractions to both domestic and international tourists (UNWTO, 2016). Masha district, located in the Sheka zone, boasts a wealth of cultural, historical, and natural attractions. Its distinct and pleasant climate, diverse flora and fauna, waterfalls, spring waters, mineral waters, and hospitable people position it as an important potential tourist destination. The district's unique cultural traditions, including celebrations, weddings, mourning rituals, traditional dress, songs, and dances, have the potential to attract numerous international and domestic tourists. The current status of ecotourism in Masha district, Ethiopia, remains largely untapped, characterized by inadequate infrastructure, low community awareness, and limited promotion of its natural and cultural attractions. However, despite the abundance of natural and cultural attractions, the ecotourism potential of the district remains largely untapped, necessitating proper planning and resource management.

The selection of potential ecotourism sites involves considering various natural, environmental, social, and economic factors. Suitability site selection analyzes the interaction of these factors and assigns suitability ranks accordingly. Geospatial technologies, such as Geographic Information System (GIS) and Remote Sensing (RS), play a crucial role in the development of ecotourism (Ajibade et al. 2020; Berisa and Birhanu 2015; El Maguiri et al. 2016; Islam et al. 2020; Ng'ang'a et al., 2014; Okot et al. 2019; Poorna and G, 2016; Şener et al. 2011). The integration of GIS and Multi-Criteria Evaluation Method (MCE) is currently the most common decision support approach for selecting potential ecotourism sites. GIS facilitates data acquisition, storage, retrieval, manipulation, and analysis, while MCE assesses different alternatives based on various criteria to identify suitable sites (Ghavami 2019; Kiavarz et al. 2018; Patanè and Spagnuolo 2016; Sadeghi et al. 2010; Saidi et al. 2017).

The previous studies have highlighted the Masha district's significant ecotourism potential due to its status as a biodiversity hotspot with diverse endemic species, untouched natural landscapes, rich cultural heritage, varied ecological zones for outdoor activities, valuable ecosystem services, opportunities for local cultural experiences, limited infrastructure preserving the environment, educational possibilities, and a willingness for conservation-focused partnerships, making it an attractive destination for responsible ecotourism development (Abdissa and Fitwi, 2019; Ambecha et al. 2020; Bekele and Tadesse, 2018; FDRE et al. 2009; Furo et al. 2020; Mekonnen, 2018; Tadesse et al. 2018; Van et al. 2019). However, these studies have not specifically focused on the GIS-based delineation of potential ecotourism sites. The district

faces challenges in sustainable management of its natural and cultural resources and in ensuring equitable benefits for local communities, despite its untapped ecotourism potential. Therefore, this study aims to scientifically select potential ecotourism sites using geospatial technologies in the Masha district. The findings of this study will assist policymakers in mobilizing local resources, enhancing the local economy through ecotourism development, and providing valuable input for effective planning of natural resource rehabilitation, protection, and conservation. The main objective of this study is to identify potential ecotourism sites in the Masha district, Southwest Ethiopia, by integrating geospatial technologies with Multi-Criteria Decision-Making (MCDM) techniques.

The potential ecotourism site selection in the Masha district, Southwest Ethiopia, holds significant possibilities for reporting new information. This region possesses unique ecological and cultural characteristics that have yet to be extensively explored and documented. By conducting a comprehensive study focused on potential ecotourism sites in this area, we have the opportunity to uncover previously unknown or overlooked areas of ecological and cultural importance. Additionally, the integration of geospatial technologies, such as GIS and remote sensing, provides a unique opportunity to generate novel information about the spatial distribution of resources, land use patterns, and accessibility, enhancing our understanding of the suitability and potential of ecotourism sites in the Masha district. Furthermore, the utilization of Multi-Criteria Decision-Making (MCDM) techniques allows for an objective evaluation and selection of suitable ecotourism sites, fostering balanced and sustainable development. Overall, by focusing on this under-explored region and utilizing innovative methodologies, our study has the potential to report fresh insights and contribute to the scientific knowledge base in ecotourism research, benefiting both academia and the stakeholders involved in sustainable tourism development.

Geospatial technologies, including Geographic Information System (GIS) and Remote Sensing (RS), are specifically selected for potential ecotourism site selection due to their unique capabilities and advantages. GIS allows for the integration of diverse spatial data layers, enabling comprehensive analysis of multiple criteria simultaneously. It facilitates spatial visualization through maps, aiding in the identification of suitable ecotourism areas based on specific criteria. GIS also offers various spatial analysis and modeling techniques to assess the relationships between different factors and generate suitability maps. Moreover, remote sensing data, such as satellite imagery, contributes valuable information on land cover, vegetation, and topography, enhancing the accuracy and reliability of the site selection process. Overall, geospatial technologies offer a comprehensive and efficient approach, integrating diverse data sources



and supporting evidence-based decision-making in ecotourism development.

Materials and methods

Description of the study area

Masha district is located in Sheka administrative zone in Southern Nation Nationalities and Peoples' Regional State (SNNPRS) in the southwestern part of the Ethiopia. It is located at a distance of about 676-km southwest of Addis Ababa, the national capital. Astronomically, it extends between 07°32'0" and 07°56'0" north latitudes and 35°6'0"–35°48' east longitudes (Fig. 1). The district shares borders with the districts of Dedulalo in the north, Andracha in the south, Gesha in the east, and Sele-Nono in the west. The total area of the district is about 81,656.56 hectares.

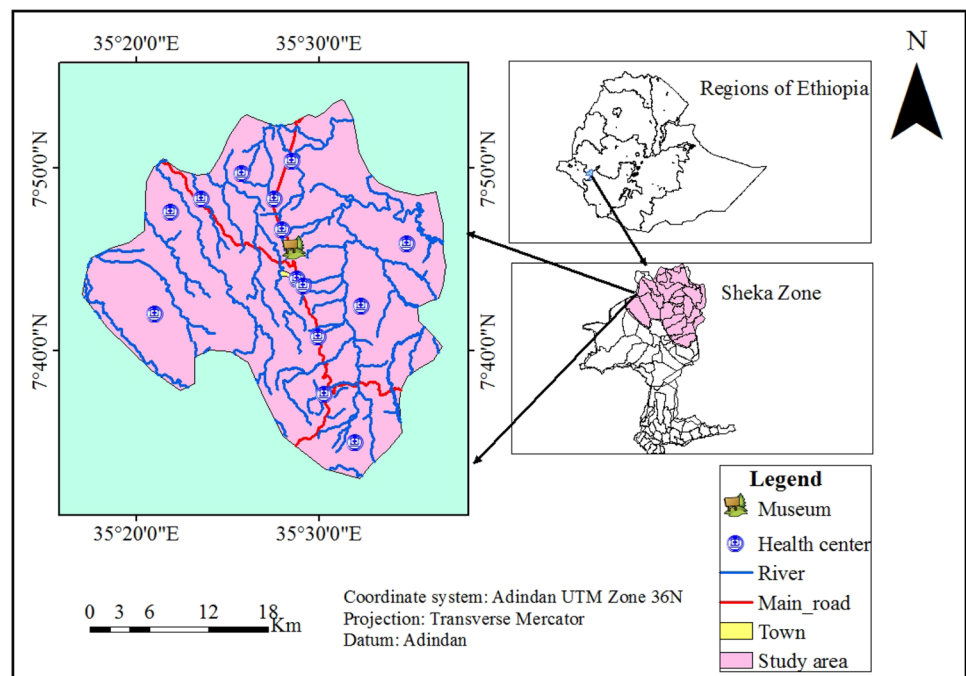
Agro-climatically, the area is predominantly of the midland type, comprising approximately 75% of the total area. It exhibits a unimodal rainfall distribution due to its topography. The mean annual rainfall is estimated to exceed 2200 mm. The mean maximum temperature ranges between 25 and 34 °C, while the mean minimum temperature falls between 10 and 15 °C. Similar to other parts of southwestern Ethiopia, the area is characterized by Cenozoic and Proterozoic volcanic sediments. The soil is primarily composed of red and brownish ferrisols derived from volcanic parent material.

In the Shekacho (Sheka people) culture, there exists a strong relationship between the wetlands, rivers, and

forests in their environment. Consequently, due to such cultural beliefs and the presence of captivating water bodies, the area holds significant potential for ecotourism development. The district boasts high habitat diversity, with the dominant forest type being Afromontane rainforest. It consists of broadleaf forests, wetlands, bamboo forests, moorland, and riverine forests. It is within this forest type that wild *Coffea arabica* shrubs are found in the shrub layer (Senbeta et al. 2007). The forests are abundant in fauna species, including highland and forest bird species such as Abyssinian catbirds, Abyssinian woodpeckers, Wattled Ibises, and Thick-billed Ravens. The most common mammals observed in the area are bushbuck, lion, porcupine, various cat species, buffalo, bush pig, wild boar, black duiker, leopard, waterbuck, colobus monkey, and Anubis baboon. Additionally, the area is home to a variety of amphibians, reptiles, butterflies, and orchid species. Cattle, goats, sheep, horses, and chickens are among the most commonly raised animals in the district (Gole et al. 2014).

Overall, Masha district is blessed with unique biodiversity that can be harnessed for ecotourism development. As mentioned earlier, the area is rich in plant and animal species, as well as other captivating natural and cultural resources. Among the natural attractions, there are approximately 29 stunning waterfalls, 23 mineral waters, caves, and other noteworthy features found in the district (Tadesse et al. 2018). These natural environments offer a range of recreational opportunities that can be utilized for ecotourism development since tourists typically visit specific locations due to their attractions or series of attractions (see Fig. 2).

Fig. 1 Location map of the study area



The district has a total population of 40,810, with 20,116 men and 20,694 women. Urban dwellers make up 16.63% of the population, while the remaining 83.37% reside in rural areas. The majority of the inhabitants (56.5%) identify as Protestants, 32.82% practice Ethiopian Orthodox Christianity, 7.15% follow traditional beliefs, and 1.56% are Muslims (CSA, 2007).

Data sources

Primary data were collected using Garmin Global Positioning System (GPS), a digital camera, observation, and questionnaires. Additionally, secondary data were gathered from various published and unpublished sources. The spatial data utilized in this study included a satellite image of Operational Landsat Imagery-Thermal Infra-Red (OLI-TIRS) Landsat 8 (30*30 m) from 2017, which was used to generate a land use–land cover map obtained from www.earthexplorer.usgs.org. The Shuttle Radar Topographic Mission Digital Elevation Model (STRM DEM) data were used to extract slope, elevation, and river maps. Other data, such as road maps, town maps, and museum maps, were employed

for proximity analysis of ecotourism sites. GPS data were also utilized to validate the results.

Socioeconomic data, including population and economic activity data, were incorporated to provide background information about the study area, aiding readers in obtaining detailed information about the research location. The adoption of Landsat 8 (OLI-TIRS) imagery and STRM DEM data was instrumental in creating the land use–land cover map for the study site. The data used in this study were crucial in generating important parameters for identifying potential ecotourism sites.

For this study, non-probability sampling techniques were employed to select key informants and kebeles for data collection. Specifically, the researcher utilized purposive sampling to select seven experts from governmental and nongovernmental offices. Three experts were chosen from the Masha district Cultural, Tourism, and Communication Office, three from the Masha district Agricultural and Rural Development Office, and one expert from MELCA. These selected experts possessed extensive experience and knowledge in the field of ecotourism. Key Informant Interviews (KII) were conducted to analyze and evaluate both physical and socioeconomic factors that influence the selection of potential ecotourism sites, prior to conducting suitability evaluation and classification. Before utilizing the classified land use–land cover (LULC) data of the district, the researcher deliberately selected four kebeles out of 19 based on the availability of attraction sites to validate how well the results corresponded with the actual conditions on the ground. The overall framework of the study is presented in Fig. 3.

Methods

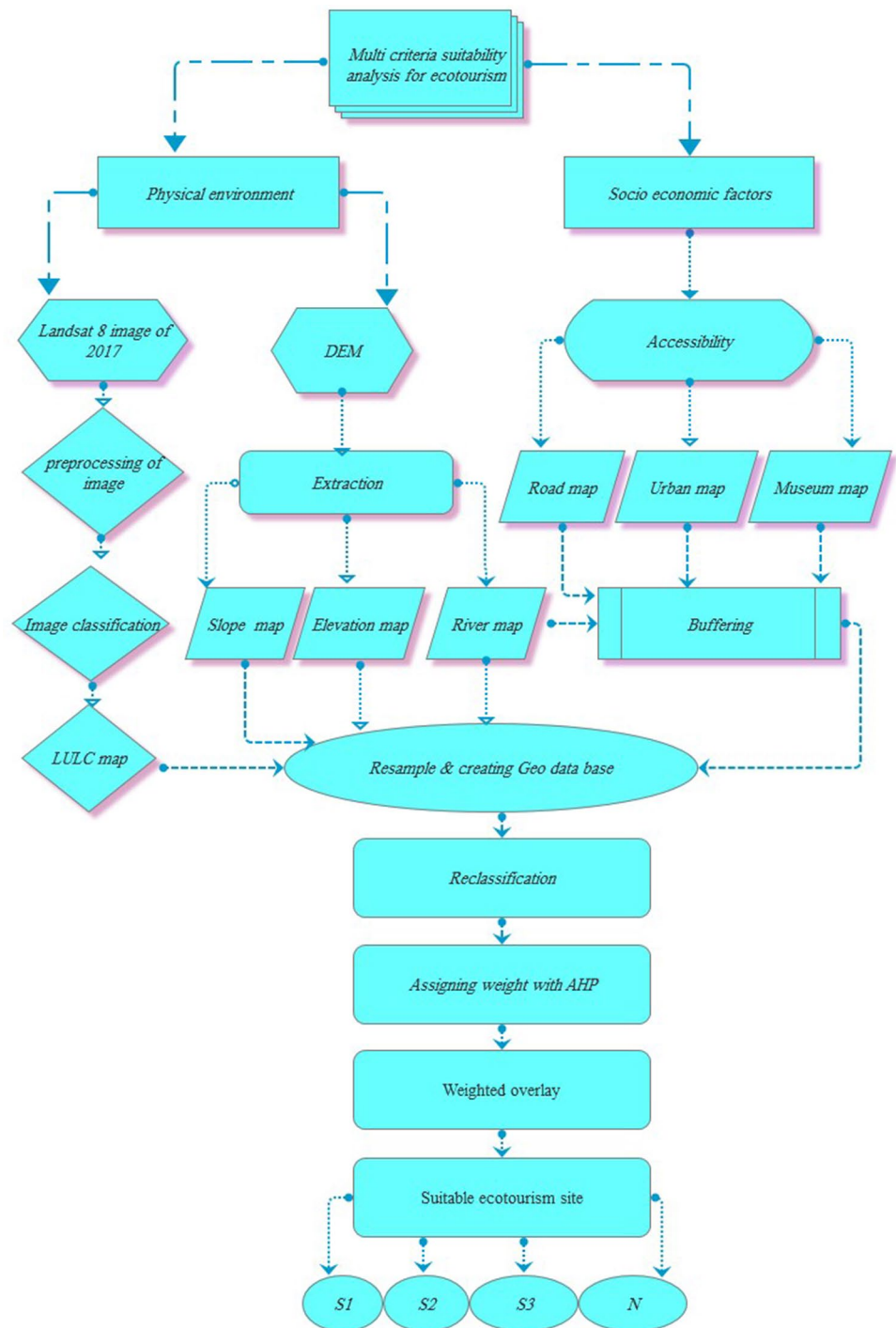
The weighted overlay has been carried out in GIS environment for suitable site selection of ecotourism. An assigning weight to each raster in the overlay process controls the influence of different criteria in the suitability model. Finally, all reclassified maps of LULC, elevation, slope, river, road, urban area, and museum were computed by the weighted overlay tool in a GIS environment and produced a suitable potential ecotourism site as highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (S4). Different researchers adopted different land use–land cover types for the selection of ecotourism site. In the present study, the views of Abrehe et al. (2021) and Ambecha et al. (2020) were the base for ranking of land cover class from ecotourism perspectives. Accordingly, forest, open land, built-up areas, and croplands are considered as highly suitable (S1), moderately suitable (S2), marginal suitable (S3), and not suitable (S4) for ecotourism development, respectively.



Fig. 2 Partial ecotourism treasures of the study area **a** waterfall within forest, **b** people with their cultural demonstration, **c** cultural home style in the study district, **d** part of diversified forest, and **e** rivers and water resource



Fig. 3 Conceptual framework of the study



The patterns of land cover; the presence of endemic and attractive biodiversity is closely related to the topography of the area. The rainfall and temperature patterns are also influenced by the elevation. This, in turn, exerts a major effect on the distribution and abundance of biodiversity due to its effect on climatic conditions. In fact, the highland area is more suitable for the existence of living things, including human beings because of its favorable climatic conditions. Thus, it is necessary for analysis elevation suitability

classes for identification of suitable sites for ecotourism. Different researchers set a different elevation suitability class for screening of potential site. In this study, the analysis of elevation is based on the standard employed by Abrehe et al. (2021).

MCDM is the study of identifying and choosing alternatives to find the best solution based on different factors and considering the decision-makers' expectations (Hwang and Yoon 1981; Tzeng and Huang 2011). GIS-based MCDM

techniques are mostly found for potential ecotourism site selection by using Analytical Hierarchy Process. The AHP in MCDM exercises was found to be a useful method to determine the weights for each individual factor (Saaty 1980).

The Analytic Hierarchy Process (AHP) is a decision-making technique that can be incorporated into the present study methodology section for potential ecotourism site selection. AHP provides a systematic and structured approach for analyzing and prioritizing multiple criteria and alternatives based on their relative importance. This technique involves breaking down the decision problem into a hierarchical structure, comprising main criteria, sub-criteria, and site alternatives. The main criteria encompass factors such as natural resources, environmental sustainability, cultural significance, community engagement, accessibility, infrastructure, and market potential. Decision-makers then conduct pairwise comparisons to assess the relative importance or preference between these elements. Through numerical values assigned on a scale, the strength of preference is determined, allowing for the calculation of priority weights. These weights represent the relative importance of each criterion, sub-criterion, and alternative. To ensure the reliability of judgments, AHP performs consistency checks, calculating consistency ratios and making adjustments as necessary. The priority weights obtained from pairwise comparisons are then aggregated, considering the hierarchical structure, to determine overall scores or rankings for the alternatives. By utilizing the AHP technique,

decision-makers can make informed choices and identify the most suitable ecotourism site based on the predefined criteria. It is important to emphasize the careful consideration of the hierarchical structure, accurate pairwise comparisons, and consistency in judgments to ensure the validity and reliability of the results obtained through AHP.

The basic step of AHP is to prepare comparison matrices. The score for comparison matrices is calculated from relative importance between each pair of criteria, that is, pairwise comparison (Table 1). To calculate scores for pairwise comparison, Saaty suggested a 9-degree scale where available values are member of the set: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9}, 9 represents the absolute importance and 1/9 represents the absolute triviality. The final basic step in the AHP is an evaluation of the comparison matrices under measurement theory (Table 2). IDRISI weight module was utilized to prepare pairwise comparison matrix that helps to develop a set of factor weights that will sum to 1. A standardize eigenvector is extracted from each comparison matrix. It helps to assign weights to criteria. Consistency ratio (CR) was calculated in order to determine whether the judgment was consistent or not during the comparison of criterion. According to Saaty 1980, if consistency ratio is less than 0.10, it is within acceptable limit.

The weight for each factor map was assigned based on reviews of the pervious works together with the questionnaires distributed to selected experts. According to these questionnaires, most of the KII (85%) were prioritized the above seven factor maps in their descending order as follows: land use–land cover map, road map, river map, elevation map, slope map, museum map, and urban map. After prioritizing all the factor maps according to their relative importance, the task of assigning weight for each parameter was performed outside GIS on IDRISI Decision Wizard software.

The eigenvector of weight generated in the IDRISI software module was used to produce a relative weight for all seven factor maps that were used to control their influence in weighted overlay tool in ArcGIS environments. As indicated in the following (Table 3), this module produced a set of weights for each parameter that sum to 1 which was used

Table 1 Saaty (1980) pairwise comparison scale

Extent of weight	Definition
1	Equal importance
3	Moderate importance of one over another
5	Strong importance
7	Very strong importance
9	Extreme importance
2, 4, 6, and 8	Intermediate values between the adjacent judgments

Table 2 Pairwise comparison matrix in IDRISI software (own processing, 2017)

Reclassified map layers	LULC	Road	River	Elevation	Slope	Museum	Urban area
LULC	1						
Road	1/2	1					
River	1/3	1/3	1				
Elevation	1/5	1/5	1/3	1			
Slope	1/5	1/5	1/3	1/3	1		
Museum	1/7	1/7	1/5	1/5	1/3	1	
Urban area	1/9	1/9	1/7	1/7	1/5	1/5	1

Table 3 Eigenvector of factor map weights (own processing, 2017)

No.	Factor maps	Eigenvec-tor weight	Weight in %	Consistency ratio
1	LULC	0.3446	34.46	0.08
2	Road	0.2845	28.45	
3	River	0.1545	15.45	
4	Elevation	0.0902	9.02	
5	Slope	0.0651	6.51	
6	Museum	0.0412	4.12	
7	Urban area	0.0199	1.99	

as input for multi-criteria evaluation. The consistency ratio in the current study was $0.08 < 0.1$ which was an acceptable one.

Results and discussion

Parameters used for ecotourism site suitability analysis

In the analysis of ecotourism site suitability, various parameters were considered. These included land cover, elevation, slope, proximity to rivers, road networks, urban areas, and museums. By evaluating these factors, areas with dense forests, favorable elevations and slopes, proximity to rivers, and accessibility via road networks were identified as highly suitable for ecotourism development. On the other hand, areas with extensive croplands, unfavorable elevations and slopes, and proximity to urban areas and museums were deemed less suitable. The final analysis identified specific regions within the study area that is highly suitable for potential ecotourism development.

Selecting best criteria to locate ecotourism in most suitable area is important to minimize the negative effects of development on the environment and to give much emphasis on the positive impacts of such development. Selecting factor for analysis is not an easy task rather it is tedious and need much concentration because it considered both physical and socioeconomic factors. In order to meet the goal of this study, different literature were reviewed by the researcher, and then, best factors were selected as criteria (Table 4). These selected criteria were also approved by the interviewed experts. Therefore, the following parameters are selected to achieve the objective of the present study.

Land use–land cover and suitability

The satellite image was classified by the supervised image classification technique. Accordingly, four major types of land use–land cover units were obtained; namely, forest,

Table 4 Suitability standard for ecotourism site selection

Parameters	Sources
Land use–land cover	Samanta and Baitalik (2015)
Slope	Pareta (2013)
River	Geremew and Hailemeriam (2015)
Road	Cuberos et al. (2000)
Museum	
Urban	
Elevation	

open land, cropland, and built-up area. Hence, the classification result revealed that forest land constituted the largest proportion of land in the study area with a value of 62.4%, followed by cropland which accounts for 33.6%, while the smallest land of the district is occupied by 2% of built-up area and 1.9% of open land, respectively. In the above LULC, the overall accuracy of 85% with a kappa coefficient of 80.4% was achieved in the classification process means that there is strong agreement between classification and referenced data than by chance alone.

The reclassified map of the study area revealed that (Table 5) the largest part of the study area (50,937.04 ha) were found as highly suitable for ecotourism development because these huge portions of the area were covered by dense and evergreen forest which was served as the home for different biodiversities that can catch the attention of many domestic and foreign tourists.

Elevation suitability

The elevation of the district is derived from the study area SRTM DEM by using extraction tools in GIS environment. Based on the elevation of the district, majority part of the district is high land with an altitude range from 1410 m below sea level to 2655 m above sea level. In Fig. 4c, southern and southwestern tips of the district are characterized by the high elevation array. Most of the central, northern, and northeastern parts of the district have a medium altitudinal range. The area with the altitude range between 2322 and 2655 m was taken as highly suitable, because the area in this range has a good climatic condition for tourists and rich with both flora and fauna whereas the areas found between 1410 m up to 1864 m are not suitable due to its unfavorable environmental conditions.

During reclassification phase, the highest rank (1) was given in elevation ranges from 2322 to 2655 m due to its suitable environment for living things, whereas the least rank (4) was given in elevation ranges from 1410 to 1864 m relatively due to its perilous climate conditions. The result of the analysis reveals that 16,924.6 hectares (20.7%) of the study area are taken as highly suitable areas for ecotourism. On the other hand, 23,782.4 hectares (29.1%) of the district



Table 5 Parameters and suitability analysis result of LULC, altitude, and slope

Parameters	LULC types	Suitability class	Rank	Areal in ha.	Areal in %
LULC	Forest	Highly suitable	1	50,937.04	62.4
	Open land	Moderately suitable	2	1578.08	1.9
	Built-up area	Marginal suitable	3	1673.24	2.0
	Cropland	Not suitable	4	27,468.2	33.6
Altitude	2322–2655	Highly suitable	1	16,924.6	20.7
	2118–2322	Moderately suitable	2	23,782.4	29.1
	1864–2118	Marginally suitable	3	17,446.6	21.4
	1410–1864	Not suitable	4	23,502.96	28.8
Slope	0–2.86	Not suitable	4	4020.96	4.9
	2.86–7.15	Marginally suitable	3	17,723	21.7
	7.15–13.58	Moderately suitable	2	28,442.48	34.8
	13.58–68.12	Highly suitable	1	31,470.12	38.5

were moderately suitable while 17,446.6 hectares (21.4%) and 23,502.96 hectares (28.8%) of the study area were marginally suitable and not currently suitable for potential ecotourism site, respectively. The suitability classes of elevation are clearly shown in the following (Fig. 4d) of the district. Because of the elevation, the district is characterized by high elevation ranges which creates an interesting landscape matrix that is crucial for a potential ecotourism site.

Slope suitability

The slope profile of the study area varies from 0 to 68.12°. Its slope is extracted from the study area SRTM DEM. It is important for ecotourism because all terrain features are derived from a complex landmasses. Therefore, expressing the complexity of the area in terms of the slope is an imperative factor in the suitability analysis for ecotourism.

The slope suitability class was analyzed and revealed that the areas found between 0 and 2.86° were taken as not suitable, because the areas within this slope range are characterized by less variation in its slope profile, whereas the areas found between 13.58° and 68.12° were taken as highly suitable, because the areas in this slope range were rich by cliff and hanging wall landscape that creates nice scenic beauty which attracts many tourists. Areas found between 2.86° and 7.15° were taken as marginally suitable, and areas within slope range between 7.15° and 13.58° were moderately suitable for ecotourism site due to their medium slope ranges.

During slope reclassification process, the highest value (1) was assigned to steep slopes due to its complexity of the land features that create cliff and hanging wall landscape that attracts many tourists; whereas, the lowest value (4) was assigned to gentle slopes due to the absence of nice scenic beauty that attracts tourists. The areal coverage and suitability class of the study area are depicted in Fig. 4e.

The result in Table 5 revealed that 38.5% of the total area (31,470.96 ha) are in the slope range between 13.58

and 68.12 degree which is highly suitable for ecotourism, and 28,442.48 hectares (34.8%) of the study area are in the slope range between 7.15 and 13.58 degree which is also considered as marginally suitable for screening of potential site for ecotourism. The remaining 21.7% of the total area (17,723 ha) is found within marginally suitable class, whereas 4020.96 hectares (4.9%) of the district are considered as not currently suitable site and found within the slope range of 0–2.86 degree. This indicates the ratio of slope suitability class which is highly and marginally suitable for ecotourism covers a large area (59,912.6 hectares) in the district. In other word, the smallest portion of the district (21,743.96 hectares) is occupied by marginally and not currently suitable class of slope from the ecotourism point of view.

Results in the present study are consistent to the works of Abrehe et al. 2021; Ambecha et al. 2020; Bunruamkaew and Murayama, 2011; Fang 2017; Gigović et al. 2016; Mahdavi and Niknejad 2014; and Yuwono et al. 2021. Accordingly, slope is considered to be important factors that affect the suitability of area for potential ecotourism site selection.

Proximity to river suitability

The proximity of the attraction site to river is one of the vital parameters in the evaluation of rivers suitability for the ecotourism site selection as they provide recreation and other enjoyment for ecotourism activities due to their richness with biodiversity. The selected potential ecotourism sites should be near to river because the existence of water in a stunning form in landscape like waterfall may increase the esthetic value of landscape that can attract many visitors. The presence of river in a landscape also creates variety and diversity of biodiversity that is interesting to many tourists. On the other hand, areas so far to river are not recommended for ecotourism attraction site due to the absence of visually attractive geomorphologic features because tourists usually

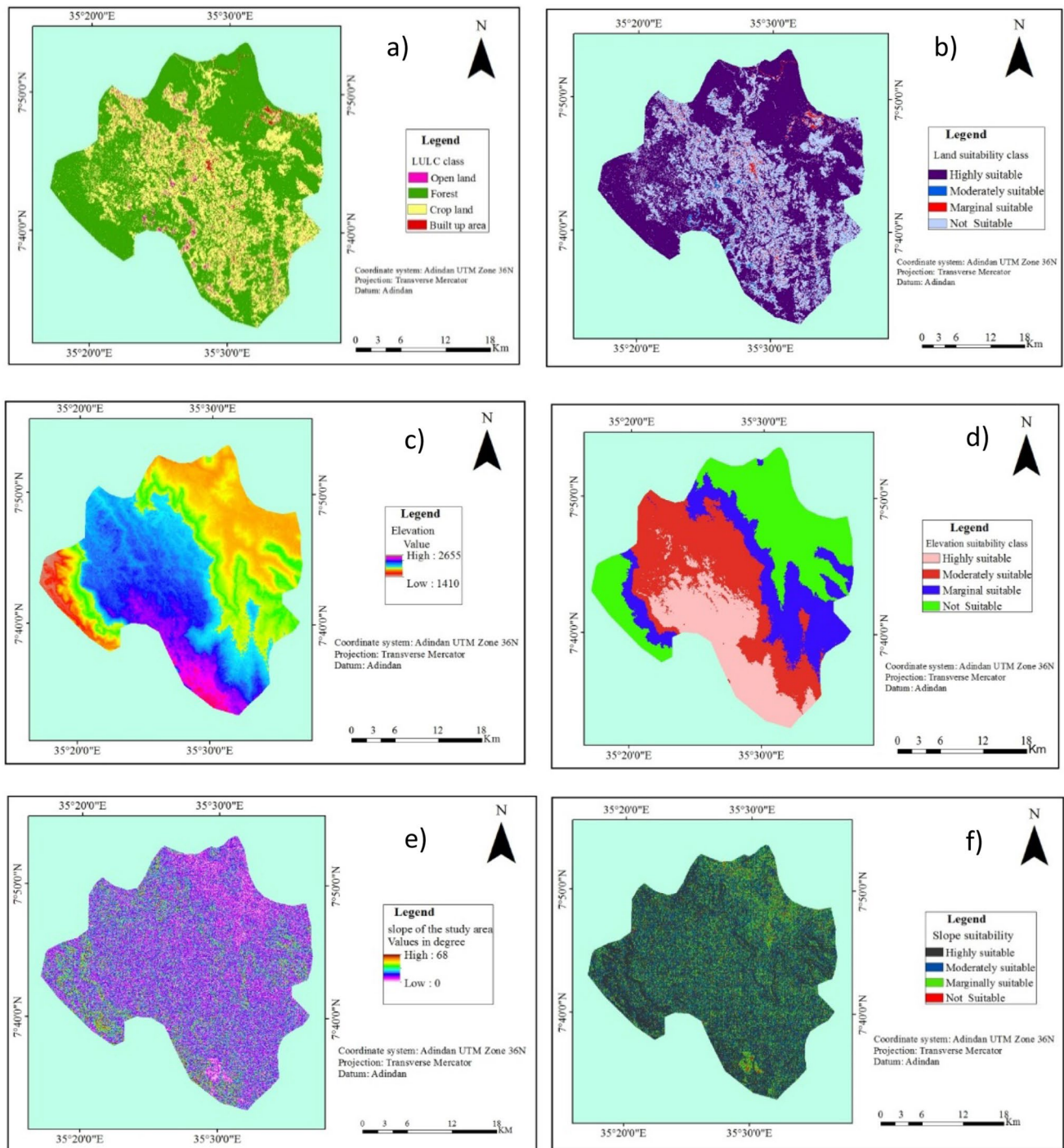


Fig. 4 a Land use–land cover map, b land use–land cover suitability map, c elevation map, d elevation suitability class, e slope of the study area, and f slope suitability map

visit particular locations for the scenic attractiveness of that landscape. Therefore, the following (Table 6 and Fig. 5) were clearly depicted proximity analysis of the river in this study.

As stated in Table 6, areas in close proximity to the river are more suitable for potential ecotourism sites. During the

reclassification process, the highest suitability rank (1) was assigned to areas within a buffer distance between 0 and 0.5 km, because the area at close distance to the river is highly suitable for scenic beauty and bottling whereas the lowest score (4) was assigned to areas out of 2-km buffer distance from the rivers for their low potential attraction

Table 6 Parameters and suitability analysis result of river, urban area, road, and museum

Parameters	Suitability class	Buffer distance (km)	Area in ha.	Area in %	Rank
River	Highly suitable	0–0.5	40,552.84	49.7	1
	Moderately Suitable	0.5–1	24,535.16	30.0	2
	Marginally suitable	1–2	14,443.92	17.7	3
	Not suitable	2–5	2124.64	2.6	4
Road	Highly suitable	0–1	48,107.00	58.9	1
	Moderately Suitable	1–2	17,718.68	21.7	2
	Marginally suitable	2–3	7981.08	9.8	3
	Not suitable	> 3	7849.8	9.6	4
Urban area	Highly suitable	> 10	45,243.8	55.4	1
	Moderately Suitable	6–10	21,873.44	26.8	2
	Marginally suitable	3–6	10,027.68	12.3	3
	Not suitable	0–3	4511.64	5.5	4
Museum	Highly suitable	0–1	337.04	0.4	1
	Moderately Suitable	1–3	2512.56	3.1	2
	Marginally suitable	3–10	28,588.84	35	3
	Not suitable	> 10	50,218.12	61.5	4

site. Areas within a buffer distance between 0.5 and 1 km and 1–2 km were under moderately and marginally river suitability classes, respectively. To sum up, the above table, the largest portion of the district was found as highly suitable with a value of 40,552.84 hectares (49.7%); whereas, the smallest part of the district is not suitable for the selection of potential ecotourism sites with a value of 2124.64 hectares (2.6%). But, the remaining 24,535.16 hectares (30%) and 14,443.92 hectares (17.7%) of the district were found as moderately and marginally suitable for potential ecotourism site screening as the areas were found in intermediate distance between highly and not currently suitable areas.

Road network suitability

Road map (Fig. 5) was represented by the line feature which is not compatible for weighted overlay analysis. These line features were converted into raster feature and reclassified. The results from Table 6 indicate, 48,107 hectares (58.9%) of the area in the district were highly suitable which is followed by 17,718.68 hectares (21.7%) of moderately suitable for the selection of potential ecotourism sites. Depending on how close they were to tourist attractions, four classes for road network suitability were created. The area in close proximity to road networks (buffer distance from 0 to 1 km) was ranked as highly suitable for ecotourism because the area near to the road networks is easily accessible to the tourist which can save both time and cost related to transportation. The areas greater than a buffer distance of 3 km were considered as not suitable because the area far away from the road networks was inaccessible and resulted in high cost of transportation. However, the areas within a buffered

distance of 1 up to 2 km and from 2 to 3 km were moderates and marginally suitable, respectively. During reclassification, the highest value (1) was given to the areas in close proximity to road networks, and the lowest value (4) was given to areas far away from the road.

Remaining 7981.08 hectares (9.8%) and 7849.8 hectares (9.6%) of the area in the district were marginal and not suitable, respectively. In general, from ecotourism points of view, the largest portion of the study area was categorized under highly suitable class, but, only the smallest portions of the district were found within not currently suitable class. Therefore, the road network proximity suitability map of the district is clearly indicated in Fig. 5c.

Proximity of urban area suitability

An urban area is defined as a human environment with high population density and infrastructure of the built environment. To evaluate urban area's suitability for the selection of potential ecotourism sites, urban map of the district represented by polygon format is not compatible for MCE. Firstly, the polygon feature was converted to raster formats and reclassified based on the distance from the town of the study area. The area within 3 km from the urban area is not recommended for ecotourism site selection to avoid urban noise and contestation. Based on the above standard, the area far away from the urban area was ranked as highly suitable for potential ecotourism site and represented by a value (1) because of their serene and healthy environment. Whereas, the areas near by urban center were ranked as not suitable and represented by the value (4) since they have high noise disturbance and urban pollution (Fig. 5e).

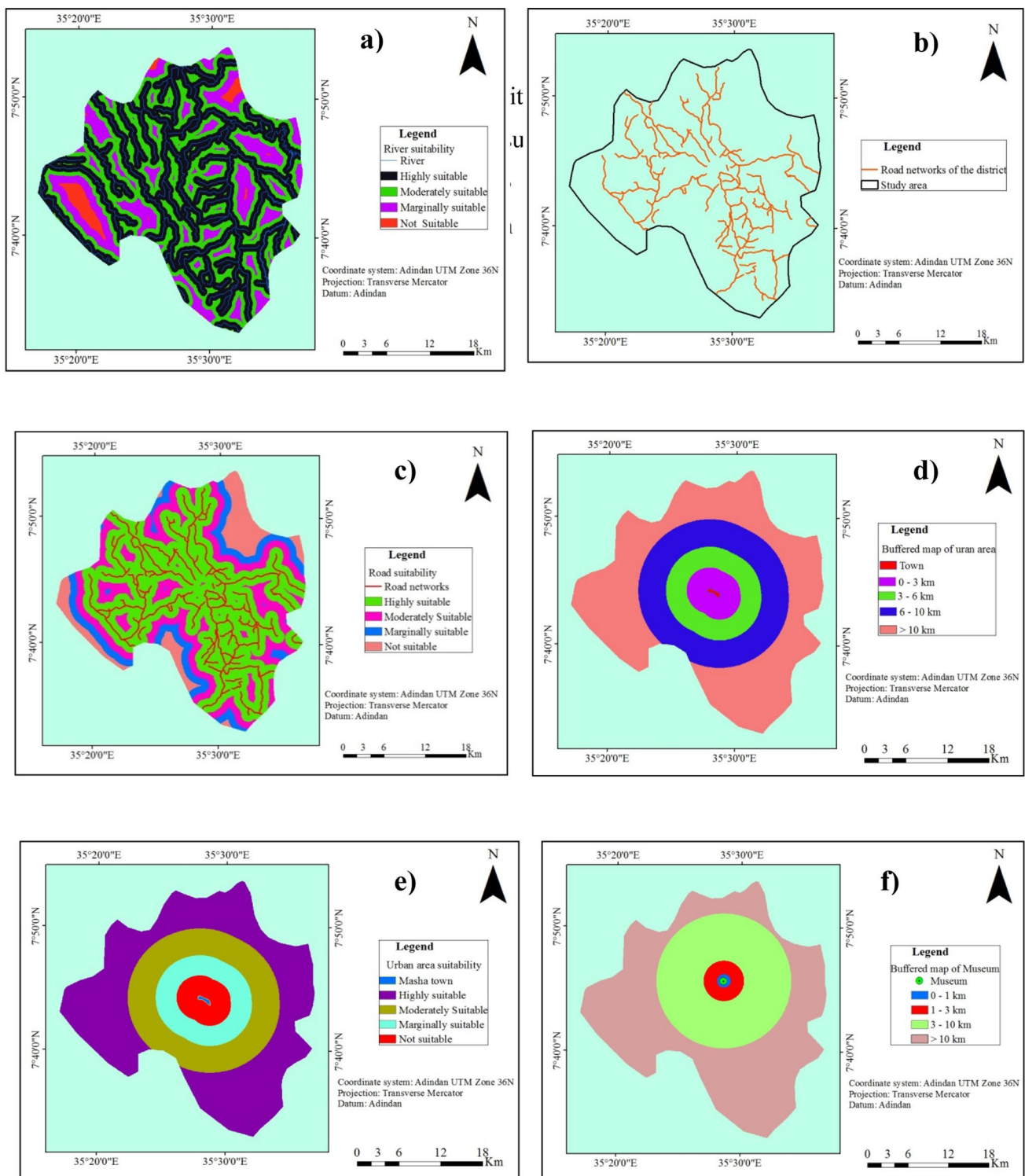


Fig. 5 a River suitability map, b road map, c road suitability map, d buffered map of urban area, e urban area suitability and, and f buffered map of museum

To analyze the museum area suitability in the present study, a museum map of the district represented by point features was converted to raster format because point features

are not compatible with the Multi-Criteria Decision-Making process. After conversion to raster format, it was reclassified according to its suitability class for the selection of

ecotourism potential site. During analysis of suitability class, the area nearby museum was ranked as highly suitable for potential ecotourism site and represented by a value (1) because tourist can relax with cultural and other historical objects with minimum cost in a short period of time and its closeness enhances the patronage of the tourist resort. The areas far away from museum were ranked as not suitable and represented by the value (4).

During the reclassification process, the areas within a buffer distance between 0 and 1 km and 1–3 km were under highly and moderately suitable class of museum area suitability classes, respectively. Whereas the areas within a buffer distance between 3 and 10 km were under marginally suitable class, but areas above 10-km buffer distance were taken as not suitable class for potential ecotourism sites. Based on the museum proximity and suitability (Table 6), the largest part of the study area was dominated by not suitable site which account about 50,218.12 hectares (61.5%) and followed by 28,588.84 hectares (35%) of marginally suitable site.

Table 7 Weighted overlay results for each suitability class (own processing, 2017)

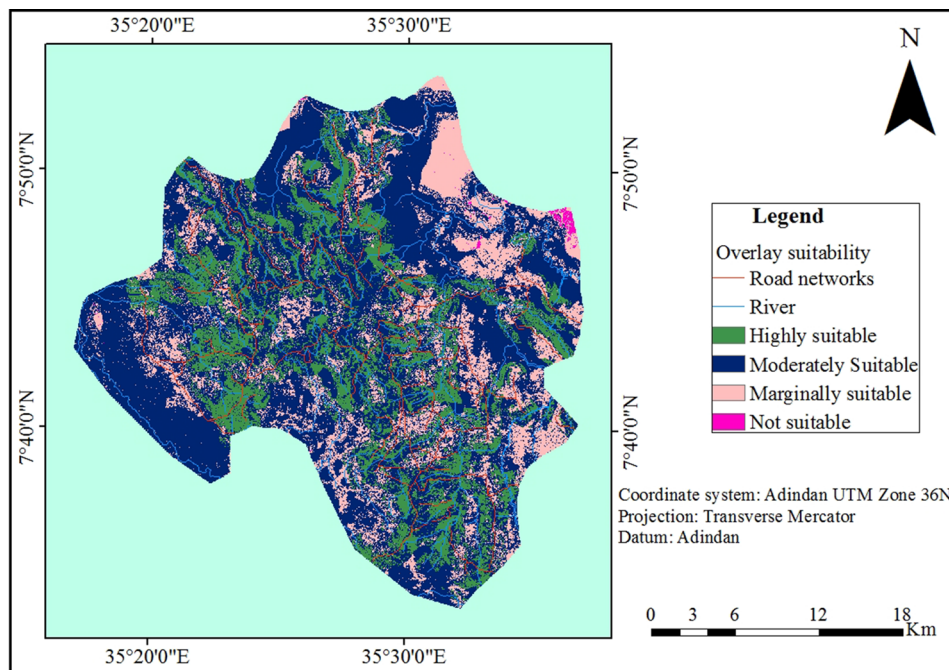
No.	Suitability class	Areal in ha.	Area in %
1	Highly suitable	17,274.52	21.2
2	Moderately suitable	48,140.20	59.0
3	Marginally suitable	15,955.40	19.5
4	Not suitable	286.44	0.4
Total	81,656.56	100	

Results of weighted overlay

The weighted overlay tool is a vital tool in ArcGIS environment that helps to solve the problems which arise due to different influential values of the various criteria in potential ecotourism site selection. In the current study, all the weighted and standardized criteria that used in the analysis were combined together with weighted overlay tools to generate a final suitable ecotourism map of the district. As clearly indicates in Table 7, the suitability classes and percentage shares of final weighted overlay map of the district that paves the way which policies and strategies should be formulated for the development of ecotourism in the study area.

According to the obtained results from weighted overlay suitability (Fig. 6 and Table 7), the area with about 17,274.52 hectares (21.2%) was found as highly suitable for potential ecotourism development because these areas fulfilled both physical and socioeconomic criteria used in the current study. The largest part of highly suitable area lies in the central, northern, northwestern, southern, and southwestern part of the district. These areas can be used as the main ecotourism attraction site because the area is endowed with evergreen forests, wildlife (both flora and fauna), and rich cultural and historical heritage. Whereas the area with about 48,140.20 hectares (59%) was classified as moderately suitable for ecotourism development and lays almost all parts of the district excepts some extreme part of northeastern, northwestern, southeastern, and some central part of the district. The areas were also characterized by their green areas, forest covers, and unique natural

Fig. 6 Weighted overlay suitability map



landscape. These largest portions of moderately suitable site in the district are also significantly important for conservation and environmental sustainability that can be developed in ecotourism through improvement of infrastructure and other ecotourism services.

On the other hand, the area with about 15,955.40 hectares (19.5%) of the district was found as marginally suitable for potential ecotourism site. The largest portions of this area located in the northeastern and southeastern part of the district. Its smallest portions were also lying in southwestern, northwestern, and some central part of the study area. However, the area with only about 286.44 hectares (0.4%) of the district was considered as not currently suitable for potential ecotourism site and located in the extreme northeastern part of the district because these areas were unable to fulfill the standards used in the present study. The areas under marginally and not currently suitable categories are less important for ecotourism activities and environmental sustainability that should be developed to ecotourism through continuous impact assessment, reasonable environmental plan, and management.

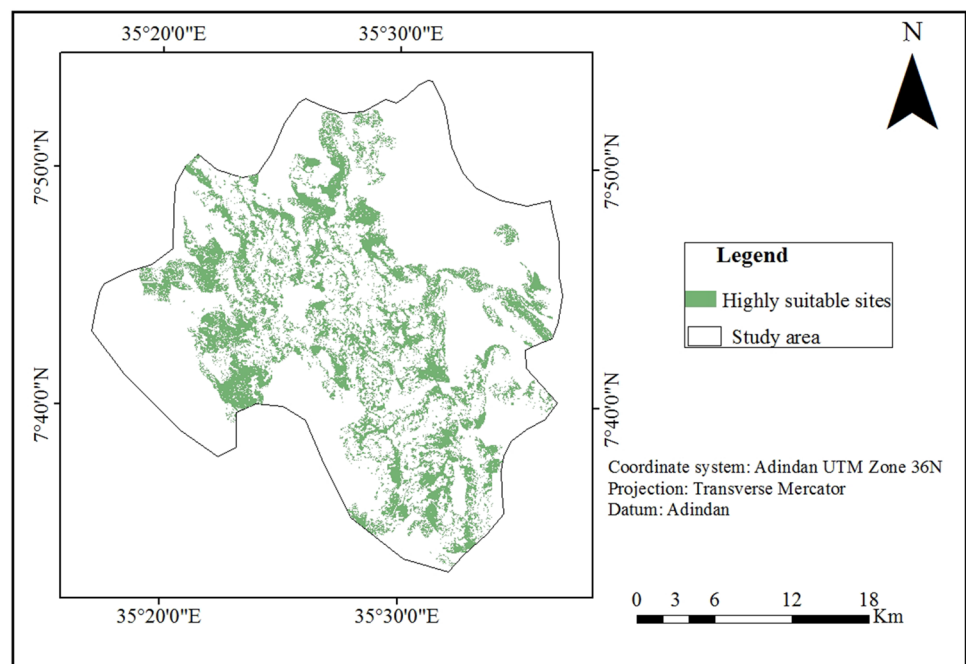
The suitability map of the district (Fig. 7) clearly shows that the area has a great ecotourism potentials to be developed into ecotourism. The results of this study basically useful for the development of ecotourism and conserving its biodiversity from being destroyed. These areas can be used for research, education, natural resource management, and community-based ecotourism development with the certain limitations, and guidelines for those areas involve the most sensitive areas. Some guidelines to protect the ecosystem in the area includes restricting the

number of tourists, limiting the duration of accessing the area, and reducing the amount of visitor pressure in these areas in order to keep the originality of the site because once they are destroyed, it was difficult to rehabilitate. Similar to the present study, Geremew and Hailemeriam (2015) were recommended to develop any necessary codes of conduct for the sensitive areas to conserve and manage in a sustainable way.

Thematic map of highly suitable ecotourism site

Thematic map is a type of map that is designed to show the distribution of the highly suitable potential ecotourism site in the district that fulfilled all the criteria that were selected for the current study. As shown in Fig. 6, weighted overlay ecotourism suitability map contains all suitability classes, namely, highly suitable, moderately suitable, marginally suitable, and not currently suitable for potential ecotourism site of the districts. Therefore, it is essential to show only highly suitable ecotourism site of the district to take a reasonable decision for the development of the ecotourism sector in the study area. In order to produce the thematic map of the selected suitability class, the raster map of weighted overlay result was converted into polygon by using the conversion tool in ArcGIS environment. After the conversion process, the shape file of highly suitable area was selected and exported in ArcGIS software to generate the final thematic map of highly suitable site (Fig. 7).

Fig. 7 Thematic map of highly suitable ecotourism site in the district



Types and status of potential ecotourism site in Masha district

According to the expert's opinion, the district was rich with historical, cultural, and natural ecotourism attraction types. This is because there was a long history of protecting and managing these entire attraction sites, including the forests in the district. The people in the study area have also a deep-rooted culture of conserving flora and fauna species. Forest and other landscape such as steep slope, hill land, and wetland have special cultural values among the communities in the district. Specially, forests have given a valuable consideration by the society due to their traditional and religious beliefs. For example, there are worshipping activities taken place in a protected forest area like sacrificing animals. These activities enhance the management and conservation of forest from being cut. Due to this kind of conserving and protecting habit of the people in the study area, the forests and other ecotourism attraction resources were well known in the district. Till now in the some parts of the district, there are few members of communities' practices these traditional systems of protecting the resources from being destruction. Such types of the traditional practices have emphasized harmony between man and nature that plays an important role in biodiversity conservation.

On the contrary of the above paragraph, all respondents were arguing that this kind of protecting and conserving forests and resources within forest becomes diminished due to increasing of the communities who were not willing to participate in the practices of forest conservation in traditional and religious ways. Nowadays, the forest and other endemic biodiversities in the district were under threat due to the increasing demands of the people for agricultural land, the rising demand of charcoals, and increasing of large scale tea plantation in and around the forest area. These increasing of deforestation and other pressures on forest area resulted in diminishing of flora and fauna in both quantities and qualities in the district.

The results of the study indicate the land use–land cover and suitability for ecotourism development in the study area. The satellite image classification revealed that the largest proportion of land in the study area is forest land, accounting for 62.4% of the total area. Cropland occupies 33.6% of the area, while built-up areas and open land occupy 2 and 1.9%, respectively. The overall accuracy of the classification process was 85%, indicating a strong agreement between the classified data and the referenced data. The selection of suitable land cover classes for ecotourism development was based on the perspectives of the previous researchers. Forest, open land, built-up areas, and croplands were ranked as highly suitable, moderately suitable, marginally suitable, and not suitable, respectively. The reclassified map showed that a large part of the study area, approximately 50,937.04 hectares, was highly

suitable for ecotourism development due to the presence of dense and evergreen forests, which attract domestic and foreign tourists.

Elevation suitability was analyzed based on the elevation range of the district. The area between 2322 and 2655 m was considered highly suitable due to favorable climatic conditions and rich biodiversity. On the other hand, areas between 1410 and 1864 m were deemed not suitable due to unfavorable environmental conditions. The analysis revealed that 16,924.6 hectares of the study area were highly suitable for ecotourism, while 23,782.4 hectares were moderately suitable. The slope suitability analysis categorized slopes into different classes. Steep slopes with a range of 13.58°–68.12° were considered highly suitable due to the presence of cliff and hanging wall landscapes, which are visually appealing to tourists. Slopes between 2.86° and 7.15° and 7.15°–13.58° were categorized as marginally suitable and moderately suitable, respectively. The results showed that 38.5% of the total area was highly suitable for ecotourism, while 34.8% was marginally suitable.

Proximity to rivers was evaluated as an important parameter in ecotourism site selection. Areas within a buffer distance of 0–0.5 km from rivers were considered highly suitable due to their scenic beauty and rich biodiversity. Areas beyond a buffer distance of 2 km were classified as not suitable. The analysis revealed that 49.7% of the district was highly suitable for ecotourism, while 2.6% was not suitable. Road network suitability was assessed based on proximity to road networks. Areas within a buffer distance of 0–1 km were ranked as highly suitable, as they are easily accessible to tourists. Areas beyond a buffer distance of 3 km were considered not suitable due to high transportation costs. The analysis showed that 58.9% of the area was highly suitable, while 9.6% was not suitable for ecotourism. Proximity to urban areas and museums was also evaluated for suitability. Areas within a buffer distance of 3 km from urban areas and museums were considered not suitable, while areas beyond a buffer distance of 10 km were classified as highly suitable. The analysis indicated that 61.5% of the area was not suitable for ecotourism based on urban area proximity, and 35% was marginally suitable based on museum proximity. The final weighted overlay analysis combined all the criteria and generated a final suitable ecotourism map of the district. Approximately 21.2% of the area was classified as highly suitable for potential ecotourism development, with the largest portion located in the central, northern, and southwestern parts.

Conclusion

Masha district is one of the most biodiversity rich areas in Ethiopia mainly for its endemic and threatened flora and fauna species. Despite these huge potential areas in the



district, ecotourism is not well developed, and its potential area remains untouched and delineated in terms of ecotourism destination. The integration of GIS- and AHP-based land suitability analysis has been used to determine the suitability of *ecotourism* in Masha district by using both physical and socioeconomic factors, namely, land use–land cover, elevation, slope, river, road, distance from the museum, and urban areas.

Based on the findings, 21.2% of the study areas were highly suitable for potential ecotourism site. These selected sites were fulfilled all the standards used in the analysis and lie in the central, northern, northwestern, southern, and southwestern part of the district. Only 0.4% of the district were considered as not currently suitable site and located in the extreme northeastern part of the district. Whereas the remaining 59 and 19.5% were classified as moderately and marginally suitable sites for ecotourism development, respectively. A demonstrative plan is needed for ecotourism development based on locally available natural and cultural resources. This will help to conserve and maintain the biological richness of the areas and provide employment opportunities for the local people. Furthermore, additional investigation is needed for highly suitable ecotourism sites to abstain from traveling in sensitive areas which are easily affected and difficult to rehabilitate to its original conditions.

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