GeoJournal of Tourism and Geosites
ISSN 2065-1198, E-ISSN 2065-0817

Year XVI, vol. 46, no. 1, 2023, p.252-261
DOI 10.30892/gtg.46128-1022

IDENTIFYING POTENTIAL ZONES FOR ECOTOURISM DEVELOPMENT IN BATTICALOA DISTRICT OF SRI LANKA USING THE GIS-BASED AHP SPATIAL ANALYSIS

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Citation: Pathmanandakumar, V., Goh, H.C., & Chenoli, S.N. (2023). IDENTIFYING POTENTIAL ZONES FOR ECOTOURISM DEVELOPMENT IN BATTICALOA DISTRICT OF SRI LANKA USING THE GIS-BASED AHP SPATIAL ANALYSIS. *GeoJournal of Tourism and Geosites*, 46(1), 252–261. https://doi.org/10.30892/gtg.46128-1022

Abstract: Ecotourism makes a significant contribution to long-term development. However, a spatial analysis-based multi-criteria process has been widely used in ecotourism development planning. Batticaloa district is one of the tourism hotspots in the country which distinctive views play a significant role in fostering the potential for ecotourism. However, no specific study or planning has been carried out to identify appropriate zones for ecotourism development. This study attempts to identify suitable zones for ecotourism development in Batticaloa District. In this research AHP method was used in GIS environment. Five thematic layers such as landscape, protected area, topography, accessibility, and community characteristics were given appropriate weights and integrated into the GIS through the weighted overlay analysis. Accordingly, five potential ecotourism zones were identified in the study area. The research revealed that the area very suitable for ecotourism development is largely distributed in the northern, western, and south-western parts of the Batticaloa district. Finally, 12.53% of the land area of the District falls under the "very suitable to extremely suitable" area for ecotourism development. The findings of this study can assist tourism planners and the government in precisely selecting locations for ecotourism development and relieving pressures on the region's tourism demand.

Key words: eco-tourism, site suitability, AHP, GIS, MCDA, Batticaloa

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INTRODUCTION

Ecotourism has emerged as a critical component of the tourism industry in order to raise environmental awareness, reduce the negative consequences of tourism, and sustainably use natural and cultural tourist assets (Kaymaz et al., 2021). It is one of the most successful means of balancing economic development and conservation of natural resources (Aneseyee et al., 2022). Definitions of ecotourism have been provided in the tourism literature. One of the earliest definitions is that "ecotourism is a sustainable form of natural resource-based tourism that focuses primarily on experiencing and learning about nature. It is ethically managed to be low-impact, non-consumptive, and locally-oriented (control, benefits, and scale). It typically occurs in natural areas and should contribute to the conservation or preservation of such areas"(Fennell, 2008: 26). Ecotourism is the most appealing aspect of the tourism industry, which, if properly handled, will contribute to the protection of natural resources and local development (Izwar et al., 2020; Waswa Wanyonyi et al., 2016). It plays a greater role in the economic growth and conservation initiatives of developing countries (Waswa Wanyonyi et al., 2016).

Therefore, several tourism destinations considered ecotourism as a potential approach to address their environmental and economic issues (Sahani, 2019). Sri Lanka has a long history of being a tourist destination because of its strategic and unique position as an Island in the Indian Ocean. It is famous for its tropical beaches, waterfalls, deep-sea fishing, scuba diving, coral reefs, and whale and dolphin watching. Furthermore, heritage sites, natural forests with dense fauna and flora, wildlife sanctuaries, etc., attract more tourists (MTDCRA, 2016). Sri Lanka's tourism sector has shown a strong return to conflict and natural disasters since 2009, despite having suffered almost three decades of war and Tsunami. Since 2012, the tourism business in Sri Lanka has performed successfully, reaching a record high of over 2 million (2,050,832) international tourist arrivals in 2016 (SLTDA, 2016). Sri Lanka recorded the highest growth rate (2333, 796) in 2018 with US$ 4380.6 million in earnings, a rise of 10.3% from the previous year, making it the third-largest foreign exchange earner in Sri Lanka (SLTDA, 2018). The government of Sri Lanka has taken leaps in order to establish a new strategy (alternative tourism) to boost the economic impact of tourism by reviewing everything connected to tourism demand, investments, and constraints (MTDCRA, 2016). Unfortunately, International tourist arrivals fell by 61.7% in 2021 due to the unprecedented

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outbreak of the COVID-19 pandemic. Sri Lanka received 194,495 international tourists in 2021, a 61.7% decrease compared to the 1,913,705 international tourists that visited the country in 2019 (SLTDA, 2021).

The Batticaloa District was selected as a case study because of its natural tourist attractions: extensive sea, clean, sandy, and attractive beaches, protected area, dense forest, flowers, plants, and species. In addition, the district attracts tourists' attention from a socio-cultural and economic perspective: the rural house, rural life, rural agriculture, and local products. The district contains potential resources for initiating eco-tourism. However, a lack of suitability analysis to identify the potential ecotourism sites refrain from fulfilling potential tourism investments. This is the first study, to the best of the authors' knowledge, to apply a Geographic Information System (GIS)-based Multi-Criteria Decision Analysis (MCDA) to identify ecotourism locations in Sri Lanka. In order to address this significant knowledge gap in the increasing literature, this study attempts to identify suitable zones for ecotourism development in Batticaloa district using GIS-AHP spatial analysis.

The GIS and AHP technique is a valuable, cost-effective and time-efficient tool for identifying potential locations for ecotourism development (Ghorbanzadeh et al., 2018; Mahdavi et al., 2015; Sahani, 2019). The combination of remote sensing with GIS is regarded as an efficient method for environmental management, management of a large amount of spatial data, and analyzing the relationship between spatial data and tourism locations (Ghorbanzadeh et al., 2018, 2019; Sahani, 2019). Different MCDA methods are available, the most effective and commonly used for suitability analysis is the Analytical Hierarchy Process (AHP) (Kahsay et al., 2018; Wong and Fung, 2016). In AHP, each theme can be compared based on its relative importance for identifying potential zones. Multiple disciplines utilize GIS-based MCDA for supporting decision-making (Benke and Pelizaro, 2010; Sahani, 2019). GIS, together with MCDA, is one of the most appropriate approaches for a range of optimization applications and offers data structure, weighting, and integration techniques (Debesa et al., 2020; Feizizadeh and Kienberger, 2017; Ghorbanzadeh et al., 2019). The integrated approach of GIS and MCDA is considered essential for evaluating the potential sites for nature-based tourism (Ghorbanzadeh et al., 2018, 2019). GIS and MCDA have been applied to evaluate potential ecotourism sites with a wide range of techniques (Bunruamkaew and Murayama, 2011, 2012; Jeong, 2016; Sahani, 2019). GIS and AHP technique, can help categories, examine, and organize the available data concerning choice possibilities for spatial planning (Zabihi et al., 2019). The application of AHP technique and the spatial analysis approach for selecting potential ecotourism sites will maximize the economic value of appropriate land while minimizing negative environmental impacts (Mansour et al., 2019).

The literature analysis shows that a set of spatial variables (Factors/Thematic layers and criteria) has been evaluated to identify potential ecotourism sites within a GIS platform. Bunruamkaew and Murayama (2011) employed GIS and AHP to assess potential sites to develop ecotourism in Surat Thani province, Thailand, based on five factors: landscape, wildlife, topography, accessibility, community Characteristic characteristics, and land use. Mahdavi et al. (2015) applied five thematic layers: climate, topography, geo-pedology, environmental, and socio-economic for a fuzzy multicriteria decision method for locating eco-tourism. Waswa Wanyonyi et al. (2016) also used GIS together with AHP for the analysis of potential sites for ecotourism based on five thematic layers such as landscape, wildlife, topography, accessibility, and settlement size. Bingöl (2017) used four thematic layers such as landscape, wildlife, topography, and accessibility for Identifying potential sites for ecotourism in Burdur Province using GIS and AHP. Çetinkaya et al. (2018) applied fourteen thematic layers such as slope, elevation, aspect, earthquake risk, flood risk, rainfall, temperature, wildlife, vegetation diversity, distance from the road, proximity to cultural sites, proximity to water resources, proximity to lithology, distance from population centers to identify ecotourism sites using GIS and AHP.

Adigana and Sih Setyono (2019) also used GIS and AHP for ecotourism site suitability analysis based on five thematic layers such as landscape, wildlife, topography, accessibility, and community characteristics. Mansour et al. (2019) used thirteen thematic layers such as elevation, slope, aspect, geology, soil types, distance from built-up areas, distance from Road network, distance from sandy beaches, distance from fault lines, Distance from marine turtles zone, Distance from marine birds zone, Distance from mangrove zone, distance from coral reefs to analysis ecotourism land suitability in Masirah Island, Oman using GIS and AHP. Ghorbanzadeh (2019) applied four thematic layers: water attractions, Scenic spots, Mountain attractions, and forest attractions to identify potential tourism area in in East Azerbaijan Province, Iran by applying GIS-AHP. Ambecha et al. (2020) applied GIS together with AHP for ecotourism site suitability evaluation based on three thematic layers such as topography, elevation, and proximity to river. Eraku et al.(2021) identified ecotourism potentials of botutonuo beach in bone based on physical parameter, distance, amenities, attraction, attractiveness, availability of clean water, management, security, food and souvenir stalls, spatial arrangement.

Acharya et al. (2022) used eleven thematic layers to identify the potential location for ecotourism development such as relief, slope, drainage, forest, population density, tourists spots, infrastructure, health, road density, scenic beauty and LULC. Also, Aneseyee et al. (2022) applied creteria such as naturalness, wildlife, topography, accessibility, cultural heritage, and community characteristics to identify locations to develop community-based ecotourism in Abijiata-Shalla Lakes National Park, Ethiopia using GIS and AHP techniques. Chaudhary et al. (2022) identified suitable sites for sustainable ecotourism development in the Himalayan region on the basis of landscape, biodiversity, topography, climate, accessibility, attractiveness, and protection using geospatial technology and AHP. Khazaee et al. (2022) applied permanent settlements, roads, power line, mines and factories, dam, slope, vegetation, wildlife to assess ecotourism in mountainous landscape using GIS and MCDA approach (Quinta-nova and Ferreira (2022) identified the suitable sites for ecotourism development in Beira Baixa region based on the nature conservation, birds richness, mammal richness, landscape diversity, landscape value, geological value, water bodies area, accommodation offering and path network. Based on the above studies and the availability of natural resources in the study area, this study employs five thematic layers, including landscape, protected area, topography, accessibility, and community characteristics to locate potential sites for ecotourism development in Batticaloa District of Sri Lanka. Hence, the study's findings will enable decision-makers and planners to implement an investment plan to develop ecotourism in the district effectively.

STUDY AREA

The Batticaloa District lies on a coastal plain on the eastern coast of Sri Lanka between the longitudes of 81°15'00" and 81°50'00" East and the latitudes of 7°25'00" and 8°15'00" North (Figure 1). It is characterized by a tropical climate, with an annual rainfall of around 1000-1500 mm distributed irregularly throughout the year (primarily from the northeast monsoons (about 60%), during October to February) (District Secretariate Batticaloa, 2020; Jayasingam, 2008). The mean annual temperature is 30°C, although typically, this ranges from 25°C on cooler nights during the rainy seasons to 35.4°C during the rare day in the hot summer months (District Secretariate Batticaloa, 2020). It has a land area of around 2854 km^2 and an interior waterway of approximately 229 km^2. The district comprises 3.8 % area of the country and is inhabited by a population number of 574836 (District Secretariate Batticaloa, 2020). The district has an attractive lagoon with several small islets, forest landscapes covered with abundant vegetation and mangroves, considerable wildlife, and socio-cultural uniqueness, providing ample ecotourism opportunities. Hence, on the eastern coast of Sri Lanka, the Batticaloa District is considered one of the prime locations for tourists to visit.

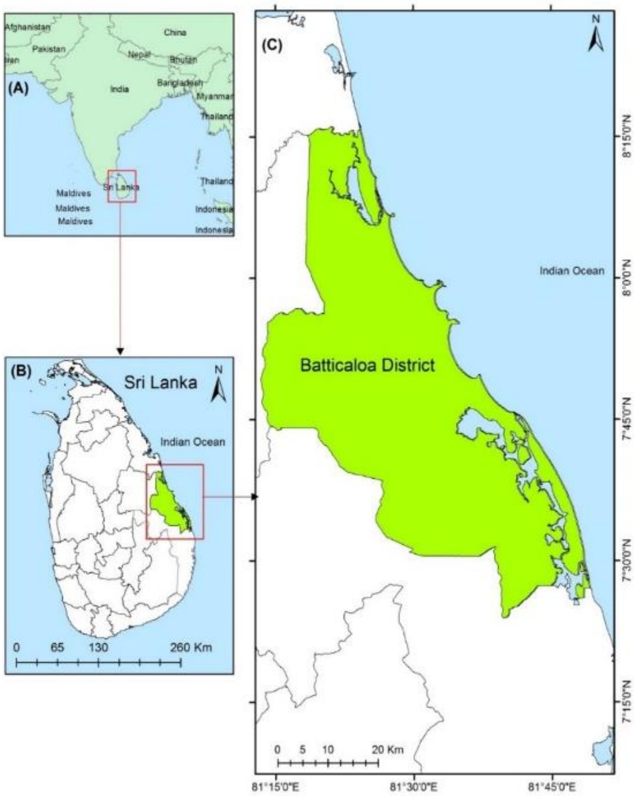

Figure 1. Location of the study area:
(a) Map of South Asia; (b) location of Sri Lanka; and
(c) the extent of Batticaloa district (Source: Authors, 2022)

MATERIALS AND METHODOLOGY

Data source

In this study, data was collected from multiple sources (Table 1). The factors and criteria influencing ecotourism in the Batticaloa District were determined through literature surveys.

Table 1. List of data layers and their sources (Source: Authors, 2022)

Elements	Data	Spatial Resolution	Source
Elevation	Aster DEM	30 m	U.S Geological Survey (USGS)
Visibility	Aster DEM	30m	U.S Geological Survey (USGS)
River Network	Aster DEM	30m	U.S Geological Survey (USGS)
Land Cover 2019	Sentinel-2	10m	U.S Geological Survey (USGS)
Surface Water	Sentinel-2	10m	U.S Geological Survey (USGS)
Boundary map	Topographical Map	1:50,000	Survey Department of Sri Lanka
Forest reservation	Topographical Map	1:50,000	Survey Department of Sri Lanka
Road network	Topographical Map	1:50,000	Survey Department of Sri Lanka
Cultural attraction sites	Topographical Map	1:50,000	Survey Department of Sri Lanka
Population Data	Census of Population and Housing report		Divisional secretariat Batticaloa (2018)

METHODOLOGY

Figure depicts the activities involved in selecting potential locations for ecotourism development utilizing GIS and AHP (Sahani, 2019).

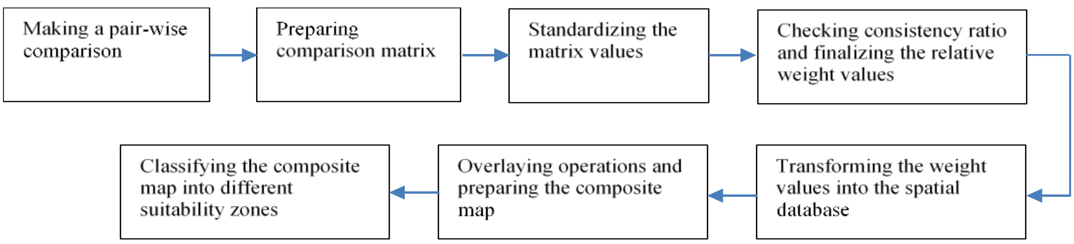

Figure 2. Flow chart for GIS-AHP based ecotourism site suitability analysis (Source: Authors, 2022)

Generation of thematic layers

The initial step of the procedure was to identify the factors and criteria (Thematic layers). The extent of the availability of data in the study area has a significant influence on selecting the number of thematic layers (Rahmati et al., 2015). The factors and criteria responsible for the Batticaloa District's ecotourism potential were selected in terms of their importance, and information from relevant literature (Table 2) (Adigana and Sih Setyono, 2019; Bingöl, 2017; Bunruamkaew and Murayama, 2011; Çetinkaya et al., 2018; Ghorbanzadeh et al., 2018, 2019; Mahdavi et al., 2015; Mansour et al., 2019; Nino et al., 2017; Sahani, 2019; Waswa Wanyonyi et al., 2016).

The potential ecotourism locations are primarily dependent on the themes and criteria. The entire process of the identification of potential ecotourism locations is shown in Figure 3. Five thematic layers, such as landscape, protected area, topography, accessibility, and community characteristics and 12 criteria such as visibility, land use, reservation, elevation, proximity to historical sites, proximity to the surface water, proximity to streams, proximity to lagoons, proximity to mangroves, distance from roads, distance from population centers, and settlement density, were chosen to assess potential ecotourism sites (Figure 3 and Figure 4). Criteria maps were prepared based on the factor suitability rating (Table 2). The row scores for factors in Table 2 cannot be compared to one another as they have different scales of measurement. Therefore, to process comparison, the standardization of factors was performed based on five levels, viz. extremely suitable, very suitable, moderately suitable, slightly suitable, and not suitable (Table 2).

Table 2. Factors and criteria in identifying potential ecotourism locations
(Source: Approach adopted from (Bunruamkaew and Murayama, 2011; Waswa Wanyonyi et al., 2016)

Factor/ Thematic layer	Criteria	Unit	Factor Suitability Rating					Preferred Situations
			Extremely suitable	Very suitable	Moderately suitable	Slightly suitable	Not suitable	
Landscape	Visibility	Km	>26	7-12	4-7	4-2	<2	Eco-tourism sites should be located at a place with more visibility
	Land cover	Class (NDVI)	Dense forest (0.60-.80)	Sparse forest (0.45-0.60)	Grassland & Agricultural (0.33-0.45)	Bare land (0.12-0.33)	Urban (-0.99-0.12)	Ecotourism sites should be located close to the dense forests for a better experience
Protected Area	Reservation	Km	<14	14-32	32-47	47-64	>64	Eco-tourism sites should be located close to protected areas for better observation
Topography	Elevation	M	>106	57-106	34-57	15-34	<15	Eco-tourism sites should be located at high elevations for a better view
Accessibility	Proximity to historical sites	Km	<13	13-25	25-36	36-50	>50	Eco-tourism sites should be located close to historical sites
	Proximity to surface water	Km	<2.5	2.5-5	5-7.5	7.5-10.5	>10.5	Eco-tourism sites should be located close to the lake, ponds, etc.
	Proximity to stream	M	<700	700-1500	1500-2700	2700-4500	>4500	Eco-tourism sites should be located close to a stream
	Proximity to lagoons	km	<12	12-22	22-31	31-42	>42	Ecotourism sites should be located close to a lagoon
	Proximity to mangroves	Km	<6	6-11	11-16	16-22	>22	Eco-tourism sites should be located close to mangroves
	Distance from population centres	Km	>27	20-27	13-20	7-13	<7	Eco-tourism sites should be located away from the population centers
	Distance from roads	Km	Area >15 km buffer around major roads	The area within 7-10 km buffer around major roads	The area within 4-7 km buffer around major roads	The area within 1-4 km buffer around major roads	Area <1 km buffer around roads	Eco-tourism sites should be located far away from the major road for better protection of nature
Community Characteristics	Settlement size	Population density per Km^2	< 45	45-85	85-205	205-1440	>1440	Eco-tourism sites should be located in a less populated area

Determination of Normalized weights for each thematic layer using AHP

Saaty's AHP was used to normalize the weights of different thematic layers and their features (Table 3). Suitable weights were assigned to the selected thematic layers and their features. Comparison matrices were generated on different hierarchical levels (Table 4). AHP process compares all thematic layers in pairings and outputs their relative weights. The normalized value is the thematic layers' final weights (Table 5) (Çelik, 2019).

Saaty's 1–9 scale was employed for pair-wise comparison of different thematic layers (Table 3), with a value of 1 expressing "equal importance" and a value of 9, which indicates that the factors have an "extreme importance" over another factor (Bunruamkaew and Murayama, 2011; 2012; Mansour et al., 2019; Muralitharan and Palanivel, 2015; Rahmati et al., 2015; Sahani, 2019).

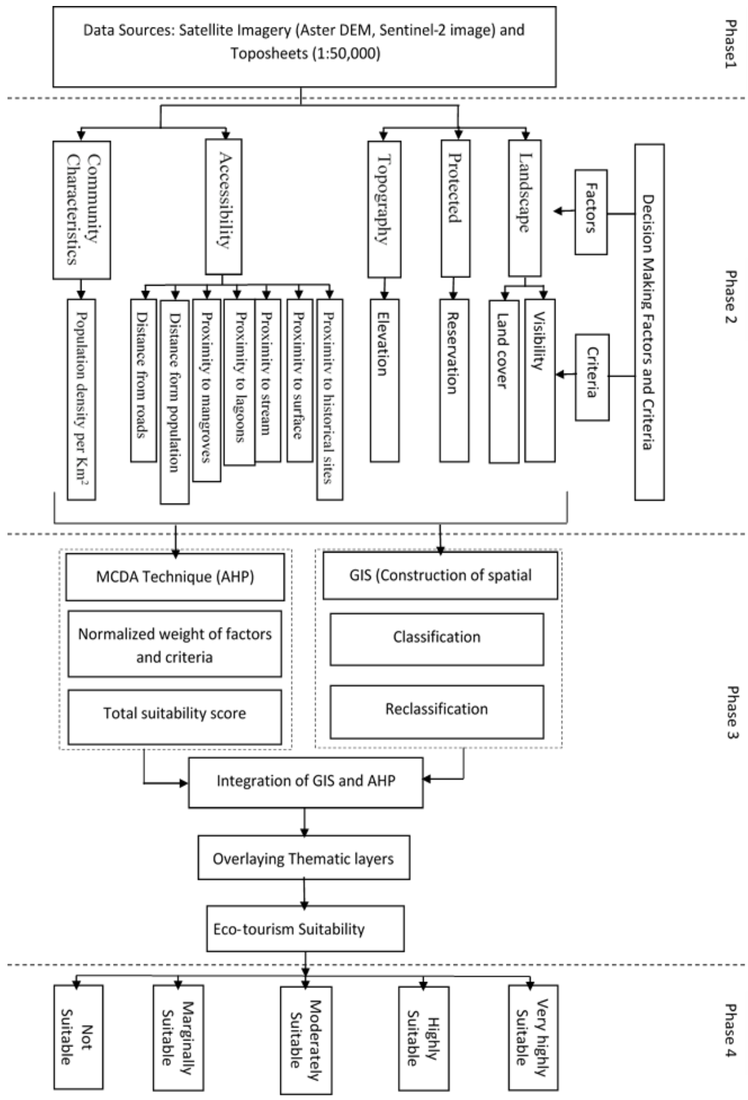

Figure 2. Flow chart of the methodology for Ecotourism site suitability analysis (Source: Authors, 2022)

Table 3. Saaty's 1-9 scale for the pairwise comparison (Source: Çetinkaya et al., 2018; Mansour et al., 2019; Wong and Fung, 2016)

Intensity of Importance	Definitions
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very strong to extremely importance
9	Extreme importance

Table 4. Pair-wise comparison matrix of thematic layers (Source: Authors, 2022)

Themes/Factors	(LS)	(TP)	(WL)	(AC)	(CC)
Landscape (LS)	1.00	4.90	4.96	4.52	3.00
Topography (TP)	0.20	1.00	0.68	2.17	1.93
Wildlife (WL)	0.25	1.47	1.00	2.63	3.90
Accessibility (AC)	0.20	0.46	0.38	1.00	1.82
Community Characteristics (CC)	0.22	0.52	0.26	0.55	1.00

The Table 5 displays a pair-wise comparison matrix of five themes used to identify potential ecotourism locations in the study area. The following equation (Equation 1) (Aneseyee et al., 2022; Chaudhary et al., 2022; Sahani, 2019) is used to calculate the Consistency Ratio:

$$CR = \frac{CI}{RI} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

where RI - Random index, CI - Consistency index. CI can be expressed as follows (Equation 2) (Aneseyee et al., 2022; Chaudhary et al., 2022; Sahani, 2019):

$$CI = \frac{\lambda max - n}{n - 1} \dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Here, (λmax) is a principal eigenvalue, n is the number of factors, and CI is the consistency index. Consistent weights should have a CR value less than 0.10; otherwise, weights should be re-evaluated (Saaty, 1980). In this study, the consistency ratio (CR) is found 0.04536 (CR<0.10, λmax = 8.70, n = 5, RI = 1.11, CI = 0.0504); this demonstrates that the pairwise matrix comparison yields a reasonable level of consistency (Table 5). The AHP method used here has thus been found to be quite accurate in predicting potential ecotourism locations.

Table 5. Determining the normalized weights for thematic layers (Source: Authors, 2022)

Themes/Factors	(LS)	(TP)	(WL)	(AC)	(CC)	Normalized Weight (W)	Consistency Measures
Landscape (LS)	0.535	0.587	0.681	0.416	0.258	0.50	5.678
Topography (TP)	0.107	0.120	0.093	0.200	0.166	0.14	5.194
Wildlife (WL)	0.134	0.176	0.137	0.242	0.335	0.21	5.118
Accessibility (AC)	0.107	0.055	0.052	0.092	0.156	0.09	4.980
Community Characteristics (CC)	0.118	0.062	0.036	0.051	0.086	0.07	5.038
Consistency index (CI)							0.0504
Random index (RI)							1.11
Consistency Ratio (CR)							0.04536

Normalized weights of attributes of thematic layer

Table 6 displays the assigned rank and normalized weights of the different features of the individual themes on their potential for ecotourism (Chaudhary et al., 2022; Chowdary et al., 2013).

Definition of the EPI

The ecotourism potential index (EPI) is a number with no units that predict where there might be good places for ecotourism in an area. It was calculated using the weighted linear combination method (Sahani, 2019). Potential ecotourism destinations were calculated using the following equation 3, which was used to integrate all of the themes. The EPI values were classified into five groups: Extremely suitable (7.000000001 – 8.00), Very suitable (6.000000001 – 7.00), moderately suitable (5.000000001 – 6.00), Slightly suitable (4.000000001 –5.00), and not suitable (>4), using the quantile classification method which has been adopted by many researchers in this field because of its classification efficiency (Rahmati et al., 2015). The weighted overlay analysis was used to produce a composite suitability map. Each spatial layer was transformed into a raster format and reclassified to a measurement suitability scale using ArcGIS 10.4 (Table 7).

Table 6. Normalized weights of different features of thematic layers (Source: Authors, 2022)

Factor/ Thematic layer	Normalized Weight (w)	Criteria	Feature Normalized Weight (wf)	Total Suitability Score (w*wf)
Landscape (LS)	0.50	Visibility	0.42	0.21
		Land cover	0.58	0.29
Wildlife (TP)	0.14	Reservation	1.00	0.14
Topography (WL)	0.21	Elevation	1.00	0.21
Accessibility (AC)	0.09	Proximity to historical sites	0.15	0.01
		Proximity to mangroves	0.23	0.02
		Proximity to surface water	0.12	0.01
		Distance form lagoons	0.11	0.01
		Distance form streams	0.13	0.01
		Distance form roads	0.26	0.02
Community Characteristics (CC)	0.07	Settlement size	0.60	0.04
		Distance form populations centres	0.40	0.03

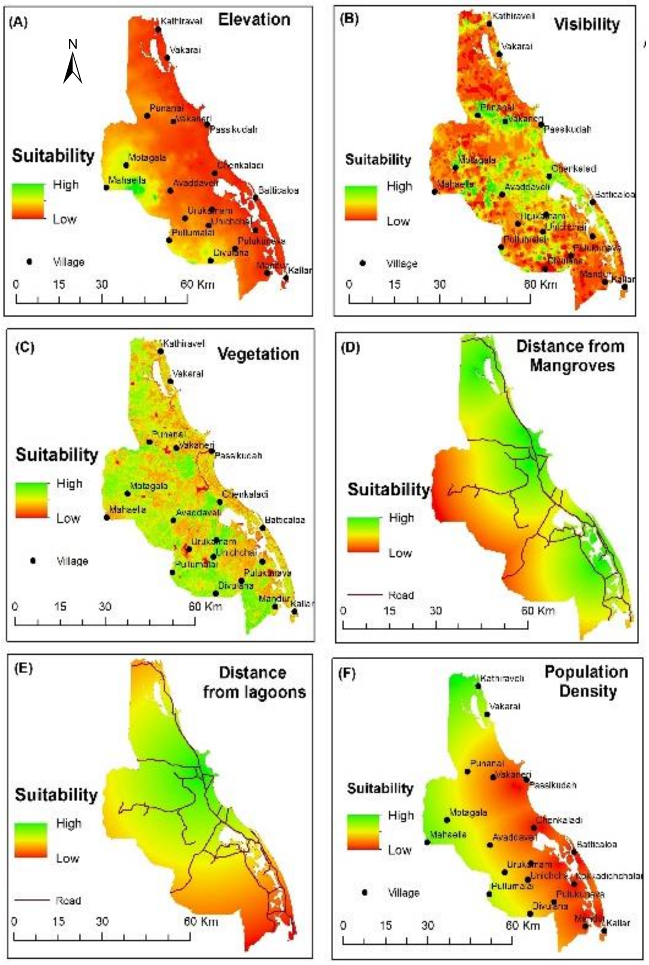

Figure 3. Criteria maps for ecotourism suitability: (A) Elevation (B) Visibility (C) Vegetation (D) Distance from mangroves (E) Distance from lagoons (F) population density (Source: Authors, 2022)

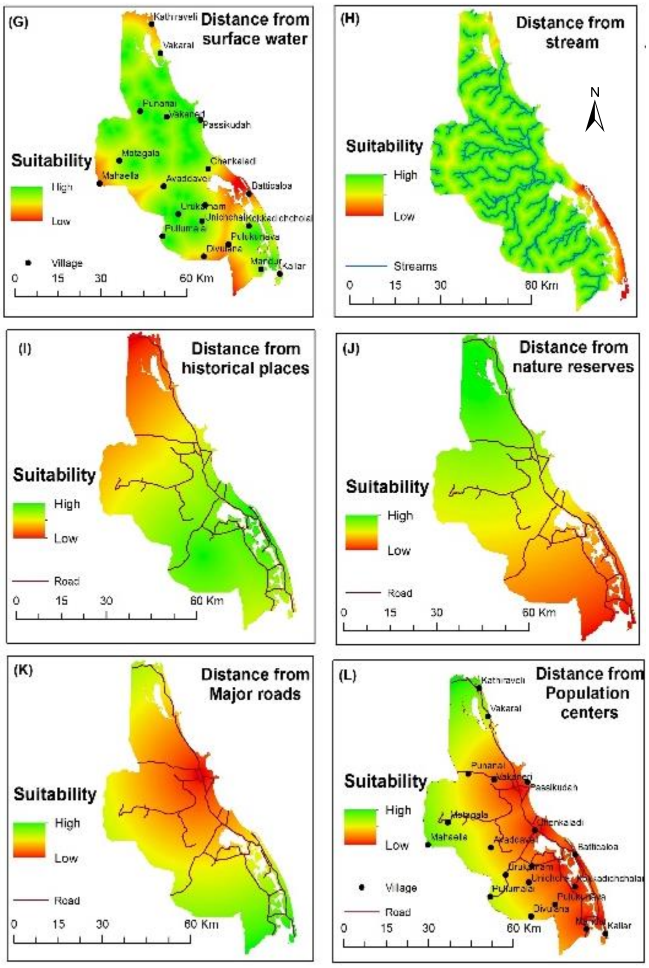

Figure 4. Criteria maps for ecotourism suitability: (G) Distance from surface water (H) Distance from streams (I) Distance from historical places (J) Distance from natural reserves (K) Distance from major roads (L) Distance from population centers (Source: Authors, 2022)

The following equation 3 modified from (Aneseyee et al., 2022; Chaudhary et al., 2022; Sahani, 2019).

$$EPI = \{ (LS_w LS_{wf}) + (TP_w TP_{wf}) + (WL_w WL_{wf}) + (AC_w AC_{wf}) + (CC_w CC_{wf}) \} \quad (3)$$

Where Sl—Landscape, TR—Topography, WL—Wildlife, AC—Accessibility, CC— Community Characteristics, the subscriptions 'W'— the normalised weight of the theme obtained through AHP and 'Wf'— the normalised weight of the individual theme features.

Table 7. Spatial data and analysis list (Source: Authors, 2022)

Criteria	Influences	Analysis
Visibility	3	view shed
Land cover	28	NDVI
Reservation	9	Euclidean Distance
Elevation	3	Normalization
Proximity to historical sites	8	Euclidean Distance
Distance from streams	5	Euclidean Distance
Proximity to surface water	5	Euclidean Distance
Distance from lagoons	5	Euclidean Distance
Distance from Mangroves	7	Euclidean Distance
Distance from roads	13	Euclidean Distance
Settlement size	10	Density
Distance from population centres	4	Euclidean Distance

Table 8. Area coverage of land usability for eco-tourism (Source: Authors, 2022)

Suitability class		Score range	Area coverage	
			Km^2	%
Extremely suitable		7.001 - 8	2.78	0.12
Very suitable		6.001 - 7	299.5	12.41
Moderately suitable		5.001 - 6	1509.1	62.51
Slightly suitable		4.001 - 5	594.42	24.62
Not suitable		>4	8.34	0.35

RESULTS AND DISCUSSION

The integrated GIS and AHP techniques are advantageous for identifying potential ecotourism sites in an area and providing reliable preliminary information on locations cost-effectively (Ghorbanzadeh et al.,2019; Sahani, 2019). This study produced a map of potential ecotourism sites through the weighted overlay analysis of various thematic layers on the GIS platform. It comprises five classes of suitability (Figure 6): extremely suitable, very suitable, moderately suitable, slightly suitable, and not suitable (Table 8).

The map shows that the potential locations for ecotourism development are dispersed unevenly across the district. The Extremely suitable location, about 0.12% (2.87km^2) of the total area, is in the district's Northern part. Further, a few more "Extremely suitable" locations are in the Northwest part of the district. The "Very suitable" area is primarily distributed in the Northern, Western, and Southwestern parts of the region, which is about 12.41% of the total land area. About 62.51%, or 1509.1 km2 land area of Batticaloa District (mostly in the district's middle) is classified as "moderately appropriate. The concentration of the "Slightly suitable" area (594.4Km^2) is found in the district's Southeast part. Further, a few more "Slightly suitable" areas are located in the Northern, Western, and Southwestern parts of the district. Likewise, only a 0.35% of the total land area around urban settlements in the south is classified as "not suitable" for ecotourism development that should be excluded from any successful ecotourism planning. The finding indicates that very suitable and extremely suitable areas (12.53% of the total land area) for ecotourism development are found near protected areas and dense forest areas in the Batticaloa district, which has abundant biological diversity and is considered an important area for fauna and flora protection. These areas have the most ecotourism attractions, as well as very rich wildlife and ecological diversity.

This finding revealed that that the extremely, highly and moderately suitable areas for ecotourism development are located near protected areas, wildlife, dense forest, scenic beauty, and marine environment that are suitable for ecotourism as previously indicated by other authors (Ambecha et al., 2020; Aneseyee et al., 2022; Chaudhary et al., 2022; Kaymaz et al., 2021). The major part of "Slightly suitable and not suitable" areas are mostly located in bare lands, built-up and urban areas. These areas have high human influences and housing growth, and are described as having low natural resources (attractions), making them less suitable for ecotourism (Mansour et al., 2019). There are numerous potential economic benefits to developing ecotourism in the Batticaloa district of Sri Lanka. Both domestic and international tourists can benefit from ecotourism in districts, which can boost income generation throughout the country. Previous studies (Ambecha et al., 2020; Aneseyee et al., 2022; Chaudhary et al., 2022; Kaymaz et al., 2021) have highlighted the importance of considering environmental and ecological factors when planning for optimal ecotourism development. As a result, coastal areas, beaches, fauna and flora, marine environments, and wilds, among other things, can be developed into ecotourism attractions in the Batticaloa district. Sustainable development and biodiversity conservation in the Batticaloa district can be achieved by implementing appropriate ecotourism spatial planning. It has a high level of ecological and marine diversity. Therefore, the district will become a popular ecotourism destination and a location for ecosystem conservation.

Implementing appropriate infrastructure and amenities will turn the district into a major ecotourism destination in Sri Lanka. Tourism infrastructure should be developed in collaboration with the local environment and district identity. Previous research has highlighted the importance of infrastructure and land use in the development of ecotourism (Acharya et al., 2022; Ambecha et al., 2020; Aneseyee et al., 2022; Kaymaz et al., 2021; Mansour et al., 2019). Similarly, ecotourism facilities in the Batticaloa district should be able to promote ecosystem conservation while also ensuring reliable and safe access to ecotourism sites. The major part of the district can be considered for ecotourism development owing to its rich ecological and biological diversity. Therefore number of ecotourism activities can be developed across the district.

However, extremely suitable and highly suitable areas have an abundance of natural resources as well as fragile and sensitive ecosystem. The original ecosystem should be preserved while developing ecotourism in the district. A comprehensive guidelines may be introduced to minimize the negative environmental impacts. In fact, most of the moderately suitable areas for ecotourism development have sufficient natural resources. Thus, these areas also can be developed as appealing ecotourism destinations. Areas that are slightly suitable and not suitable for ecotourism development have low values. However, those areas can be used to build ecotourism infrastructure.

However, the growth of the mass tourism industry along the coast in Batticaloa District could threaten the sustainability of ecotourism. Continuous land cover changes in areas with the potential to become natural tourist attractions have the possibility to harm the district's ecotourism industry. It indicates that about 13% of the area, including several villages, have the greatest amount of potential to apply the ecotourism concept. This location has the potential to become a major ecotourism attraction on the island if better infrastructure and services are developed.

However, infrastructure should be built following local contexts and identities. Population growth in these villages has the potential to threaten ecotourism in the future. Villages with a lot of potential for ecotourism should be observed, assisted, and evaluated to see how they can use the idea of ecotourism to meet demand. If these potential locations are guided in terms of ecotourism development and earnings, it might lead to overcapacity, which can affect the environment. Thus, appropriate attention should be paid to tourist behaviors, marketing techniques, and destination management. A sustainable ecotourism management plan for the area is essential for the long-term financial advantages of ecotourism, ensuring that natural resources are protected and managed responsibly. In order to keep the ecotourism environment thriving, it is important that demand is managed in a way that respects the interests of both the locals and the visitors.

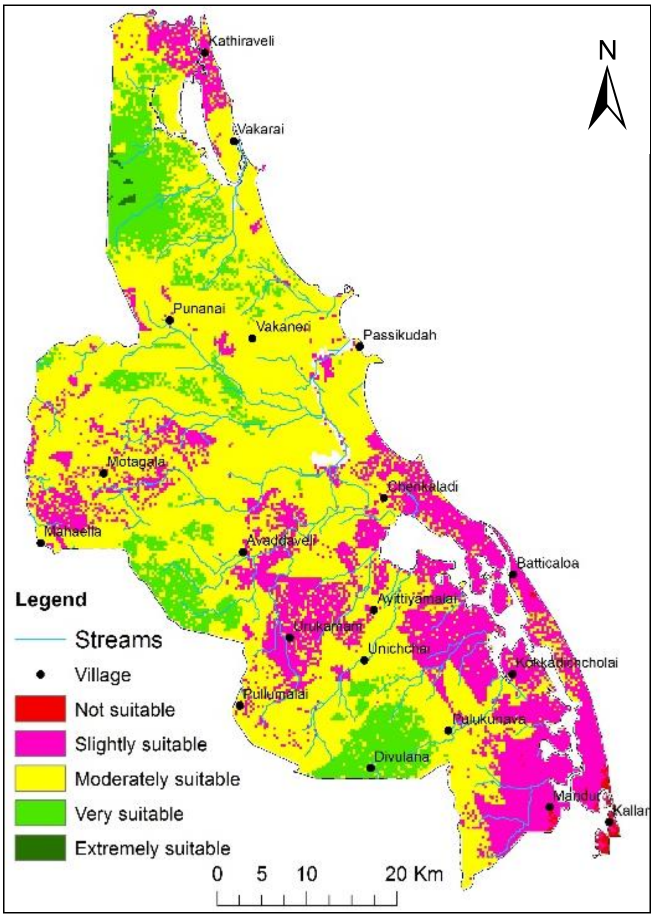

Figure 5. Potential Ecotourism zones of Batticaloa District (Source: Authors, 2022)

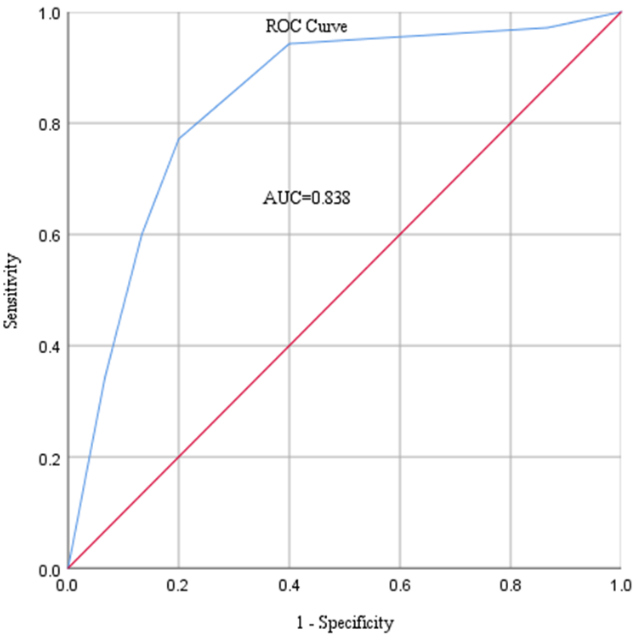

Figure 6. Receiver Operating Characteristics (ROC) curve (Source: Authors, 2022)

Validation of the ecotourism potentiality

It is more important for the result to be validated in order to have scientific significance. (Chaudhary et al., 2022; Rahmati et al., 2015; Saha, 2017). Ecotourism suitability is validated using a variety of methods. However, the Receiver Operating Characteristics (ROC) curve is commonly used method to validate the ecotourism suitability (Chaudhary et al., 2022; Pramanik et al., 2021).

The ROC is a graphical representation of all possible threshold values by plotting the false-positive (Y-axis) and false-negative (X-axis) values (Chaudhary et al., 2022; Pramanik et al., 2021). The Area Under Curve (AUC) in ROC curve analysis indicates prediction accuracy by describing systems' ability to anticipate the absence and presence of predefined "events" (Chaudhary et al., 2022; Pramanik et al., 2021). Based on the value of AUC, prediction accuracy is classified as poor (0.5–0.6); average (0.6–0.7); good (0.7–0.8); very good (0.8–0.9); and excellent (0.9–1) based on the value of AUC (Andualem and Demeke, 2019; Pathmanandakumar et al., 2021; Rahmati et al., 2015).For the validation of the model, 50 randomly distributed points were generated on the ecotourism potential map of the AHP model and compared to existing ecotourism sites. An error matrix was constructed on the basis of the existing ecotourism location and random points, which was then validated using subsequent observed versus predicted values (Chaudhary et al., 2022; Pramanik et al., 2021). The ROC plot indicates that the area under the curve corresponds to an AUC value of 0.838, which represents 83.8% accuracy of prediction (Figure 6). The AUC value of 83.8% shows that predictions made using the AHP method to generate the potentiality maps are reliable. Hence, the model employed in this study provides a more accurate prediction of suitable ecotourism sites.

CONCLUSION

The extremely suitable area is predominantly situated in the Batticaloa district's Northern part, which is highly favorable for ecotourism prospecting. A minor portion of the district's land area is located in its extreme southern part, which is the least favorable for ecotourism development. The findings of this study make a significant contribution toward a better understanding of the opportunities for the development of ecotourism in the Batticaloa District. The use of GIS in conjunction with the AHP method has proved to be beneficial for ecotourism planning. This study has highlighted the significance of finding suitable lands for ecotourism development in the Batticaloa district. Moreover, the empirical evidence clearly shows the spatial distribution pattern of ecotourism resources in the Batticaloa district. This research has primarily contributed to the compilation of important criteria and features for ecotourism site selection that may be used in any future site selection process to develop ecotourism in Sri Lanka.

The findings of this study can assist tourism planners and the government in precisely selecting locations, developing related activities, and relieving pressures on the region's tourism demand. Those interested in using GIS techniques in conjunction with the AHP approach to identify potential locations for ecotourism development may benefit from this study. The lack of high-resolution satellite imagery, and governmental programs and proposals to initiate ecotourism in the Batticaloa District restricted this study. However, to the best of our knowledge, no ecotourism site suitability study employing GIS and AHP techniques to identify potential ecotourism development locations has been conducted in Sri Lanka. It is also not available in any popular scientific literature databases.

Further, this research can be improved by extending socio-economic criteria for ecotourism site selection under the GIS platform. The findings have broader implications for the United Nations Sustainable Development Goal-15 (SDG-15) of improving life on land by preserving natural heritage, wilderness areas, and traditional culture. It can help to create jobs for locals while also providing profits to local communities.

Acknowledgements

The authors wish to express their sincere thanks to the Eastern University-Sri Lanka and the University of Malaya for their constructive support.

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Article history: Received: 15.11.2022 Revised: 24.01.2023 Accepted: 01.03.2023 Available online: 08.03.2023