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Original Research Paper

Identification of Preferable Ecotourism Destinations in Purulia District, West Bengal (India): AHP and GIS Approach

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Abstract

Ecotourism has gained popularity among travelers in recent years due to the detrimental effects of conventional tourism. Purulia district in West Bengal (India), with its diversified picturesque landscape such as lush green forest, mesmerizing riverscape, lakes, waterfall, hills and uniqueness in the local community's culture gives ample potentiality of ecotourism development. The aim of this paper to explore potentiality of ecotourism in Purulia district, West Bengal, India using Analytical Hierarchy Process (AHP) and Geographical Information System (GIS). Initially, ecotourism inventory dataset was developed based on following criteria: Elevation, slope, proximity to river, distance from road, distance from settlements, distance from ecological sites, distance from railway, distance from tourism sites using ARC-GIS 10.6.1 software. Later, the suitability map of ecotourism development has been developed by applying Weighted Linear Combination (WLC) with combination of the criteria with their respective weights and categorized into five suitability classes as highly suitable (S_1), moderately suitable (S_2), suitable (S_3), less suitable (S_4) and unsuitable (S_5). Finally, after the identification of suitable zones, six alternatives ecotourism destinations are identified. This proposed method may be helpful for the local stakeholders and public administration in identifying potential ecotourism destination and planning for sustainable ecotourism development.

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1 INTRODUCTION

The conceptual definition of ecotourism is a form of tourism, which is ecologically responsible, economically viable with minimum environmental damage and respect towards the cultural tradition of indigenous people. It ensures an ethical visit to natural site, makes a contribution to the preservation of the natural environment and helps to improve the standard of living of the local community (TIES, 2015; Elena and Thomas, 2018). Ecotourism as a substitute for traditional tourism has become increasingly popularize due to detrimental effects that conventional tourism had on both the natural environment and the cultural practices of the native population (Dwyer *et al.*, 2010). The conventional way of tourism severely impacted the environment, loss of habitats and destruction of nature and natural landscape, pressurizing local resources and the loss of cultural uniqueness of the local community (Palazzo *et al.*, 2022; Sunlu, 2003; Liu *et al.*, 2014). The fundamental difference between conventional tourism and ecotourism is how they interact with nature; conventional tourism is less concerned with the welfare of locals and the preservation of nature, whereas ecotourism aims to have the least possible negative effects on both the environment and people (Kontogeorgopoulos, 2004; Singh, 2015; Jackson, 2022). Ecotourism, namely an alternative form of tourism that gives travelers ecological experience, feels the uniqueness of nature encouraged them to protect the ecological landscape and benefit the local communities economically and help them preserve the environment (Ullah and Hafiz, 2013; Wight, 1993). The concept of ecotourism popularized in 1990s, came out as reaction of traditional tourism which less bother about environment, severely affect diversity, environment and culture of indigenous people. Ecotourism emerged as a potential and effective

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tool to address the drawbacks of conventional tourism with the aim of sustainable development and empowers locals with financial security (Bunruamkaew *et al.*, 2011; Reddy, 2019). Due to many beneficial aspects of ecotourism, developing countries of the world are interested for investing in ecotourism sector as a tactical tool for their economic growth and conservation strategies to build environmental awareness (Stem *et al.*, 2003). In order to develop land for ecotourism, one must engage in meticulous planning and the gradual inclusion of land while keeping in mind the need of preserving the natural environment (Kiper, 2013; Burgoyne and Mearns, 2022). Ecotourism development needs to be managed and adapted to the local ecosystem's sensitivity and natural values if it is to have a less detrimental impact. The increasing number of people interested in ecotourism and the conservation prospects it present one-of-a-kind opportunities to integrate rural development, tourism resource management and protected area management in a variety of locations across the globe. For several nations, like Costa Rica, Cambodia, Laos, Thailand, Maldives, Bhutan, etc., ecotourism is not a simple recreational activity to support financial assistance for protection of environment but also provides a sizeable economic contribution to the host country (UNWTO, 2013; Manzoor *et al.*, 2019). Ecotourism as a concept relatively new one in India though it has the tremendous potentiality of ecotourism because of diversifying natural landscapes and rich flora and fauna (Patel, 2020). India is blessed with a diverse range of natural marvels, from the snow-capped panoramic view of the Himalayan Mountain in the north to the quaint and refreshing seacoast of Kanyakumari in the south. In contrast, the western part of India is full of magnificence glory and cultural paradise of the deserts in Rajasthan, whereas Northeast portion of India covered with rare and exotic flora and fauna that yet to be unexplored. India thus has the potential to develop into a popular ecotourism destination as a consequence of its abundant natural wealth. Present study area Purulia district is one of the potential destinations of ecotourism in the state of West Bengal (India), with its splendid natural landscape hills, forests and wildlife sanctuaries, rivers, reservoirs, waterfalls, places of historical importance, tribal culture and crafts that offer us perfect destination of a nature lover to explore the ecotourism spots. Tourists are always searching for the most advantageous and convenient location for staying from where the rest of the targeted areas can be explored (Ilban and Yıldırım, 2017). Every traveler has a different view and preference before choosing tourist destination based on beneficial factors such as natural beauty, connectivity, food preferences, cultural attractiveness and non-beneficial factors rugged topography, harsh climate, per day cost, distance, safety and security (Pileliene and Grigaliunaite, 2019).

Particularly, in the light of ecotourism advancements, remote sensing and GIS have become essential tools for exploring and monitoring tourism resources. GIS considered as one of the powerful, cost-effective time saving, tool for mapping ecotourism potential with decent accuracy (Abed *et al*., 2019; Ali and Maryam 2014; Acharya *et al*., 2022). Different researchers across the world have used remote sensing and GIS techniques to explore potential ecotourism sites (Boyd *et al*., 1994; Geremew *et al*., 2015; Taye *et al*., 2019). The multi-criteria decision-making analysis (MCDA) coupled up with GIS has a powerful tool for judging the credibility of a place in terms of tourism. It helps to compared relevancy among alternative sites and chooses the best alternative from a tourist point of view, which is economically viable, communicationally sound and near to the tourism destination (Onder *et al*., 2013; Moghaddam *et al*., 2022). Since last twenty years different multi-criteria weightage methods have been widely used for ecotourism study and proved its effectiveness for predicting and monitoring tourism resources (Ghamgosar, 2011; Kumari *et al*., 2010). Multi-criteria decision-making tools can deal with different spatial or non-spatial criteria and determine those factors which have a significant influence in the assessment of the tourism attractiveness of destinations (Islam *et al*., 2022; Garedew and Walabu, 2020; Sahani, 2019). Although several MCDA methods have been tested and analyzed in diverse problem-solving scenarios, the Analytical Hierarchy Process (AHP), which was developed by Saaty (1980), continues to be the most extensively used and simple to comprehend MCDM techniques (Chandio *et al*., 2013; Satty and Vargas, 2001; Wu *et al*., 2022). AHP could able to provide assistance to improve decision-making in various tourism related problem solving, particularly in situations in which this entails such as relevance of each criteria in determining the choice of desired location, comparing tourism facilities and environment of tourism spots, resort location selection. AHP does this by providing a hierarchy of criteria according to their importance, which assists administrators and other stakeholders in the decision-making process. Some of the previous literature regarding the suitability of ecotourism spots using AHP and others MCDM techniques are described in greater detail below (Table 1).

The ideas suggested in this research could substantially help the management and preservation of environmentally sensitive landscapes and provide decision-makers with a suitable blueprint for developing strategies for the establishment of ecotourism sites in the area under study. This is due to the paper's emphasis on the identification of the best alternate sites, one of the most important components of ecotourism growth. This research was conducted with the intention of identify potential ecotourism development locations in the Purulia district and assessed their capacity to meet visitor needs. The intention of this research is to determine an ecotourism site spatially using multi-criteria decision analysis within a GIS environment. It was already mentioned that the AHP MCDM method has been employed in this research to demarcate ecotourism potential zone in ARC-GIS Environment.

Table 1. Studies conducted on ecotourism site suitability using MCDM methods

MCDM	Authors	Study area	Results
AHP	Abed *et al.* (2011)	North of Iran	Utilizing various socioeconomic, environmental, land-use, tourist-service, and infrastructure parameters to identify suitable tourism destination.
Weightage overlay	Pareta (2013)	Hoi An, Quang Nam province (Vietnam)	Good road network, proximity to railway stations, airport this coupled with nearness to scenic beauty showed strong tourist potential site for tourism development and mapping.
AHP and TOPSIS	Önder *et al.* (2013)	Turkey	The “safety and security”, “health and hygiene” and “price” are determined as the three most important criteria by AHP.
AHP, TOPSIS and fuzzy logic	Göksu *et al.* (2014)	Bosnia and Herzegovina	Natural beauty and historical and cultural criteria are the most significant factors for attracting tourists.
P Method	Nahar *et al.* (2015)	Bangladesh	Six criteria such as cost, distance, accommodation facilities, transportation system, safety and architectural and natural beauty were used.
AHP	Dhami *et al.* (2016)	West Virginia (USA.)	Examined and mapped nature-based tourism areas based on visitors’ perception and expert perception for spatial suitability mapping.
Weights overlay	Nisa (2017)	Kohistan District (Pakistan)	Implementation of ecotourism being a positive change in their economic life and beneficial for the tourism industry of Pakistan.
AHP method and GIS technique	Asmamaw *et al.* (2018)	Hugumburda Forest (Ethiopia)	Land use land cover was the most important in this evaluation and soil, slope, elevation, scenic attractiveness, rainfall and temperature were the much important, respectively.
AHP	Mansour *et al.* (2019)	Masirah Island, Oman	Most important criteria with higher influential impacts are proximity to marine turtle zones and coral reef coasts, followed by proximity to road network, sandy beaches and geological structures.
Fuzzy AHP and TOPSIS	Oo and Hnin (2019)	Thailand, Singapore, Malaysia, Indonesia, Philippine, Vietnam, Cambodia, Brunei	FAHP is used in determining the weight of criteria and TOPSIS method is used for determining the final ranking of the alternatives and preference of island selection of these countries.
AHP	Sahani (2019)	Himachal Pradesh, India	Criteria such as slope, topographic roughness, vegetation, surface water accessibility, elevation, protected area, climate, visibility, road proximity, village proximity, soil, groundwater and geology have been taken into consideration.
AHP	Amin *et al.* (2021)	Gilgit-Baltistan, Pakistan	Fifteen factors influencing the ecotourism were selected based on local knowledge and expert opinion. The criteria layers cover natural beauty, infrastructure, physical and social parameters of the study area.
AHP	Othman *et al.* (2022)	South Kelantan, Malaysia	The criteria such as land use, slope, elevation and proximity to road were selected to identify the potential area for ecotourism.
AHP	Chaudhary *et al.* (2022)	Garhwal Himalayan region	Areas adjacent to the densely forested areas, cool climate with frequent snowfall areas, U and V-shaped valleys, very attractive landscapes sites suitable for ecotourism.

2 STUDY AREA

Geologically, Purulia district is a part of Chotanagpur plateau, located western bordering district in Indian states of West Bengal. Spatial extension of this district is from 22°42'35" to 23°42'00" north latitudes and from 85°49'25" to 86°54'37" east longitudes, respectively (Bhattacharyya, 1997). The Census of India (2011) has enumerated the total population of the district as 2930115 with a geographical expansion of 6259 km^2. The percentages of people who belong to Scheduled Castes and Scheduled Tribes, were 19.38% and 18.45%, respectively. Considering the climatic properties in this district has subtropical in nature, the average temperature during the summer months is quite high above 40 degrees with high evaporation and low precipitation. Winter months are cooler, with temperatures occasionally falling below ten degrees. Purulia is a land of natural uniqueness, the untapped beauty of the lush green landscape, verdurous hills, thick forests, river and lakes, exotic plants and animals have yet to be explored by the tourism point of view. It offers a pleasant ambiance, seclusion and bucolic way of living to make perfect ecotourism destinations for the refreshment of mind of city dwellers. The prominent tourist places of the district like Ajodhya Hills, Jaychandi Pahar, Panchet hill, Duarsini Hills, Murguma Dam, Baranti lake, Khairabera lake and Forests draw a sizable number of tourists to Purulia each year. Tribal customs, red soil, elegancy of red Palash flowers, the distinct folk culture and Chhau dance, these rituals glorify the tradition of Purulia district (Figure 1).

3 MATERIALS AND METHOD

3.1 Methodology

A survey of relevant literature on ecotourism, tourist activities and related aspects was also taken into account for the research. Based on previous studies on potentiality of tourism sites with available information and suggestion from tourism experts, extensive experience in the local area, as well as perceptions gained via field surveys in the Purulia district eight priorities of factors, such as elevation (C1), slope (C2) proximity to river area (C3), distance from road (C4), distance from settlement patches (C5), distance from ecological sites(C6), distance from railway track (C7) distance from existing tourism sites (C8) are taken as a criterion for determining potential ecotourism suitable zones of Purulia District.

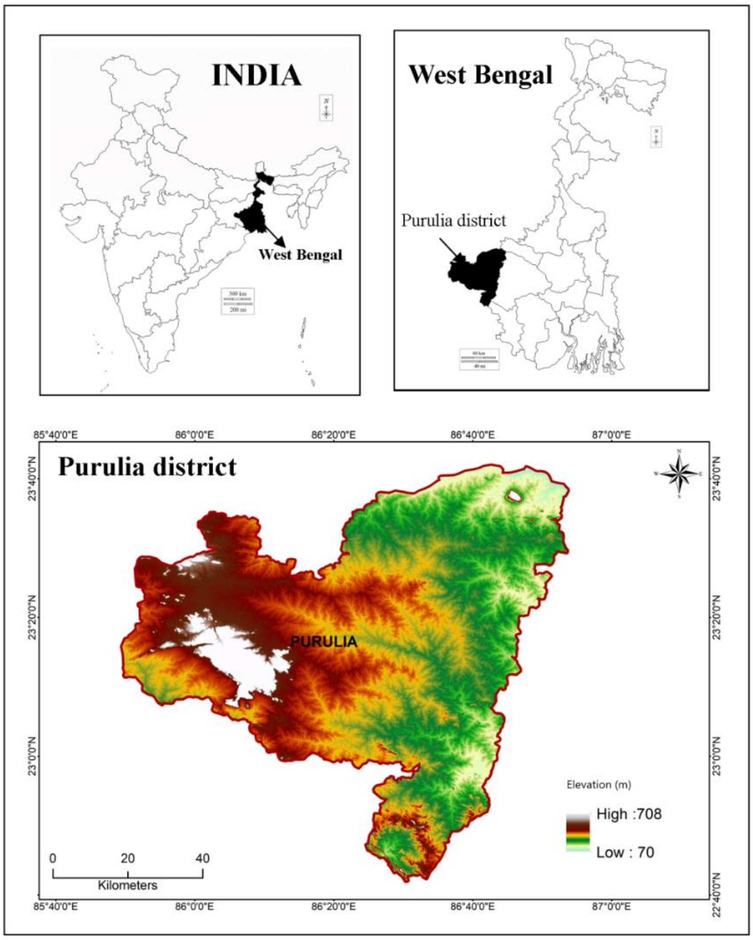

Figure 1. Study area: Purulia district, West Bengal (India)

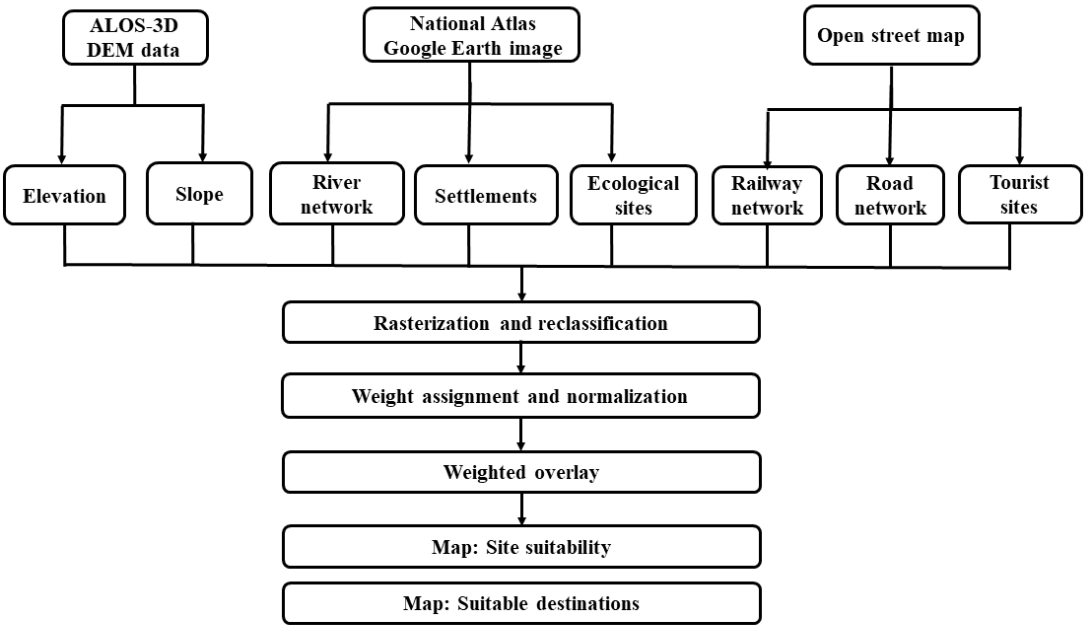

Figure 2. Methodology

Table 2. Database

Criteria	Data sources	Applications
Elevation (C1)	30-meter global Dem	Reclassified five classes according to elevation value.
Slope (C2)	https://www.eorc.jaxa.jp/ALOS/en/aw3d30/	Extracted degree values from DEM and classified into five classes.
Proximity to river area (C3)	The shapefile from: https://www.openstreetmap.org/	Distance from the river is calculated and classified.
Distance from road (C4)	The shapefile from: https://www.openstreetmap.org/	Distance from the main road are calculated using buffer analysis and classified.
Distance from settlement (C5)	Google Earth images: https://www.google.com/earth/	Distance from the villages and urban settlements are calculated.
Distance from ecological sites (C6)	The shapefile from: https://www.openstreetmap.org/	Distance from ecological sites like forests, dam, reservoir, etc. are calculated.
Distance from railway track (C7)	The shapefile from: https://www.openstreetmap.org/	Distance from railway tracks are calculated using buffer analysis.
Distance from existing tourism sites (C8)	The shapefile from http://purulia.nic.in/tourism/	Distance from tourism centers are calculate using proximity analysis.

For mapping the elevation, DEM data with 30-meters resolution ALOS World-3D was downloaded from JAXA's global ALOS portal (https://www.eorc.jaxa.jp/ALOS/en/aw3d30).

Mosaicking and subset functions were performed to delineate the area of interest (AOI) using ArcGIS software. After geometric and atmospheric correction of image raster map of elevation was derived from DEM data using ARC-GIS 10.6.1. The rivers and settlement patches are digitized from Google Earth image. Road, tourist sites, ecological sites and railway datasets were downloaded from open street mapping. All the criteria are categorized into five suitability classes according to index values, highly suitable (S_1), moderately suitable (S_2), suitable (S_3), less suitable (S_4) and unsuitable (S_5). After adopting the AHP approach to determine weights for each criterion and sub-criterion, all of the criterion maps are combined together with the help of a weightage linear combination in order to determine potential areas for ecotourism development. After that six alternative tourism destinations were depicted from first two suitability class (S_1 and S_2) to rank the best alternative tourist destination according to the tourist point of view (Table 2).

3.2 Criteria

Numerous factors, including natural attractions, topographical variation, climatic decency, rainfall, overall cleanliness of the place, cuisine, shopping, transportation and the quality of hotels and restaurants are considered when determining whether or not an area is suitable for ecotourism. For this study, fourteen criteria are initially selected based on previous literature of study area and consider physical, socio-economic, and cultural set up of Purulia district but finally, according to the local stakeholders' and experts' preferences, eight factors are found more relevant in this study area for exploring the potentiality of ecotourism. Following is a discussion on selected criteria and how they affect the growth of ecotourism.

3.2.1 Elevation (C1)

High elevation always enhancing the degree of landscape attractiveness which draw tourists because of the stunning natural beauty, many recreational opportunities and extensive cultural history. The vertical relief creates diverse attractiveness, unique biodiversity with natural vegetation and native wildlife considering temperature and climatic variation (Ahmadi *et al*., 2015; Bunruamkaew *et al*., 2012; Foggin, 2016; Kumari *et al*., 2010). Those locations that are blessed with significant differences in altitude, tourists can enjoy a magnificent vista of the valley, the grassland, and any other picturesque attractions further downstream. Present study area Purulia district, enriched with undulating land with scattered hills like Joychandi Pahar, Panchet hill and Ajodhya hills which is easternmost part of Chhotanagpur plateau and extended portion of Eastern Ghats range. The elevation map was depicted from DEM data segmented into five classes and weights were given based on attractiveness of the landscape where higher elevation consider being more suitable. The entire area has been divided into four categories based on elevation: 70-185m, 185-235m, 235-285m and 285-350m, respectively (Table 3; Figure 3A).

3.2.2 Slope (C2)

The degree of slope determines topographical steepness and curvature in an area where slope inclination can be retrieved directly from DEM data. Slope profile gives the impression of having a visually appealing appearance to spectators across a greater geographical area. Owing to its attraction slope is regarded as an important criterion factor in the evaluation of a location's viability for ecotourism. Higher slopes are better for the expansion of ecotourism since they are more attractive but excessively steep slopes could impede tourism growth owing to transportation challenges (Sahani, 2019; Bunruamkaew and Murayama, 2012; Kumari *et al*., 2010). The completely flat region has very little chances of dense vegetation cover and wildlife, whereas the hilly and mountainous terrain offers the best possibilities for nature-based tourism. After computing the slope degree from the DEM data, it was further reclassified into the appropriate class based on suitability for ecotourism. Therefore, slope map divided into following segments 0.00-2.50° (unsuitable), 2.50-5.00° (less suitable), 5.00-10.00° (suitable), 10.00-20.00° (moderately suitable) and >20.0° (highly suitable) (Table 3; Figure 3B).

3.2.3 Proximity to Rivers (C3)

Rivers and riverfronts are possible destinations for water sports including rafting, kayaking, swimming and bird observation. They also provide a sense of heritage and adventure as well as links with the environment and natural world and can be developed to create tourist attractions (Prideaux and Cooper, 2009). The river was considered in evaluating the suitability of the ecotourism location for the aforementioned reason. Rivers such as Kangsabati, Kumari, Silabati, Dwarakeswar, Subarnarekha and Damodar are flowing across Purulia district. Following the preparation of maps depicting the network of streams and the computation of distances, the areas that are geographically closest to the rivers have been assigned the highest rating. Based on the distance from various river network, this district has been divided up into five different suitability zones such as highly suitable (<500m), moderately suitable (500-1000m), suitable (1000-1500m) and less suitable (1500-2000m) and unsuitable (2000-2500m) (Table 3; Figure 3C).

3.2.4 Distance from Road (C4)

Accessibility is a precondition for the growth of ecotourism, for engaging in tourism related activities, there must be adequate connectivity between the point of origin and the tourist attraction. Comfortable and secure road access to the desired ecotourism destination boosts visitor possibilities (Chandio *et al*., 2013; Istomina *et al*., 2016). In any steep hills, the highways are viewed as the main business and tourist routes, this system establishes the connections between the locations, outdoor activities and lodging. Rugged terrain and sloppy ground make it difficult to build other modes of transportation where road networks can be a convenient means of transport (Taye *et al*., 2019). Many potential ecotourism destinations such as deep forests, waterfalls, lofty hills and historical and archaeological sites may remain unexplored if there is insufficient or poor connectivity. As ecotourism activities located far away from road access are unsuitable for ecotourism development that's why areas nearest to the road were given the highest grade. For the identification of ecotourism sites, five zones of 250m, 250-500m, 500-750m, 750-2000m and 2000-15400m from the road network have been prepared (Table 3; Figure 3D).

3.2.5 Distance from Settlements (C5)

Although locations that are away from the hustle and bustle of cities tend to be more appealing to tourists being in close proximity to a city ensures that visitors have access to essential public services and amenities, like lodging, transit, food and shopping centers, banks, and ATMs (Tanjung and Hutagaol, 2019). Ecotourists essentially desire to stay in locations where it is possible to engage in cultural interactions with locals, that's why there's a good correlation between human settlement and ecotourism growth. There are just a few minor towns with greener environs in the study region at the moment, the largest of which being Purulia town (1.21 lakh people), followed by Raghunathpur (25561), Balarampur (24431), Jhalda (19544), Baghmundi (4035) and other census towns. Distance from the settlement areas were mapped and classified it into five categories highly suitable (0-1000m), moderately suitable (1000-2000m), suitable (2000-3000m), less suitable (3000-4000m) and unsuitable (4000-11050m) areas, respectively (Table 3; Figure 3E).

3.2.6 Distance from Ecological Sites (C6)

It has been found that landscape naturalness and ecotourism attractions, specifically scenic appeal and vegetation cover, have a favorable association with one another (Roque *et al*., 2020; Cetin and Sevik, 2016). The lush green forested panorama usually offers pleasure to the human mind increases our desire for travelling. Tracking through dense forests cover always thrilled the tourists by its beauty of natural landscape. In the Purulia district, lots of eco-park, eco-sites, nature-based tourism sites, mountaineering sites and climbing sites are established to encourage nature lover, Gorgaburu Eco-resort, Palash Bitan Jungle Hut at Murguma, and Eco-Adventure Resort at Khairabera are examples of

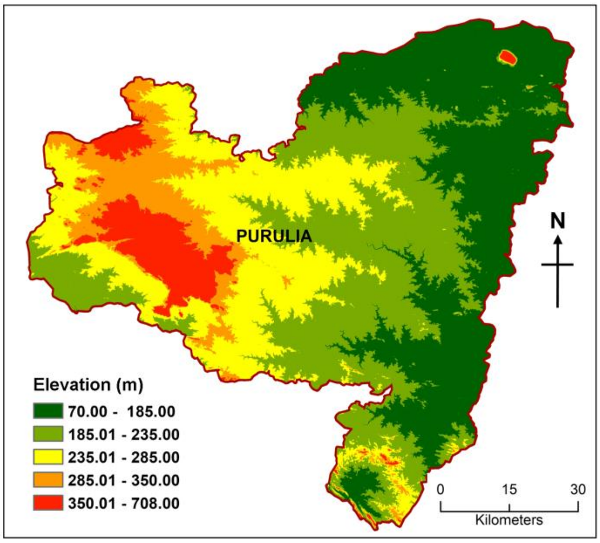

Figure 3A. Elevation

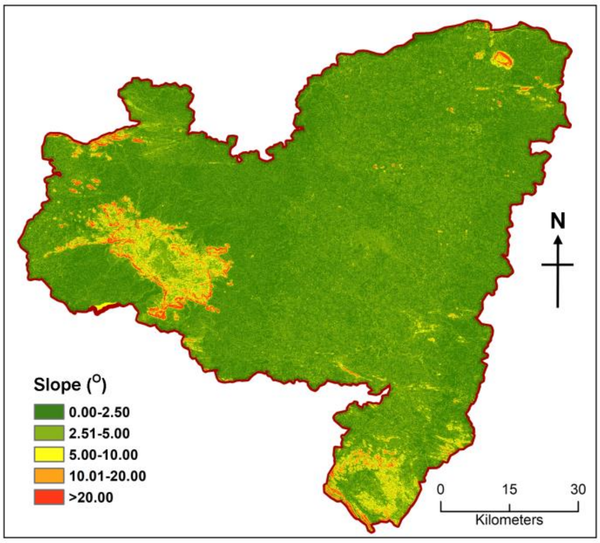

Figure 3B. Slope

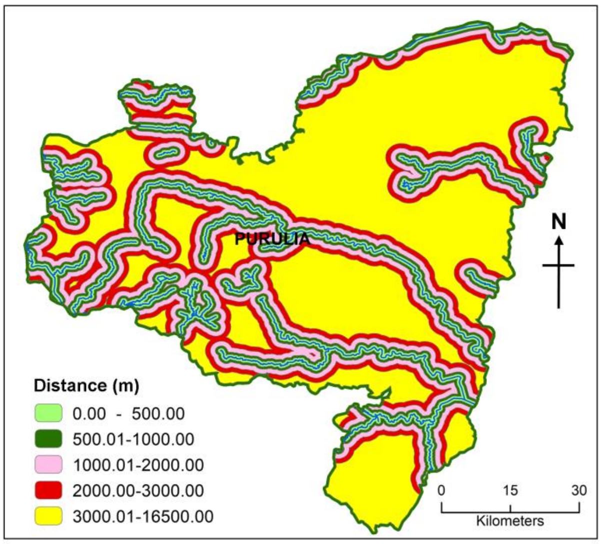

Figure 3C. Proximity to rivers

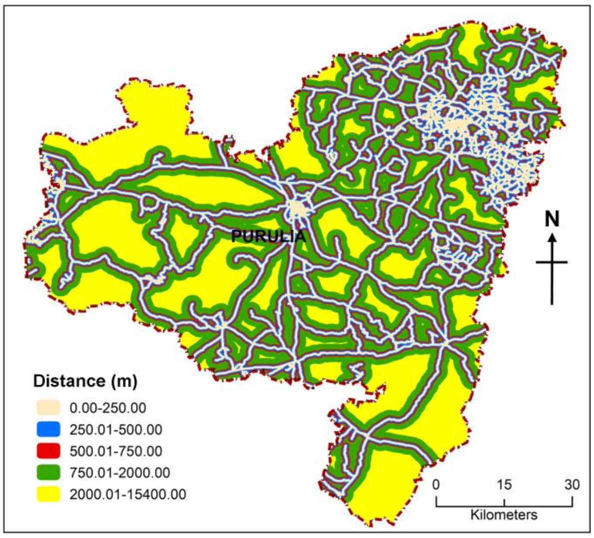

Figure 3D. Distance from roads

ecotourism development. This region is covered with thickly forested ranges like as Balarampur, Bagmundi, Ajoydhya, Arsha, and Jhalda. After preparing a map of forest cover and ecotourism sites, priority was given to those areas which are nearer to ecological sites. Distances were calculated from those ecological sites and classified into five namely 0-1000m (highly suitable), 1000-3000m (moderately suitable), 3000-5000m (suitable), 5000-7000m (less suitable) and 7000-23000m (unsuitable) for tourism perspective (Table 3; Figure 3F).

3.2.7 Distance from Railway Track (C7)

There is no commercial airport in this district so only way to reach this area from other parts of India through railways and roadway. It provides connectivity between tourism spots and other cities of India. Rail connectivity is not only more affordable than other forms of communication but also safer and faster. Areas that are connected to the railway network and road network have a better chance of expanding into larger tourist hubs.

Railway has an important role in Purulia district for the development of ecotourism there was three major railway stations which connected with this tourism sites with other parts of the country. Purulia, Asansol, Adra junction are the major railway junction in this area. Distance from the railway track were mapped and sub-divided into five distinct categories 0-1500m, 1500-3000m, 3000-4500m, 4500-6000m and 6000-5200m (Table 3; Figure 3G)

3.2.8 Distance from Tourism Center (C8)

Because already established tourist destinations have the essential infrastructure, including lodging, restaurants, shops, transportation, dining, shopping, banking and ATMs, they are advantageous for continued tourism growth and economic development. Furthermore, building tourism infrastructure like hotels and highways would be expensive for the government and commercial developers, thus locations closer to already established tourist destinations are given more weight. Purulia district there are several hills and small mounds, the important ones are Ayodhya hills, Joychandi hill, Panchkot hill as well as other popular tourist destinations baranti lake, Garpanchkot. Waterfalls like Machkanda falls and Bamni falls, the artists village Charida (renowned for its *chhau mask*) are popular for tourism point of view. Distance from present tourism sites are mapped and classified into five categories: 0-2000m, 2000-4000m, 4000-6000m, 6000-8000m, 8000-25000m (Table 3; Figure 3H).

3.3 Generation of Criteria and Sub-criteria and their Respective Weights

As already discussed criteria were selected from previous literature and expert guidance for suitability mapping of ecotourism sites after screening finally eight criteria were found most detrimental which influence the suitability of tourism sites in present study area Purulia district. Now criteria weights are assigned based on their relative importance to each criterion to other criteria. Ratings for sub-criteria within a set of criteria demonstrate the relative importance of each sub-criteria than other sub-criteria to satisfy the desirable

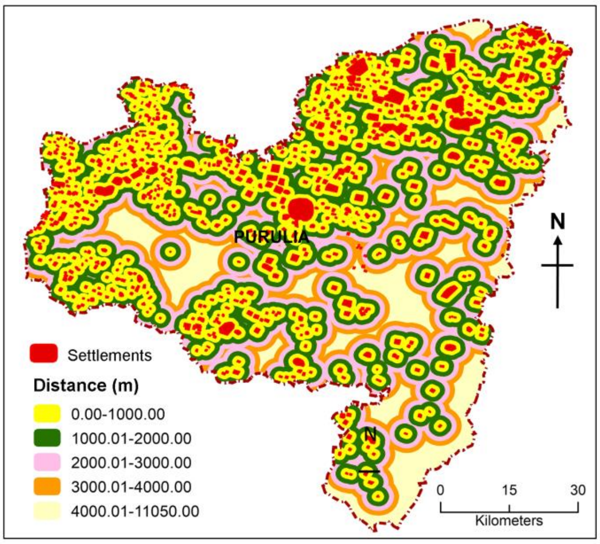

Figure 3E. Distance from settlements

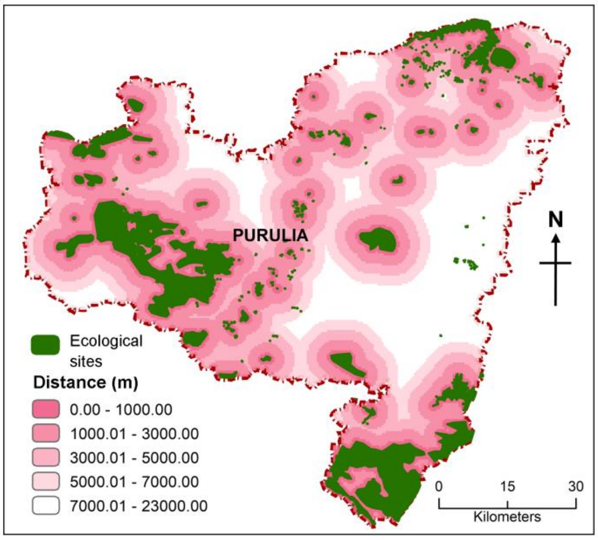

Figure 3F. Distance from ecological sites

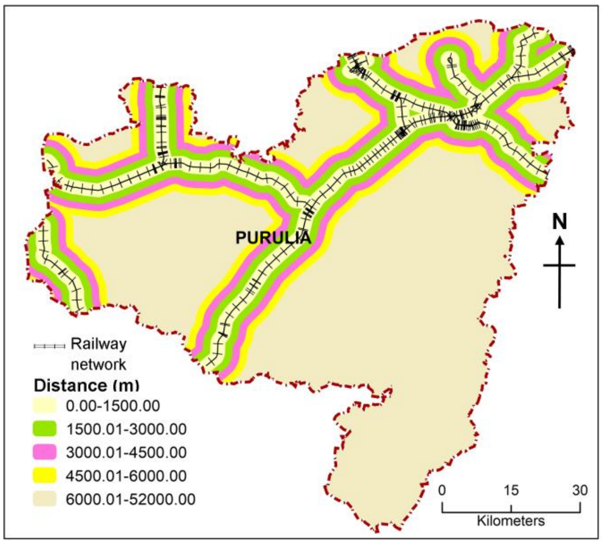

Figure 3G. Distance from railway track

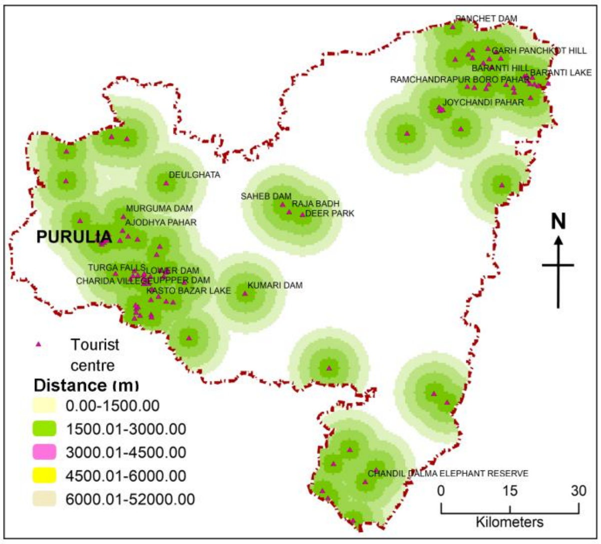

Figure 3H. Distance from tourism center

condition for suitability of land use for a particular purpose. Then each criterion was segmented divided into five sub-criteria and ranked in terms of how well it would promote to the expansion of ecotourism, such as (i) highly suitable (criteria weights = 5), (ii) moderately suitable (criteria weights = 4) (iii) suitable (criteria weights = 3), (iv) less suitable (criteria weights = 2) and (v) unsuitable (criteria weights = 1). For sub-criteria weights each sub-criterion were compared in 5 X 5 pairwise matrix tables and weights are assigned based on their suitability for each ecotourism development in AHP methods (Hanine *et al*., 2016). Spatial data set were created using each criteria and sub-criteria, generally all those dataset which are in vectors format- points (urban area, tourism sites), lines (river, railway and road) and polygon (ecological sites) converted to raster format by the process of rasterization. Euclidean distance, proximity analysis, multiple buffer were performed for each criterion based on land suitability for ecotourism. All the layer is prepared, classified and reclassify in Arc-GIS 10.6.1 software. For preparation of elevation map, required data was retrieved from DAICHI-2 satellite and classified the raster layer according to their suitability for ecotourism (Table 3).

3.4 Analytical Hierarchical Process (AHP)

AHP was initially devised by Thomas Saaty in 1980, and it serves as a productive tool when dealing with complicated decision problems by adopting pairwise comparison matrices (Saaty *et al*., 2001; Saaty, 2008; Parry *et al*., 2018). It leverages hierarchical structures by establishing priorities for many alternatives based on the decision makers' preferences, which allows it to solve complicated problems and propose answers to those difficulties (Brushan and Rai, 2004). In the present investigation, the AHP was utilized to determine the relevance of the weightings assigned to the chosen criterion by employing a matrix of pairwise comparisons (Chabuk *et al*., 2019). In general, AHP operates by establishing priorities for various options and criteria that are applied to the assessment of those alternatives based on Saaty's scale values (Saaty *et al*., 2001). This comparisons emphasis on how important each of the two factors is in assessing if something is a good fit for the stated purpose. Consequently, a pairwise comparison matrix is constructed to compare all of the factors. Accordingly, Saaty (2008) suggested scale, rating scale values ranging from 1 to 9 points to express individual preferences or judgments, criteria weights one denotes that both criteria are equally important, but criteria weights nine signify that one criterion has overwhelming superiority over the other (Zhang *et al*., 2009). The relative importance of each aspect was determined by the local experience in the field as well as the opinions of the experts. In this study eight most detrimental criteria are compared and weights were given in AHP method and finally summed up using a weighted linear combination to get desired suitability maps (Table 4).

Table 3. Criteria, sub-criteria, ranking, weights and influence

Criteria	Sub-criteria	Area in (km^2)	Suitability ranking	Suitability levels	Sub-criteria weights	Influence (%)
Elevation (m) (C1)	70.00-185.00	1776.43	1	Unsuitable	0.04	17.47
	185.00-235.00	1834.96	2	Less suitable	0.08	
	235.00-285.00	1826.89	3	Suitable	0.14	
	285.00-350.00	576.59	4	Moderately suitable	0.27	
	350.00-708.00	244.13	5	Highly suitable	0.47	
Slope (º) (C2)	0-2.50	2972.542	1	Unsuitable	0.04	6.63
	2.51-5.00	2112.808	2	Less suitable	0.07	
	5.01-10.00	519.1121	3	Suitable	0.09	
	10.00-20.00	345.7891	4	Moderately suitable	0.33	
	> 20.00	308.756	5	Highly suitable	0.47	
Proximity to rivers (m) (C3)	<500	331.38	5	Highly suitable	0.51	2.56
	500-1000	341.55	4	Moderately suitable	0.26	
	1000-2000	643.98	3	Suitable	0.13	
	2000-3000	627.06	2	Less suitable	0.06	
	3000-16500	4315.03	1	unsuitable	0.03	
Distance from road (m) (C4)	< 250	591.30	5	Highly suitable	0.42	5.57
	250-500	521.10	4	Moderately suitable	0.26	
	500-750	461.03	3	Suitable	0.16	
	750-2000	912.56	2	Less suitable	0.10	
	2000-15400	3773.01	1	Unsuitable	0.06	
Distance from Settlement (m) (C5)	0.00-1000	549.23	5	Highly suitable	0.47	11.10
	1000-2000	698.34	4	Moderately suitable	0.22	
	2000-3000	809.38	3	Suitable	0.14	
	3000.00-4000	1998.09	2	Less suitable	0.10	
	4000.00-11050	2753.19	1	Unsuitable	0.07	
Distance from ecological sites (m) (C6)	0-1000	921.22	5	Highly suitable	0.54	20.20
	1000-3000	1298.09	4	Moderately suitable	0.26	
	3000-5000	1143.7	3	Suitable	0.12	
	5000-7000	952.76	2	Less suitable	0.06	
	7000-23000	1943.23	1	Unsuitable	0.03	
Distance from railway track (m) (C7)	<1500	672.98	5	Highly suitable	0.38	9.69
	1500-3000	580.97	4	Moderately suitable	0.26	
	3000-4500	500.98	3	Suitable	0.18	
	4500-6000	434.09	2	Less suitable	0.11	
	6000-52000	4069.98	1	Unsuitable	0.06	
Distance from tourism center (m) (C8)	0.00-2000	475.68	5	Highly suitable	0.53	26.78%
	2000-4000	492.98	4	Moderately suitable	0.26	
	4000-6000	512.35	3	Suitable	0.12	
	6000-8000	562.46	2	Less suitable	0.06	
	8000-25000	4215.53	1	Unsuitable	0.03	

Table 4. Relative importance (Saaty, 1980)

Intensity of importance	Numerical rating	Reciprocal	Explanation
1	Equal importance	1	Both the criteria are contributing equally important to the activities
3	Moderate importance	1/3	One criterion is slightly favor over another to the activity concerned
5	Strong importance	1/5	Criteria Judgment strongly favor one criterion than over another for activity concern
7	Very strong or demonstrated	1/7	An criteria judgment is favored very strongly over another for activity concern
9	Extreme importance	1/9	The evidence favoring one criteria over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	1/2, 1/4, 1/6, 1/8	When compromise is needed

Reciprocals (Opposites): Used for inverse comparison

3.5 Calculation Procedure for AHP

Step-1: Suitable criteria are derived from previous literature, expert views and keeping geophysical conditions in mind for potential ecotourism sites selection. After consulting with relevant experts in the field of ecotourism including government officials, entrepreneurs, researchers and geologists, criteria weights and sub-criteria rating for each criterion were then determined.

Step-2: With the purposes of comparison each criteria a pairwise comparison matrix needs to constructed:

$$C_{ij}=\begin{bmatrix} C_{11} & C_{12}\,.... & C_{1n} \\ C_{21} & C_{22}\,.... & C_{2n} \\ C_{1n} & C_{2n}\,..... & C_{nn} \end{bmatrix} \tag{1}$$

where, C_{11} represent criteria score of row i^{th} (the first row) and column j^{th} (the first column) in the pairwise comparison matrix. Reciprocity property of the matrix mathematically stated as:

$$C_{ij}=\frac{1}{C_{ij}} \tag{2}$$

Step-3: Then, values of each column in pairwise comparison matrix are summed up for normalization purposes, which can be expressed as follows:

$$C_{ij}=\sum_{i=1}^{n} C_{ij} \tag{3}$$

Step-4: Normalizing the pairwise comparison matrix- each column values need to divide by its column total to develop a normalized pare wise matrix based on the following equation:

$$C_{ij}=\frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}}\begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix} \tag{4}$$

Step-5: Weightage matrix- then, divide the sum of the column of normalized column of the matrix by the number of criteria used (n) to generates a weighted matrix. The following equation computes the weight for each criterion:

$$W_{ij}=\frac{\sum_{j=1}^{n} c_{ij}}{n}=\begin{bmatrix} W_{11} \\ W_{12} \\ W_{1n} \end{bmatrix} \tag{5}$$

Step-6A: Consistency analysis- consistency vectors are calculated by multiplying a pairwise matrix by a weighted vector.

$$\begin{bmatrix} C_{11} & C_{12}\,.... & C_{1n} \\ C_{21} & C_{22}\,.... & C_{2n} \\ C_{1n} & C_{2n}\,..... & C_{nn} \end{bmatrix}\times\begin{bmatrix} W_{11} \\ W_{12} \\ W_{1n} \end{bmatrix}=\begin{bmatrix} Cv_{11} \\ Cv_{21} \\ Cv_{1n} \end{bmatrix} \tag{6}$$

Step-6B: Then, it is accomplished by dividing the weighted sum vector with criterion weights:

$$Cv_{11}=\frac{1}{W_{11}}[C_{11}W_{11}+C_{12}W_{21}+C_{13}W_{31}] \tag{7}$$

$$Cv_{21}=\frac{1}{W_{21}}[C_{21}W_{11}+C_{22}W_{21}+C_{23}W_{31}]$$

$$Cv_{31}=\frac{1}{W_{31}}[C_{31}W_{11}+C_{32}W_{21}+C_{33}W_{31}]$$

Step-6C: Mean of normalized values (Lambda max method)- calculating by averaging value of consistency vectors:

$$\lambda max=\sum_{i=1}^{n} Cv_{ij} \tag{8}$$

Step-7: Check the consistency- the AHP method enables us to assess the consistency of the criteria weights in order to detect and minimize contradictions in viewpoints. To check consistency Saaty suggested two index, consistency ratio (CR) and consistency index (CI) and finally compare with random index (RI) table.

Step-7A: Consistency ratio (CI)- Han and Tsay (1998) suggested following equation to measure how far a matrix is deviated from consistency.

$$\mathrm{CI} = \frac{\lambda\mathrm{max} - \mathrm{n}}{\mathrm{n} - 1} \tag{9}$$

where, n is the number of criteria and λ_{max} is the biggest eigenvalue.

$$\mathrm{CI} = \frac{8.3152 - 8}{8 - 1} = 0.0394$$

Step-7B: The consistency ratio (CR)- by comparing the CI values with the tabulated RI score, the consistency ratio is ultimately obtained (Malczewski, 2005), here (RI = 1.40), where, n is the matrix size (n = 8). Table 5 shows RI value with different criteria value.

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{10}$$

$$\mathrm{CR} = \frac{0.0394}{1.40} = 0.0281$$

If consistency ratio (CR) value was less than 0.10, it should be acceptable for further analysis in AHP If it was found that CR was greater than 0.10, it was recommended that to revise the judgmental matrix to counter inconsistency in judgment (Table 6A and B).

3.6 Standardization of Criterion

All the parameters used as criteria for suitability mapping of ecotourism development are in different statistical units, reflecting different degree of compatibility with the possibility for ecotourism (Effat and Hassan, 2013). In AHP method, all the selected criteria have to standardize to integrate it in weighted linear combination to identify potential ecotourism zone. AHP enables to incorporate all the qualitative and quantitative parameters. Standardization makes all the spatial layer unitless and make it easy to integrate (Pereira and Duckstein, 1993; Mansour *et al*., 2019). As rater format are easily integrated than the vectors format, so all the criteria converted into vectors format and reclassify in Arc-GIS.

3.7 Ecotourism Potential Priority Index (EPPI) using Weighting Linear Combination Approach

Ecotourism Potential Priority Index (EPPI) which is basically unitless spatial method use here for the delineation of ecotourism potential zone in Purulia district. All those criteria are integrated in weighted linear combination technique to get ecotourism potential map (Malczewski, 2006). In this stage, weighted overlay technique was performed to combine all weighted spatial layers and produce the ecotourism potential zone using Arc-GIS 10.6.1 (Suryabhagavan, 2015). To obtain the EPPI value for the potential areas, all these criteria map and their respective weights are summed up in Weight Linear Combination (WLC), the combined sum would be final ecotourism suitability map using the equation (Figure 4):

$$EPPI = \sum_{j=1}^{n} W_i \times C_{ij} \tag{11}$$

where, EPPI represent Ecotourism Potentiality Priority Index, Wi: weights of selected criterion i, C_{ij}: Reclassified criteria map and n denotes total number of criteria.

Table 5. Random index

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49	1.51	1.54	1.56	1.57	1.58

n = order of matrix

Table 6A. Pairwise comparison matrix and criteria weights

Criteria	Elevation (C1)	Slope (C2)	River (C3)	Road (C4)	Settlement (C5)	Ecological sites (C6)	Railway track (C7)	Tourism centers (C8)
Elevation (C1)	1	4	6	4	2	0.5	2	0.5
Slope (C2)	0.25	1	3	2	0.5	0.25	0.5	0.33
River (C3)	0.16	0.33	1	0.33	0.25	0.2	0.2	0.11
Road (C4)	0.25	0.5	3	1	0.5	0.25	0.5	0.33
Settlement (C5)	0.5	2	4	2	1	0.5	2	0.33
Ecological sites (C6)	2	4	5	4	2	1	2	0.5
Railway track (C7)	0.5	2	5	2	0.5	0.5	1	0.33
Tourism center (C8)	2	3	9	3	3	2	3	1
Total	6.66	16.83	36	18.33	9.75	5.2	11.2	3.44

Table 6B. Normalized weight matrix for AHP

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	Weighted sum	Criteria weights	Consistency analysis	Ranks
C1	0.15	0.238	0.167	0.218	0.205	0.096	0.179	0.145	1.398	0.175	8.398	3
C2	0.037	0.059	0.083	0.109	0.051	0.048	0.045	0.097	0.53	0.066	8.1786	6
C3	0.025	0.02	0.028	0.018	0.026	0.038	0.018	0.032	0.205	0.026	8.3006	8
C4	0.037	0.03	0.083	0.055	0.051	0.048	0.045	0.097	0.446	0.056	8.1297	7
C5	0.075	0.119	0.111	0.109	0.103	0.096	0.179	0.097	0.888	0.111	8.3673	4
C6	0.3	0.238	0.139	0.218	0.205	0.192	0.179	0.145	1.616	0.202	8.5011	2
C7	0.075	0.119	0.139	0.109	0.051	0.096	0.089	0.097	0.775	0.097	8.2763	5
C8	0.3	0.178	0.25	0.164	0.308	0.385	0.268	0.29	2.142	0.268	8.3697	1
Total	1	1	1	1	1	1	1	1		1	8.3152	

4 RESULTS

As mentioned previously, GIS has the potential to play a significant part in the documentation of tourism resources, as well as in the monitoring and efficient management of tourism resources (Abayneh, 2020; Moghaddam *et al*., 2019). According to earlier research, AHP techniques have been frequently utilized to solve problems including evaluating the possibility for ecotourism, selecting hotels, choosing alternative locations and analyzing ecological impacts, with generally satisfying outcomes in most circumstance (Chen, 2013; Kwatra *et al*., 2021; *Wu et al*., 2022). As the AHP method, one of the relevant methods for suitability analysis, this method is used to explore ecotourism's potentiality in Purulia district. Based on advice from experts and conducting research the socioeconomic and physical setup of the study region, the best eight feasible parameters have been identified as being relevant to assessing the potential for ecotourism in this district. After developing the matrix according to the variables' respective levels of influence on ecotourism potentiality, the AHP method was successfully implemented in order to calculate the variables' weights. The resulting weights are as follows based on how significant they are in determining tourism potential: Distance from tourist sites ranked 1st (0.2678), ecological sites ranked 2nd (0.2020), elevation ranked 3rd (0.1747), distance from settlement patches ranked 4th (0.1110), railway track ranked 5th (0.0969), slope ranked 6th (0.0663), roadway ranked 7th (0.0663) and finally river area ranked 8th (0.0256), respectively. The determined CR value is 0.0281, which indicates that the AHP matrix's weight values are consistent because it is below the permissible threshold of 0.10 (Table 6A and B) (Saaty, 1980). Finally, a suitability map was produced using the Weightage Linear combination by multiplying the resulted weights value of each criteria map with the support of ArcGIS software.

The AHP approach was used to develop the suitability map, which was then further divided into five groups based on its appropriateness for ecotourism potential (Figure 4). The results were further verified by using ecotourism potential site point data collected in the field and previous research work. Namely, highly suitable area for ecotourism development comprises 10.16 % (632.12km^2) geographical area of this district. These regions have a very rich flora and fauna and they fulfill all of the criterion conditions extremely well; as a result, they are classified as belonging to highly suitable classes. Since the majority of these areas are already well-known tourist destinations with all the necessary amenities and spectacular natural surroundings to explore, so it would be pretty natural to have higher suitability for ecotourism development. Among these regions are the Ajodhya hill and forest areas, the Muradi dam and Baranti, the Panchet hill, the Joychandi hill and Raghunathpur regions. Another 8.15% (510.34km^2) area belongs to moderately suitable classes located adjacent to existing tourism spots and covered with hill and lush green surroundings these are although not popular for tourism point of view have a potentiality for establishment future tourism units. The suitability of the sites placed in this zone also satisfies all the standards set forth but ecotourism cannot be promoted since there is not enough accommodation and there are transportation issues. Some of the less well-known tourist destinations are Jajahatu, Paprakocha dam next to Gorgaburu hill (Ajodhya Hills Range), Lawakui close to Matha forest ranges, Madhuban and Barudih close to Banduan.

After that 26.68% (1670.09km^2) area is belong to suitable class mostly nearer forest lake and hill areas Although, there is a chance for tourism owing to transportation and other barriers tourism potentiality is still unexplored. Some potential tourist destinations include Balarampur and Brindabanpur near the Ajodhya Hills Range and Nilgiri, Doladanga near the Mukutmanipur dam. To encourage ecotourism in these locations, it is necessary to build physical infrastructure including ecofriendly lodgings, resorts, restaurants, and public convenience facilities. Finally, the last two classes less suitable with 23.84% (1492.27km^2) category comprises places with low sensitivity and scant opportunities for tourism exploration. However, in order to minimize the impact of development, development should be carried out in a responsible manner. Furthermore, unsuitable classes with 31.16% (1950.54km^2) areal coverage are mostly irrelevant for tourism standpoint as these areas belong absolutely rural areas with less human habitation and are not worth exploring from tourism perspective (Figure 4 and Table 7).

Table 7. Area with suitability classes

Suitability classes	Area	
	Km^2	(%)
Highly suitable	636.12	10.16
Moderately suitable	510.34	8.15
Suitable	1670.09	26.68
Less suitable	1492.27	23.84
Unsuitable	1950.54	31.16
Total	6259.36	100

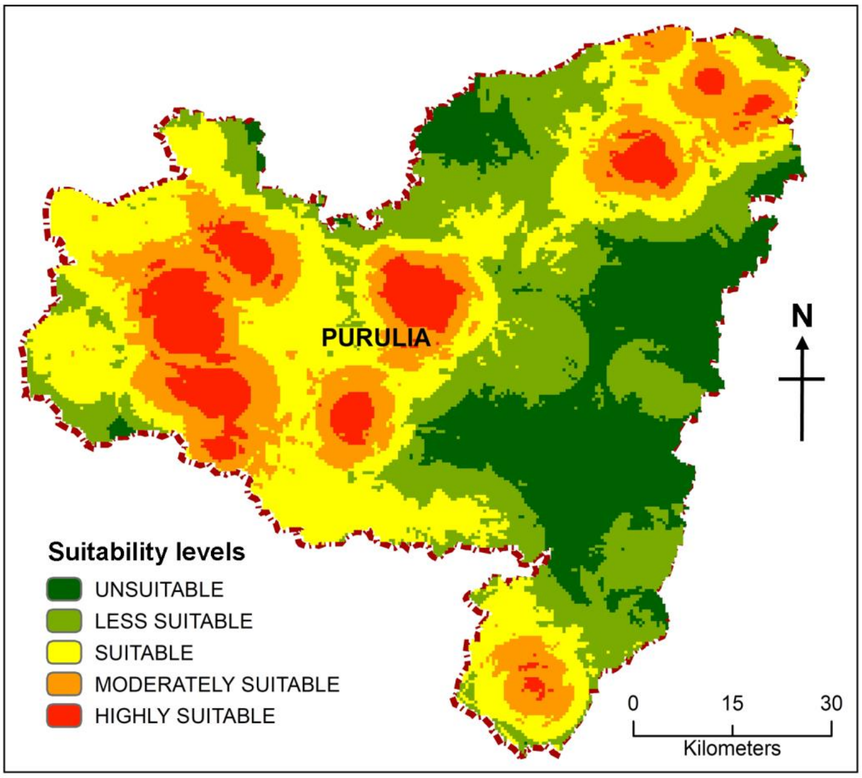

Figure 4. Suitability for ecotourism

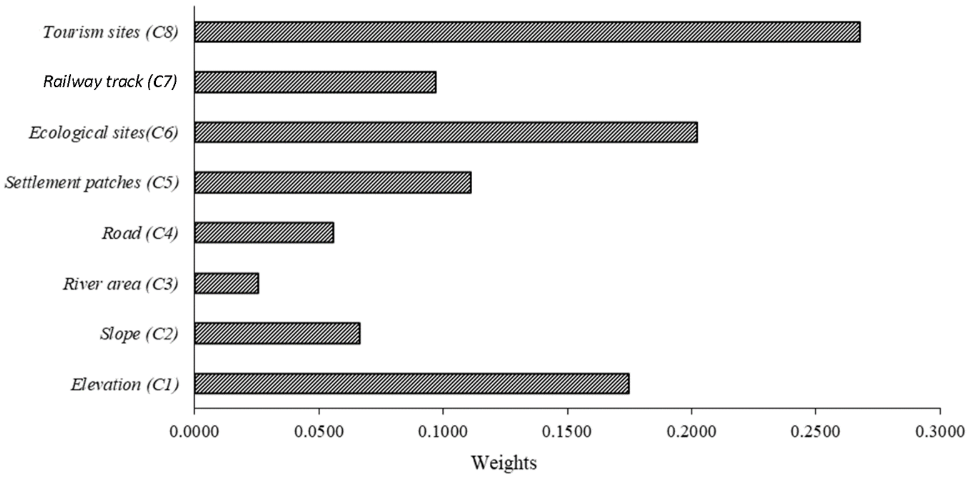

Figure 5. Criteria weights

5 DISCUSSION

To preserve the environment, guarantee of the local population's livelihood is essential, especially in isolated areas with insufficient government support; in these circumstances, ecotourism development may create additional opportunities for income generation. This research attempts to address an integrated approach for ecotourism suitability coupled up GIS with AHP after matching suitable criteria identifies most desirable area for ecotourism. Here, in this portion important eight criteria which have been selected discuss its relevance for exploring tourism potential.

1) Elevation (C1)

Higher elevation always attracts tourists for its clean, green lush environment, fresh air and panoranic view of the mountain (Ariza *et al*., 2013). The most alluring features of Purulia tourism evolved around this verdant, hilly landscape with a dense forest cover which mesmerizes city dwellers.

2) Slope (C2)

The slope of the land is extremely important to creating a prospective ecotourism site. The choices were assigned based on the relative relevance of each class and a greater slope value suggests a better likelihood of developing a potential ecotourism site and vice versa (Dashti *et al*., 2013).

3) Proximity to river (C3)

Picturesque river landscape always mesmerizing hearts of tourist by its riparian forest along the river, swampy vegetation, wetland, lake and spring near to the ecotourism sites are preferable which attracts more tourists to that area (Fachrudin *et al*., 2016). As there is scarcity of water due to location of barren land Chotanagpur plateau that's why people are mainly concentrated on river areas which help to develop tourism.

4) Distance from road (C4)

The traveler always prefers easy access to the tourist attractions via a convenient transportation system when travelling (Kim *et al*., 2011). Some of the areas also in this district remained untapped due to poor transportation.

5) Distance from settlements (C5)

Urban areas or human habitation made it easier for tourists to fulfill their fundamental requirements while engaging in ecotourism activities, which is why sites close to populated regions are given more weight than those farther away.

6) Distance from ecological sites (C6)

Visitors are attracted to a place to participate for ecotourism for a number of different reasons, including the natural, cultural and geophysical characteristics of the location. Biotic properties, such as biodiversity, wildlife and ecological regions are regarded as the most crucial factor in the creation of ecotourism sites. Forest based ecotourism approach always helps preserve forest ecology and positively impact the economy and environment of the host area and benefit local communities for their earing. In this district, recent development of tourism helped the local people for earning their daily wages.

7) Distance from railway tracks (C7)

Eastern and southeastern, southwestern part of this district don't have any railway connectivity and tourism potentiality yet to be explored.

8) Distance from tourism sites (C8)

The development of additional tourist destinations close to popular ones will draw more visitors to the region and encourage private investor and local administrator to investigate the viability of developing new sites based on existing infrastructure.

It would be a challenging task for the traveler to select a place of destination among various alternatives based on tourists' preferences. Multi-criteria decision-making techniques (MCDM) can solve suitable site selection problems after comparing various alternatives that give the best option according to tourist preferences. employing AHP approach, possible ecotourism locations in the Purulia district were mapped for site suitability. Finally, six alternative tourist destinations were identified based on this suitability map of ecotourism and field verification through a personal visit for further investigation form the perspective of visitor choice. These alternative ecotourism sites are: Purulia town (A1), Ajodhya Hill and Forest area (A2), Raghunathpur-Joychandi Pahar (A3), Baranti hill and lake(A4), Garh Panchkot and Panchet dam (A5), Chandil Dalma elephant corridor (A6) (Figure 6). A total of 120 participants are chosen, 20 for each destination, including tourists, hotel managers, owners of local businesses and professionals in charge of managing tourism related activities. Through in-depth interviews, we are learning how visitors rank this tourism spot in terms of traveler security, natural views, accessibility, and lodging. A primary survey (2021-2022) was carried out between December and March based on five characteristics that are pretty representative from the perspective of tourists*:* (i) Road connectivity, (ii) per day cost, (iii) hotel availability, (iv) scenic beauty and (v) tourist safety (Table 8).

6 CONCLUSION

Livelihood of indigenous people can be regenerated through the growth of ecotourism in collaboration with local residents and environmental initiatives. Villagers might acquire knowledge of sustainable wildlife and landscape management in this way making wise livelihood decisions without compromising their traditional values. The primary contribution of this work was to the mapping of possible ecotourism sites in the

Purulia district using AHP and GIS techniques. AHP technique was very effective at identifying the ideal ecotourism location. The CR value (0.0281) shows how well the AHP technique evaluates the weights of the criterion when looking for ecotourism locations in the Purulia district. According to the findings of the research, the MCDM is an effective tool for selecting ecotourism locations, while the AHP is useful for conducting a speedy evaluation of vast regions. Investigating the potentiality of an ecotourism destination always helps travel agencies, tourist and local entrepreneurs, tourism planners for their strategic implications for successful implementation of tourism resources. Alternative locations are compared using predetermined criteria which are providing a clear picture of the opportunity and hindrance of a particular area. The result from evaluation may help strategy makers, management authorities, travel agencies, local and domestic tourists and academicians with a deeper understanding of environmental factors for ecotourism developments. With the use of the suggested technique, future research on ranking tourist destinations and identifying priority ecotourism sites can be conducted.

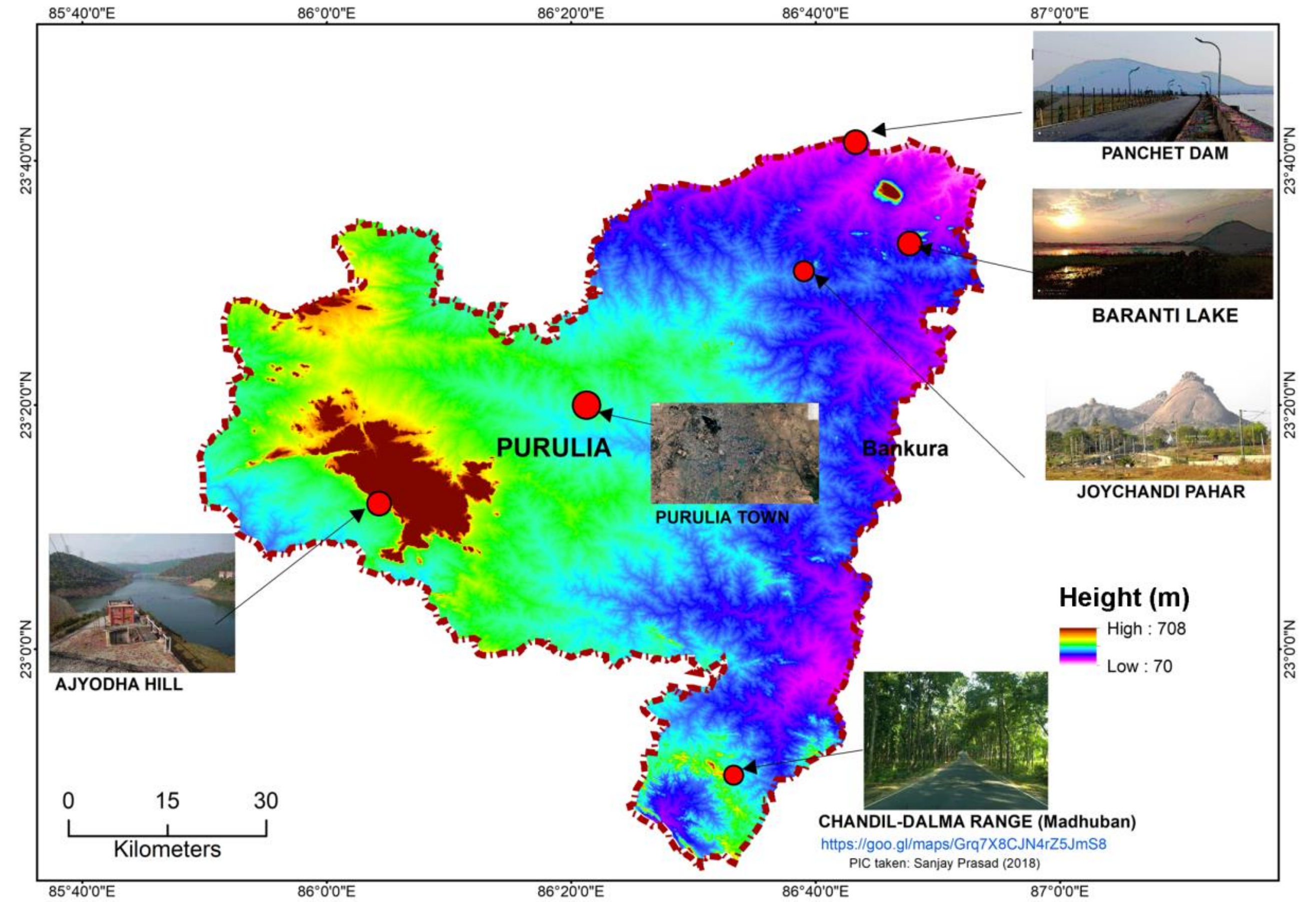

Figure 6. Alternatives candidates for preferable ecotourism

Table 8. Preferential tourism sites in Purulia district

Alternative ecotourism sites	Scenic beauty	Connectivity	Expenses (INR)	Hotels availability	Tourist safety	Remarks
Purulia town (A1): The largest town in the Purulia district is well connected to the rest of India has affordable lodging, and has urban amenities, but lack of tourist attractions in close proximity to the main town.	Densely populated urban area lacking with physical attractiveness.	Excellent road and rail connectivity	Foods and lodging: INR 1000 person/day	Room charges: INR 1000-1500	Absolutely safe for tourist even at night.	People may prefer to stay near to other ecotourism spots in order to take advantage of the natural surroundings.
Ajodhya hill and forest (A2): Most popular ecotourism destination of Purulia district enriched with diversified landscape and ecotourism spots likes Khairabera, Murguma, Gorgaburu. It is has popular place for basic rock climbing.	Excellent scenic beauty diversified natural landscape such as forest, hill area, lakes, dams, tribal dance (Bihu) and various ecotourism sites. Palash and Shimul flowers are in blossom at these places at the onset of spring.	Good road network with beautiful landscape	Foods and lodging: INR 1800 person/day	Room charges: INR 3000	Absolutely safe.	Very much popular among the tourists for ecotourism.
Raghunathpur-Joychandi Pahar (A3): Popular tourist center and major attraction for rock climbing with good connectivity with rail and road, nearness to other tourism sites.	Lacking of physical attractiveness apart from joychandi hill but near to other tourism spots.	Excellent road and railway connectivity	Foods and lodging: INR 1250 person/day	Limited options. Room charges: INR 1000-1800	Moreover safe for tourist.	Popular among rock climber but unpopular among tourist due to not much worth visiting.
Baranti hill and lake (A4): A tribal village with dam (Muradi) and hill (Baranti), spectacular view of sunset and	Attractive lake and forest view with magnificent Palash flower in spring time. This baranti laking of	Good road and railway connectivity	Foods and lodging: INR 1550 person/day	Room charges: INR 1500-3500 Lots of resort and hotels.	Fell bit of unsafe in nighttime due to lack of streetlight.	Recently popular ecotourism destination among the tourist due to beautiful lake landscape.

quiet ecotourism spots, nearness to other tourism spots like Biharinath and Garh Panchkot, costly accommodation and food.	attract migratory bird during winter months.					
Garh Panchkot and Panchet dam(A5): Located in the eastern part of India at the foothills of *Panchet Hill*. awesome scenic beauty of forest, *Panchet dam* and historical significance ruined fort of Garh Panchkot.	Attractive landscape of Panchet dam between West Bengal and Jharkhand border.	Only road connectivity	Foods and lodging: INR 1400 person/day	Room charges: INR 3000. Limited options.	Unsafe at night.	Recently popularized due to its historical significance ruined fort of Garh Panchkot at the foothills of Panchet hill.
Chandil Dalma elephant corridor (A6): Part of Dalma ranges located in border of Jharkhand and West Bengal. Still not explored properly have a potentiality to explore places like Banduan, Ghatihuli near the ecotourism spots like Dharagiri Fall, Burudi Dam of Jharkhand.	Potentiality to be explore new ecotourism sites Duarsini Forest, Madhuban, Mayurjharna elephant reserve area merging it's the border with neighbor district of Paschim Medinipur district and Bankura district	Poor road connectivity	Foods and lodging: INR 1300 person/day	Homestay charges: INR 2000. No standard hotel or homestay available.	Unsafe at nighttime.	Lack of popularity among the tourist due to lack of accommodation and road connectivity.

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ABBREVIATIONS

AHP: Analytical Hierarchy Process; **DEM**: Digital Elevation Model; **EPPI**: Ecotourism Potential Priority Index; GIS: Geographic Information System; **MCDM**: Multi-Criteria Decision Method; **WLC**: Weight Linear Combination.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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