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Original Research Paper

Ecotourism Potential Zone Mapping by Using Analytic Hierarchy Process (AHP) and Weighted Linear Algorithm: A Study on West Bengal, India

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Abstract

This study was designed to demarcate the Ecotourism Potential Zones (ETPZs) of West Bengal using the Analytic Hierarchy Process (AHP) and weighted linear algorithm by considering three sustainable tourism parameters and sixteen indicators. Those three parameters are 1) physical (P), 2) social (S), and 3) availability of scenic beauty and infrastructures (ASI). Overall, 5 parameters are merged under physical (P), 2 parameters are integrated under social (S), and 9 parameters are incorporated under availability of scenic beauty and infrastructures (ASI). A 4-step procedure has been adopted for this study: 1) a simple hierarchical structure has been outlined, 2) pair-wise comparison matrices are formed, 3) weighted linear algorithm technique is utilized to get the ecotourism potentiality zone, and 4) ecotourism potentiality map is classified into high, moderate and low categories based on the principle of Dominant and Distinctive Function (DDF). As a result, about 61.65% area is identified with high ecotourism potential zone, 17.86% area is observed under the moderate ecotourism potential zone, and 20.48% area is recognized as the low ecotourism potential zone. Thus, the study considers an exceptional methodological framework that is applicable in any region of the world.

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1 INTRODUCTION

As an essential and emerging sector, ecotourism has flourished from the axiom of sustainable development (Mnini and Ramoroka, 2020; Gu and Liu, 2013), where it must be economically feasible, environmentally productive and socio-culturally appropriate (Sahani, 2019a; Falabi and Olatunji, 2014; Mondino and Berry 2018). In recent days, ecotourism is considered as a necessary and alternative form of tourism, indicating responsible travel to the natural environment by sustaining nature's fundamental soul (Cheng *et al.*, 2017; Western, 1993). The concept of ecotourism comes into reality due to the reaction of traditional mass tourism, which disturbs the life and livelihoods of the poor people (Higgins-Destabiolles, 2008; Singh, 2017) by deteriorating the natural, social and economic environment (Dwyer *et al.*, 2010). As an alternative form of the traditional tourism model, ecotourism consists of several physical and mass-tourism-related parameters, which enhance the ecological and socio-cultural responsibilities (Barfuss *et al.*, 2017; Pawson *et al.*, 2017). Furthermore, ecotourism creates the profound scientific basis of planning and managing a particular region by merging a regions' fundamental soul and behavioral perspectives (Dias *et al.*, 2021).

Scientific principles create a precise scientific ground in modern tourism research which relies on several quantitative methods and techniques (Fennel and Ebert, 2004; Sharpley, 2014). The major arcana of this study are to identify and demarcate the Ecotourism Potential Zones (ETPZs) of West Bengal by using the Analytic Hierarchy Process (AHP), weighted linear algorithm and Geographic Information System (GIS). Strategically, suitable planning techniques can be enforced by Multi-Criteria Decision Making (MCDM) procedures which provide a readymade and unbiased way to achieve the particular goal

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(Krishankumar *et al.*, 2019; Soni *et al.*, 2017). Over several MCDM techniques, AHP gains worldwide attention for its flexibility and effective use (Kumar *et al.*, 2017; Karim and Karmakar, 2016; Aruldoss *et al.*, 2013). The consistency ratio is estimated at each step of AHP, making this method well-grounded (Liao *et al.*, 2019; Mahdavi and Niknejad, 2014). Besides it, with the help of AHP, any complex phenomena can be decomposed into several subproblems, which are solved by using pair-wise comparison matrices (Sun, 2010) and human judgment (Parthiban *et al.*, 2013). Now a day, several researchers recommend using the AHP technique to assess the tourism potentiality of a large diversified geographical region. For example, Roque Guerro *et al.* (2020) estimates potential ecotourism zones of Brazillian Municipality by utilizing AHP to promote landscape. Oreski (2012) applies AHP in the development of a strategic model for tourism. Hoang *et al.* (2018) use the AHP procedure to evaluate the tourism potentiality of Central Highland of Vietnam. González-Ramiro *et al.* (2016) uses AHP to evaluate the rural tourism potentiality of Extemmadura (Spain). Rahimi and Pazand (2017) utilize the AHP procedure to determine the tourism potentiality of Iran. Site suitability for marine tourism is analyzed by Gumusay *et al.* (2016) by using the AHP. Asadpourian *et al.* (2020) use Analytic Hierarchy Procedure (AHP) and TOWS matrix to identify priorities of sustainable ecotourism parameters of Lorestan Province, Iran. Using AHP, the attractiveness of six cultural heritage sites of Phuket (Thailand) is illustrated by Božić *et al.* *(*2018) by considering accessibility, artistic value, scenic beauty, tourist infrastructure, tourist appeal and tourist assets. Kumari *et al.* *(*2010) use AHP to identify potential ecotourism sites in West District, Sikkim using 21 geospatial layers. Crouch and Ritchie (2005) apply AHP to illustrate the competitiveness of the destination region. Chen *et al.* *(*2017) utilize the AHP-Delphi method to assess several tourist attractions of Taiwan. A bundle of works on AHP from several other disciplines can also be cited here. For example, *Ramos Quitana et al.* (2019) utilize AHP to formulate a suitable environmental management plan for Mexico. To do it, several environmental factors such as ‘CO_2 emissions’, ‘air quality’, ‘loss of vegetation cover’, ‘water availability’ and ‘solid waste’ are considered. Mosadeghi *et al.* (2015) utilized the AHP technique to identify several landuse zones in Queensland, Australia. Akbulut *et al.* (2018) use AHP to demarcate the land suitability of Beykoz District, Turkey. Javadian *et al.* (2011) illustrate the educational landuse pattern of Tehran by integrating and merging several environmental, social and economic parameters using the AHP procedure.

Similarly, weighted linear algorithms and GIS are also recognized by several researchers worldwide. Flowerdew and Green (1993) made a pioneering attempt to review several weighted overlay procedures and recommend using the weighted linear technique to merge several rasters in space. In recent times, Aliani *et al.* (2017), Masoudi *et al.* (2021), Balist *et al.* (2019), Zabihi *et al.* (2020), Jokar *et al.* (2020), Boers and Cottrel (2007), Taye *et al.* (2019) also recommend using the weighted linear procedure to merge or group several indicators within a specific parameter. Simultaneously, GIS can effectively manage, store, and visualize the geospatial data, which is recognized as a handy tool (Irizary *et al.*, 2013; Musa *et al.*, 2013). The GIS is also considered as a cost-effective tool for managing various spatial data effectively and smoothly (Hasler *et al.*, 2014; Agapiou *et al*., 2015). GIS helps to manage large-scale data, which becomes easy to understand (Tomlinson, 2007; Beeco and Brown, 2013). Five indicators, such as wildlife, ecological value, ecotourism attractiveness, environmental resiliency, and ecotourism diversity are utilized in the GIS environment by Kumari *et al.* (2010) to identify potential ecotourism sites in Sikkim. Cetin and Sevik (2016) apply GIS to identify potential ecotourism zones of Ilgaz Mountain National Park. Bunruamkaew and Murayama (2012) utilize GIS to visualize a landuse plan in Surat and Thani of Gujrat. The forest-based ecotourism area of West Virginia is illustrated in space by Dhami *et al.* (2014) using Geographical Information System (GIS). Ahmadi *et al.* (2015) evaluate land capability with the help of GIS in Illam Province. Wanyonyi *et al.* (2016) identify potential ecotourism sites of Kwale County with the help of GIS. Omarzadeh *et al.* (2021) use GIS to illustrate the ecotourism-based sustainability of West Azerbaijan Province, Iran. Apart from the above examples, Mobaraki *et al.* (2014), Oladi and Otghsara (2012), Gigović *et al.* (2016), Sahani (2019b), Aliani *et al.* (2016) also recommend using GIS to illustrate tourism potentiality spatially.

Similarly, GIS-based multicriteria decision-making analysis is widely recognized as a practical approach to depict ecotourism potentiality. For example, Gourabi and Rad (2013) apply AHP and GIS to explore and demarcate the ecotourism potentiality of Boujagh wetland by considering eight thematic layers such as sunny days, temperature, relative humidity, slope, direction, soil texture, water resources and vegetation density. Ghamgosar *et al.* (2011) use elevation, slope, aspect, soil, rock and landuse for the identification of potential ecotourism sites with the help of AHP and GIS. 15 geospatial layers are decomposed into 5 factors (such as administrative boundaries, sea and other water bodies, spring and cave locations, landscape, cultural heritage and community characteristics) by Ullah and Hafiz (2014) with AHP procedure to delimit ecotourism potentiality zone. Lee *et al.* (2013) used ANP and GIS to demarcate the ecotourism potential zones of Jangheung-gun and Jeollanam-do. Aminu (2007) uses AHP and GIS to distinguish tourism potentiality zone smoothly and clearly in space. By following and considering the above perspectives, this research has utilized AHP and GIS-based eclectic approaches to demarcate the ecotourism potentiality zone of West Bengal.

Apart from the above research reports, some are related to the tourism sector of West Bengal can also be cited here. Al Mamun and Mitra (2012) have estimated the tourism potentiality of Murshidabad district by using AHP and GIS. Dandapath and Mondal (2013) evaluated the effects of urbanization on the coastal ecotourism of West Bengal. Ray *et al.* (2012) explored rural tourism and its impact on the socio-economic condition of West Bengal. Bhutia (2014) evaluated tourism to promote the human resource development of Darjeeling district, West Bengal. Ahamed (2017) explored the heritage tourism of West Bengal with special reference to employment opportunities. Das and Ghosh (2014) explored the financial sectors of the tourism industry of West Bengal. The prospects of tea tourism in Duars are analyzed and discussed by Datta (2018). Mandal *et al.* (2013) explored the ecotourism resources along with the coast of West Bengal. Banerjee and Mukherjee (2021) formulate branding strategies for marketers with the help of heritage and people. Although several research works are found Worldwide about ecotourism potentiality, to our best knowledge, no research work is available about the ecotourism potential zone identification on West Bengal. So, considering the above perspectives, the specific objective of this research is to mark off the Ecotourism Potential Zones (ETPZs) of West Bengal (India) using the Analytic Hierarchy Process (AHP), weighted linear algorithm technique and GIS procedures.

2 METHODOLOGY AND DATABASE

2.1 Study Area

Being located in the eastern portions of India, West Bengal is India's fourth populous state stretching from the Himalayas in the North, Bay of Bengal in the South, Bihar and Jharkhand in the West and Bangladesh in the East (Figure 1). According to the recent estimates of Census of India (2011), the population growth rate of West Bengal is 13.8%, and the total population is 91,276,115. The state is composed of 23 districts. West Bengal is brimmed with picturesque magnificence with broadened scenes and outstanding natural beauty (Shakeel, 2001). Traditionally, West Bengal is dominated by agriculture and as well as small and medium scale industries. Historically, the state is an architectural and natural heritage (Das, 2020). Several tourist attractions exist all over the state include Darjeeling (Darjeeling District), Morgan House (Kalimpong), Coochbehar Palace (Coochbehar District), Dooars, Jaladapara National Park (Alipurduar District), Gorumara National Park (Jalpaiguri District), Hazarduari Palace (Murshidabad District), Nizamat Imambara (Murshidabad District), Katra Mosque (Murshidabad District), Adina Deer Park (Maldah District), Shantiniketan (Birbhum), Birbhum Terracotta temples (Bankura), Acharya Jagadish Chandra Bose Indian Botanical Garden (Shibpur in Howrah), BBD Bagh (Kolkata), Dakshineswar Kali Temple (North 24

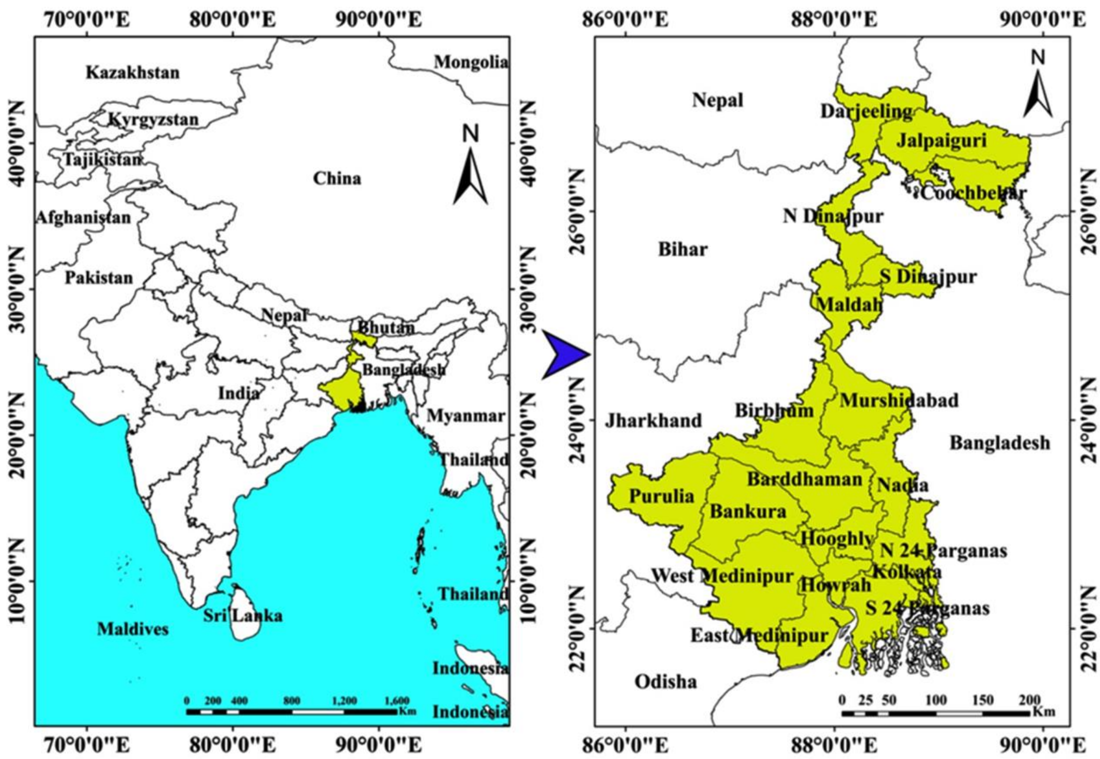

Figure 1. Study area: West Bengal, India

Parganas), Belur Math (Howrah), Victoria Memorial (Kolkata), Sundarban (Southern 24 Parganas District), Digha (Purba Medinipur District), Mandarmani (Purba Medinipur District), Mayapur (Nadia District), Kumortuli (North Kolkata) and Eden Gardens (Kolkata). The tourism of West Bengal is maintained by West Bengal Tourism Development Corporation Limited (WBTDCL), a government enterprise established on 29 April 1974 under the Companies Act, 1956 (www.wbtdcl.com).

2.2 Data

Relief, slope, aspect and drainage density are estimated from the Digital Elevation Model (DEM) obtained from Shuttle Radar Topographic Mission (SRTM), 2011 with 30-meter spatial resolution. Average annual rainfall data (2020) of every district is obtained from India Meteorological Department (IMD) Climate Research and Services Unit, Pune. Under the Social (S) category, population density and population growth rate are obtained from the Census of India (2011) website. Information on the total number of reserved forests, protected forests, unclassified forests are obtained from the Annual Report on Forest Cover of West Bengal, 2014-15. information on the average duration of stay, numbers of accommodation units and occupancy rates are obtained from the Annual Final Report of Tourism Survey for West Bengal (April 2014-April 2015). The information on roads is obtained from Mapcruzin. All spatial layers are prepared in ArcGIS 10.4.1 environment.

2.3 Analytic Hierarchy Process (AHP) Procedure

AHP is an MCDM procedure that relies on mathematics and human choice (Forman and Gass, 2001). It is developed by Saaty (1980) to find out one of the best solutions from the varieties of available options. It is an objective mathematical technique to express the pair-wise comparison between several parameters (Lin and Kou, 2015). AHP produces a consistency ratio at each step, making the method more reliable than other available techniques (Kumru and Kumru, 2014). Ishizaka and Lusti (2006) develop the AHP procedure by considering four individual steps (Figure 2).

Table 1. Description of scales for pair comparison for AHP (Saaty, 1980)

Scales	Degree of preferences	Descriptions
1	Equally important	The contributions of two factors are equally important
3	Moderate importance	Experiences and judgment slightly tend to certain factor
5	Strong importance	Experiences and judgment strongly tend to certain factor
7	Very strong importance	Experiences and judgment tend to certain factor with extreme strong
9	Extreme importance	There is sufficient evidence for absolutely tending to certain factor
2,4,6,8	Intermediate values	In between two judgments

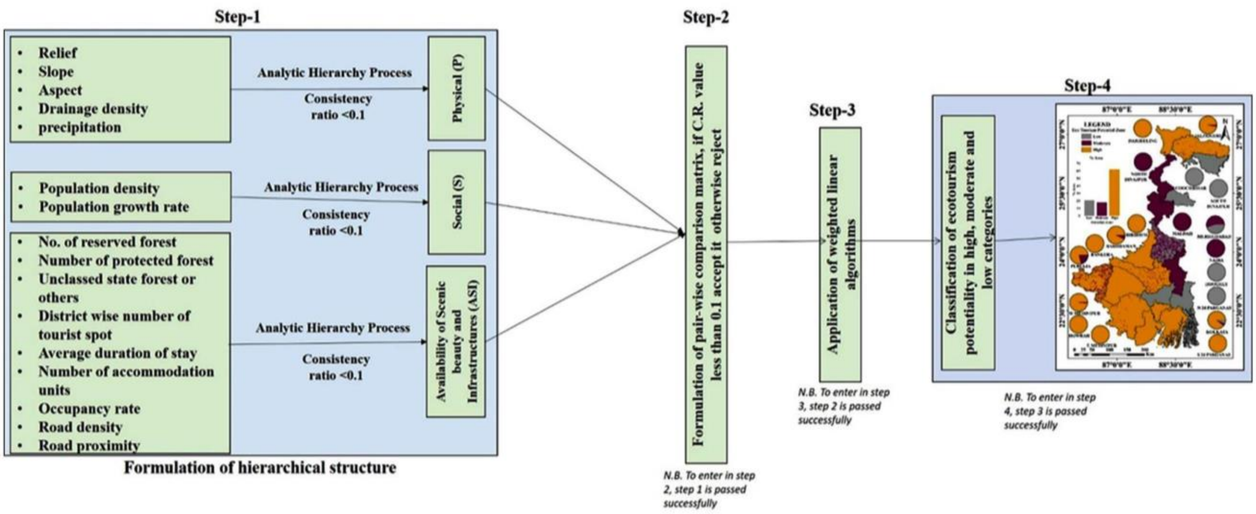

Figure 2. Methodology

Table 2. Random index value (Saaty, 1980)

Order of matrix	R.I.
1	0.0
2	0.0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48

2.3.1 *Preparation of Hierarchical Methodological Framework*

A schematic hierarchical structure has been outlined to carry out the research (Figure 2). 16 thematic layers are selected and grouped under 3 broad categories, which are physical (P), social (S) and availability of scenic beauty and infrastructures (ASI). Five parameters (i.e., slope, aspect, relief, drainage density, and rainfall) are included in physical (P); two parameters (i.e., population density and population growth rate) are included within social (S), and 9 parameters (i.e., reserved forest, protected forest, unclassified forests, district-wise numbers of the tourist spot, the average duration of stay, number of accommodation units, occupancy rate, road density and road proximity) are attached under availability of scenic beauty and infrastructures (ASI). Physical parameters express the local physical environment, creating an initial environmental setup for ecotourism (Stronza *et al.*, 2019). Social (S) parameters are needed to specify the population structure of a particular tourist spot (Gavalas *et al.*, 2014; Skibins *et al.*, 2013). Ecotourism is generally flourished with a balanced population structure. According to the report published by the Forest Survey of India (2013), a reserved forest area is notified with a “full degree of protection” (IFA, 2027; Rahman, 2000). Generally, all human activities like hunting and gathering are prohibited in these portions. However, after taking proper permission, enjoying scenic beauty from a watchtower is permissible (Ghosh, 2014; IFA, 2027). On the contrary, the provisions applied for protected forests are flexible. “All types of human activities are permitted in this portion until it is prohibited” (Ghosh, 2014; IFA, 2027). Categories of forests that are not included in the above two categories are included in the unclassified forest category (IFA, 2027). District-wise numbers of the tourist spot, the average duration of stay, number of accommodation units, occupancy rate, road density and road proximity are selected in this research following the recommendations of United Nations World Tourism Organizations (Ferguson, 2007; Mohanty, 2008; Narasimmaraj, 2014; Wickramasinghe, 2013; Abraham and Rajasenan, 2015). All parameters under ASI are in a positive relationship with ecotourism potentiality (Boley and Green, 2016). If ASI value increases, ecotourism potentiality value increases and vice-versa.

2.3.2 *Formulation of Pair-Wise Comparison Matrices*

In the second step, pair-wise comparison matrices signify the relative importance of each criterion (Table 3, Table 4, Table 5 and Table 6). Here, each criterion is rated against the other with the help of a relative dominance scale 1 to 9 (Table 1, Saaty, 1980). By containing an equal number of rows and columns, the pair-wise comparison matrix expresses the relative importance of each criterion (Fabec and Zver, 2011). For example, in table 4 (first row), relief, drainage density and rainfall are more important than the aspect. So, the aspect is coded as 3 (Moderate importance), and the relief, drainage density and rainfall are coded as 8 (Very strong to extreme importance). Table 3 signifies the relative importance of 3 broad criteria: ASI, S and P. Here, ASI is observed with the highest priority (80.60% weightage). At its successive level, social (S) and physical (P) variables are noticed with 11.70% and 7.70% importance. Table 4 denotes the pair-wise comparison matrix of the physical (P) variable by 5 criteria. In this case, the slope is observed with the highest importance (55.00% weightage) followed by aspect (25.10% weightage), relief (8.80% weightage), drainage density (6.70% weightage) and rainfall (4.40% weightage). Table 5 is determined by two criteria which are population density and population growth rate. 50% weightage is assigned for each criterion. Table 6 denotes the pair-wise comparison matrix of ASI. Here, reserved forest achieves highest priority (33.00% weightage) followed by district-wise numbers of tourist spot (18.30% weightage), unclassified forests (12.00% weightage), protected forests (11.50% weightage), average duration of stay (8.40% weightage), the number of accommodation units (5.10% weightage), occupancy rate (4.90% weightage), road density (3.80% weightage) and road proximity (3.20% weightage). In each case, the consistency ratio is calculated to judge whether the matrices are consistent or not. If the C.R value is less than 0.1, the matrix is said to be consistent and vice-versa:

$$\text{Consistency ratio} = \frac{\text{Consistency Index (C.I.)}}{\text{Random Consistency Index (RI)}} \quad (1)$$

$$\text{Consistency Index (CI)} = (\lambda_{\max} - n)/(n-1) \quad (2)$$

where, λ_{max} is the principal eigenvalue and n is the number of factors.

The random Consistency Index (Table 2) is derived from the randomly generated reciprocal matrices (Bunruamkaew and Murayam, 2011; Dashti *et al.*, 2013). According to Saaty (1980), the matrix becomes consistent if the consistency ratio is below 0.1. In our study, consistency ratios are 0.07 (Table 3), 0.056 (Table 4), and 0.012 (Table 5). So, here all matrices are consistent, and the estimated criteria weights are utilized for tourism potentiality zone identification. The pair-wise comparison matrix for each subclass (for each raster layer) is also consistent.

2.3.3 Application of Weighted Linear Algorithm

The weighted linear algorithm is applied to make the spatial assessment of each composite variable. The procedures are as follows (Gigović *et al.*, 2016; *Yang et al.*, 2015):

1) At first, all input rasters are reclassified into the relative dominance scale.
2) At the second step, all cell values of input rasters are multiplied by the weight of importance.
3) At the third stage, the resulting cell values are added together to get the final raster.

Following the above methodology, all rasters of physical (P), social (S) and availability of scenic beauty and infrastructures (ASI) are estimated. So, the weighted linear algorithm strategy can be expressed as follows:

$$\mathrm{ETPZ} = \sum_{w=1}^{m}\sum_{r=1}^{n}(T_w \times T_r) \quad (3)$$

where, ETPZ represents the ecotourism potential zone, T_w represents the normalized weight of w thematic layers. m signifies the total number of thematic layers, and n is the total number of the subclass of each thematic layer.

Table 3. Pair-wise comparison matrix of 3 broad criterions

Criterions	Availability of forests and infrastructures (AFI)	Social (S)	Physical (P)	Priority (%)	Rank	(+) (%)	(-) (%)
Availability of scenic beauty and infrastructures (ASI)	1	9	8	80.60	1	21.60	21.60
Social (S)	0.11	1	2	11.70	2	3.10	3.10
Physical (P)	0.12	0.5	1	7.70	3	2.10	2.10

Number of comparison 3, Principal Eigen value 3.074, Consistency Ratio 0.07.

Table 4. Pair-wise comparison matrix of physical (P) parameters

Criteria	Slope	Aspect	Relief	Drainage density	Precipitation	Priority (%)	Rank	(+) (%)	(-) (%)
Slope (SL)	1	3	8	8	8	55.00	1	15.20	15.20
Aspect (AS)	0.33	1	3	6	5	25.10	2	8.00	8.00
Relief (RL)	0.12	0.33	1	2	2	8.80	3	2.30	2.30
Drainage density (DD)	0.12	0.17	0.5	1	3	6.70	4	3.40	3.40
Precipitation (PR)	0.12	0.2	0.5	0.33	1	4.40	5	1.60	1.60

Number of comparisons 10, Principal Eigen value 5.253, Consistency Ratio 0.056

Table 5. Pair-wise comparison matrix of social (S) parameters

Criteria	Slope	Aspect	Priority (%)	Rank	(+) (%)	(-) (%)
Population density (PD)	1	2	50.00	1	50.00	50.00
Population growth rate (PGR)	0.50	1	50.00	2	50.00	50.00

Number of comparisons 2, Principal Eigen value 1.253, Consistency Ratio 0.012.

Table 6. Pair-wise comparison matrix of availability of scenic beauty and infrastructure (ASI)

Criterions	Reserved forest	Protected forest	Unclassified forests (UCF)	District-wise number of tourist spot	Average duration of stay	Number of accomodation units	Occupancy rate	Road density	Road proximity	Priority (%)
Reserved forest (RF)	1	2	3	5	2	9	9	7	5	33.00
Protected forest (PF)	0.5	1	2	1	1	2	2	2	3	11.50
Unclassified forests (UCF)	0.33	0.5	1	1	2	5	1	3	5	12.00
District-wise number of tourist spots	0.2	1	1	1	3	9	9	3	3	18.30
Average duration of stay	0.5	1	0.5	0.33	1	1	2	3	3	8.40
Number of accommodation units	0.11	0.5	0.2	0.11	1	1	2	2	2	5.10
Occupancy rate (%)	0.11	0.5	1	0.11	0.5	0.5	1	2	2	4.90
Road density	0.14	0.5	0.33	0.33	0.33	0.5	0.5	1	2	3.80
Road proximity	0.2	0.33	0.2	0.33	0.33	0.5	0.5	0.5	1	3.20

Number of comparisons 36, Principal Eigen value 10.065, Consistency Ratio 0.093

2.4 Classification of Ecotourism Potentiality Map

At the fourth stage, the ecotourism potentiality map has been classified into high, moderate and low categories by utilizing the Dominant and Distinctive Function:

$$\leq \frac{(\bar{x}+L)}{2} \text{ is considered as low potentiality} \quad (4)$$

$$\frac{(\bar{x}+L)}{2} \leq \text{ETZ} \leq \bar{x} \text{ is considered as moderate potentiality} \quad (5)$$

$$\text{ETZ} \geq \bar{x} \text{ is considered as high potentiality} \quad (6)$$

where, L, $\bar{x}$ and δ represent lower class boundary, the mean and standard deviation of ecotourism potentiality zone (ETPZ), respectively. All spatial assessments are done using ArcGIS-10.2, 10.4 and open access R-programming software.

2.5 Criterions

2.5.1 Physical Parameters

The physical (P) parameters include slope, aspect, relief, drainage density, and rainfall under the physical (P) parameter.

2.5.1.1 Slope

Within West Bengal, the slope varies from 0 degree to 90 degree. Overall, slope is classified to 4 groups i.e., <1 degree (about 1.65% area), 1 degree to 89.80 degree (about 5.80% area), 89.81 degree to 89.93 degree (about 26.09% area) and greater than 89.93 degree (about 66.45% area). Western and Northern parts of West Bengal are observed with moderate slope, and Southeast portions of West Bengal are noticed with flat terrain. So, overall, West Bengal is noticed with moderate to low slope value. According to their importance, the priorities are assigned to each class, where a moderate slope indicates better possibilities to develop potential ecotourism sites (Sahani, 2019a; Ambecha *et al.*, 2020). Following this rule, the slope is reclassified and coded as 1,3, 5 and 7, respectively.

2.5.1.2 Aspect

Figure 4 represents the aspect map of the study area. Relatively high aspect (>181) is noticed at the northern and western portions of the study area. On the other hand, the eastern and southern parts of West Bengal achieve a relatively low aspect (<180) value. The aspect of West Bengal is classified into four individual classes, which are less than 90 (28.52% area), 90 to 180 (26.49% area), 181 to 270 (24.71% area) and greater than 270 (20.27% area). Preferences are selected for each class following the importance where the high aspect positively influences the ecotourism potentialities (Ryngnga, 2008; Karki *et al.*, 2020). Here, the aspect is reclassified into 4 classes, and following the above principle, they are coded as 1,3, 5 and 7, respectively. As the aspect increases, ecotourism potentiality increases and vice-versa.

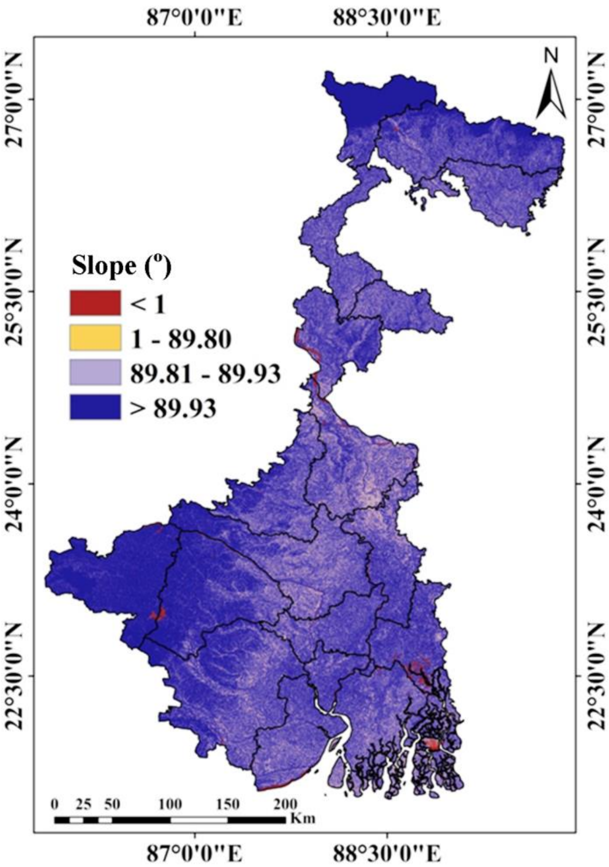

Figure 3. Slopes

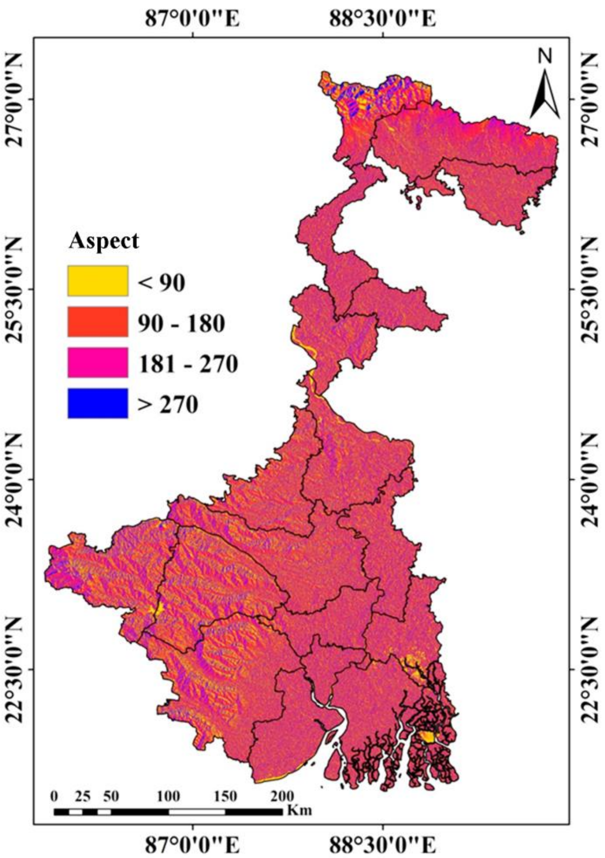

Figure 4. Aspect

2.5.1.3 Relief

Overall, the relief (in meter) (Figure 5) of West Bengal fluctuates from 0 to 1456 meters. Here, relief is classified into 4 individual categories which are <50 meter (61.74% area), 51 meter to 200 meter (28.98% area), 201 meter to 1000 meter (8.05% area) and >1000 meter (1.22% area). The highest relief (>1000 meters) is concentrated in the north-western portions of the study region. The partial portions of Northern and Western parts of the study region are observed with relatively high relief (>201 meters). On the other hand, southern and eastern portions are observed with plain land (<50 meters). Overall, West Bengal is noticed with moderate to low relief. Ecotourism potentiality is positively correlated with moderate altitude (relief) (Kiper, 2013; Stronza *et al.*, 2019). Keeping this fact in mind, the relief has been reclassified into 4 categories, and with increasing relief, they are recoded with 1,3, 5 and 7 priorities respectively. As relief increases (moderate to low), priority (weights) increases and vice-versa.

2.5.1.4 Drainage Density

Drainage density of the study region (Figure 6) varies from 0.01 km/ sq km. to 32.17 km/sq. km. Drainage densities of West Bengal are classified into 4 classes, i.e., <8.04 km./sq.km. (20.74% area), 8.05 km./sq.km. to 16.08 km/sq.km. (51.62% area), 16.08 km/sq.km. to 24.13 km./sq.km. (24.93% area) and greater than 24.13 km/sq.km. (2.71% area). Northern portions of West Bengal are observed with relatively dense drainage, and the western portions of the study area are noticed with relatively less drainage density. Drainage density enhances ecotourism potentiality (Zabihi *et al.*, 2018; Ronizi *et al.*, 2020; Fernando and Shariff, 2013). Here, drainage density is reclassified into 4 classes and considering the above rule, those classes are coded as 1, 3, 5 and 7.

2.5.1.5 Rainfall

Rainfall of West Bengal (Figure 7) varies from <1800 mm to >3100 mm within the study area. The highest rainfall (>3100 mm) is concentrated in the study area's northern and southern portions. Rest portions are noticed with less than 1800 mm. rainfall. The priorities are assigned to each class according to the importance where rainfall availability enhances ecotourism potentiality (Suddin, 2017; Rahman *et al.*, 2013). Rainfall raster map is reclassified into 4 groups and they are coded as 2 (74% area), 4 (11% area), 6 (4% area) and 8 (11% area) respectively. As the rainfall increases, ecotourism potentiality also increases and vice-versa.

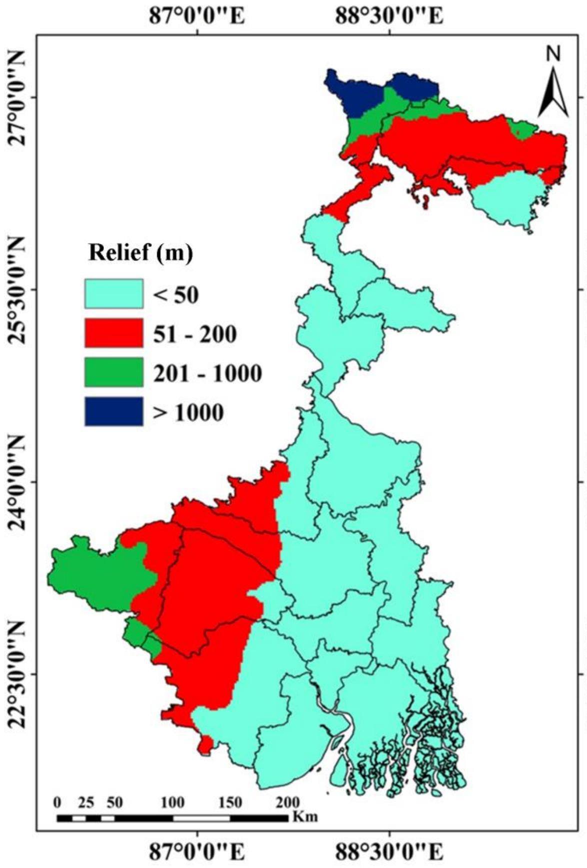

Figure 5. Relief

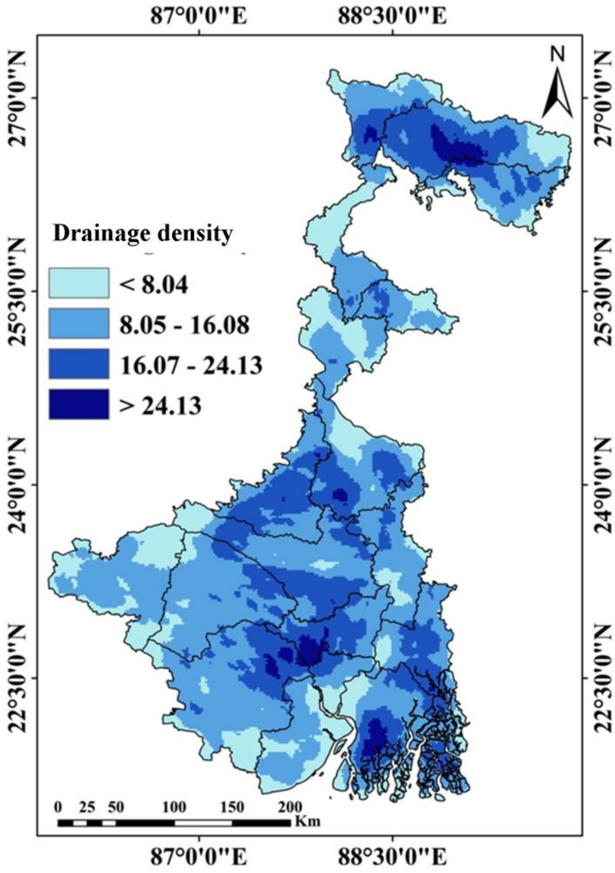

Figure 6. Drainage density

2.5.2 Social Parameters

Population density (Figure 8) and population growth rate (Figure 9) are considered under social (S), which can be explained as follows:

2.5.2.1 Population Density

Higher population densities (>2000 persons/square km.) are observed at Kolkata, North-24-Parganas and South-24-Parganas Districts. The lowest population density (<500 persons/sq km.) is noticed at Purulia District. Rest districts are noticed with 500 to 2000 persons/ km^2. population densities. Overall, population density is classified into 4 classes i.e., <500 persons/sq km. (7.27% area), 500 to 1000 persons/sq km. (52.60% area), 1001 to 2000 persons/sq. km. (31.64% area) and >2000 persons/sq km. (8.49% area). Population densities are reclassified into 4 classes and are coded according to their priority. Generally, high population densities deteriorate ecotourism potentiality (Islam *et al.*, 2011; Abdillah *et al.*, 2020). Thus, here, high population densities (>200 persons/sq km) are assigned with low priority (Code 2), and low-population densities are allocated with high priority (Code 8).

2.5.2.2 Population Growth

The population growth rate is denoted by figure 9. The lowest (negative) population growth rate is observed in Kolkata. A relatively high population growth rate (>16.11) is observed in North Dinajpur, Maldah, Birbhum, Murshidabad, and South-24 Pargana districts. Rest districts are noticed with 0% to 16.11% population growth rates. Population growth rate is classified into 4 classes i.e., <0% (1% area), 0% to 12.59% (25.73% area), 12.60% to 16.11% (48.00% area) and >16.11 % (26.17% area). The potentiality of ecotourism is hampered due to the increasing population growth rate, i.e., the population growth rate is negatively correlated with ecotourism potentiality (Torras, 2019). Here, the population growth rate is reclassified into 4 classes. Following the above rule, the lowest population growth rate is marked with the highest priority (Code 8), and the highest population growth rate is assigned with the lowest priority (Code 2).

2.5.3 Availability of Scenic Beauty and Infrastructures (ASI)

2.5.3.1 Reserved Forests

South-24 Parganas, Darjeeling, Jalpaiguri, Bankura and Purulia districts are noticed with a higher number of reserve forests (>113). Rest districts are noticed with a smaller number of reserved forests (Figure 10). Here, reserved forests (no.s) are classified into 4 classes i.e., <43 (66.91% area), 44 to 112 (15.34% area), 113 to 1483 (11.30% area) and >1484 (6.44% area). The number of reserved forests accelerates the value of ecotourism potentiality (Haque *et al*., 2016; Reza and Hasan, 2019). Here, the number of reserved forests is reclassified into 4 classes and following the above recommendations, the highest class (>1484) is prioritized with higher weightage (Code 8) and vice-versa.

2.5.3.2 Protected Forests

Jalpaiguri, Barddhaman, Bankura, Purulia, West Dinajpur and East Dinajpur districts are noticed with many protected forests (>55). The number of protected forests in South-24-Parganas, Birbhum and Coochbehar districts varies between 8 to 54. Rest districts are identified with a relatively low number of protected forests (Figure 11). Here, the number of protected forests is classified into 4 classes, i.e., <7 (37.53% area), 8 to 54 (15.90% area), 55 to 217 (15.67% area) and >217 (30.91% area). The number of protected forests is positively correlated with ecotourism potentiality (Aryal *et al.*, 2019; Hossain and Wadood, 2020). The number of protected forests is reclassified into 4 groups, and following the above recommendations, those classes are coded with 2, 4, 6 and 8. As the number of protected forests increases, ecotourism potentiality also increases and vice-versa.

2.5.3.3 Unclassified Forests (UCF)

The number of unclassified forests dominates in Coochbehar, Jalpaiguri, Bankura, Barddhaman, Birbhum, West Medinipur and East Medinipur districts (>36). Rest districts are noticed with a smaller number of unclassified forests (Figure 12). Within West Bengal, the number of unclassed state forests varies from 11 to 100 and those are classified into 4 classes i.e., <15 (44.23% area), 16 to 35 (7.27% area), 36 to 97 (32.92% area), and >97 (15.57% area). The unclassified forests create positive vibrations to increase the value of the ecotourism potentiality (Endalew, 2017). Here, the unclassified forests are reclassified into 4 classes (i.e., 2, 4, 6 and 8, respectively). As the class value increases, priority also increases. As a result, tourism potentiality also gets positive vibes.

2.5.3.4 District wise Number of Tourist Destinations

Darjeeling, North-Dinajpur, Maldah, Purulia, Bankura, Barddhaman, Birbhum, Maldah, West Medinipur, East Medinipur, South-24 Parganas and Howrah districts are observed with a higher number of tourist destinations (>6 nos). Jalpaiguri, Coochbehar, South-Dinajpur,

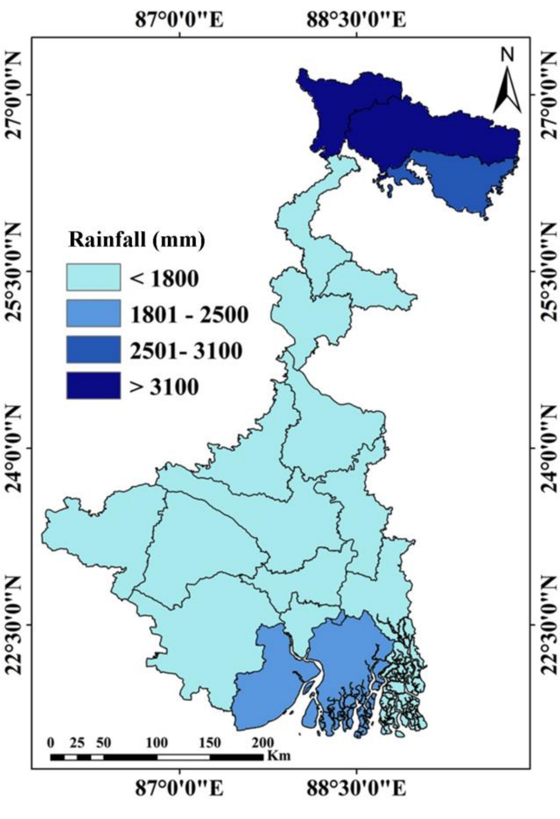

Figure 7. Rainfall

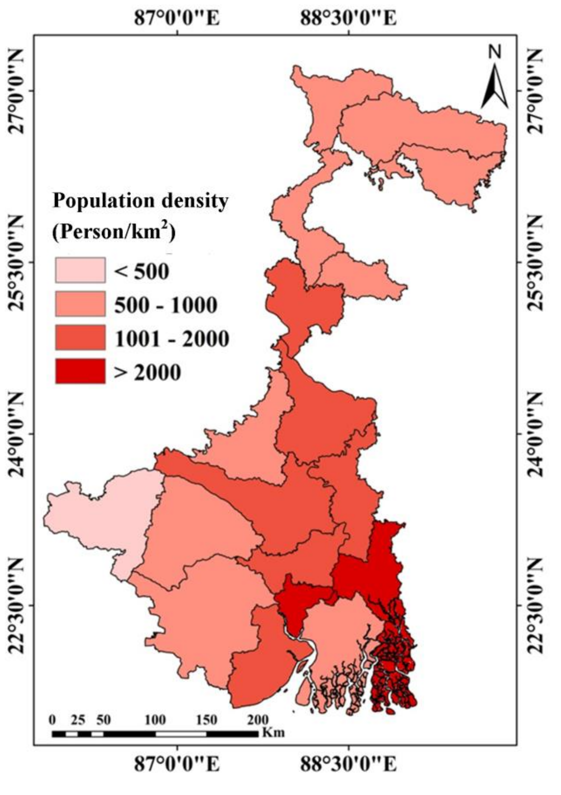

Figure 8. Population density

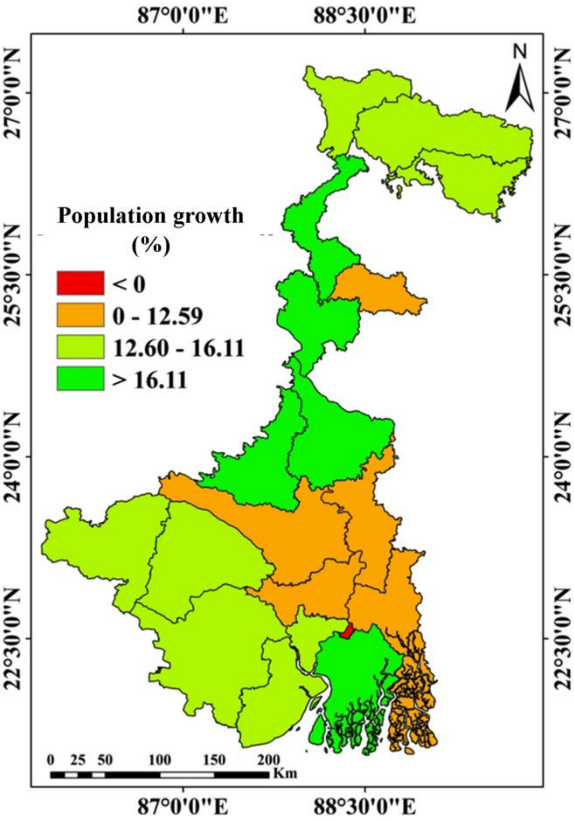

Figure 9. Population growth

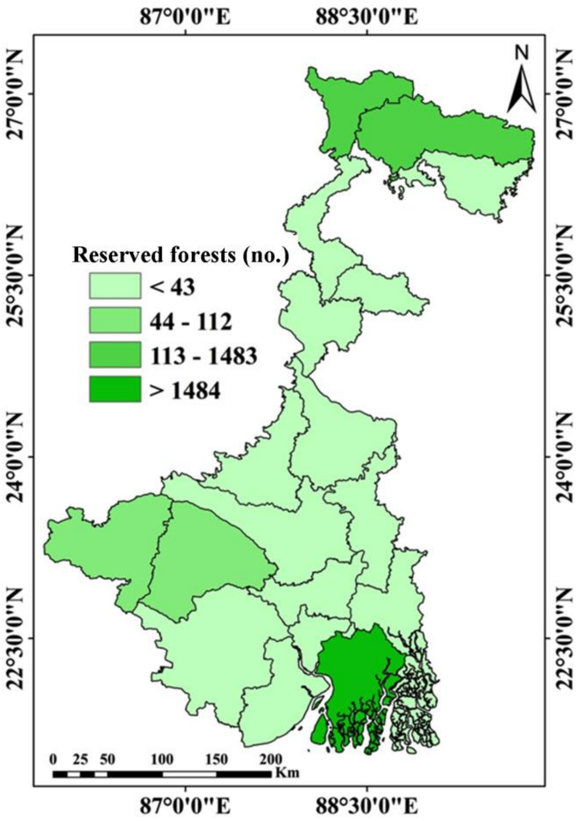

Figure 10. Reserved forests

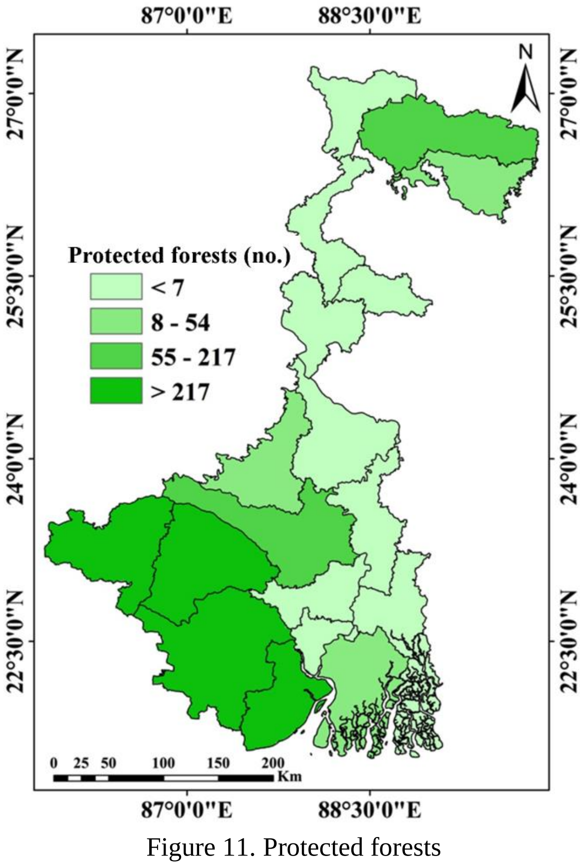

Figure 11. Protected forests

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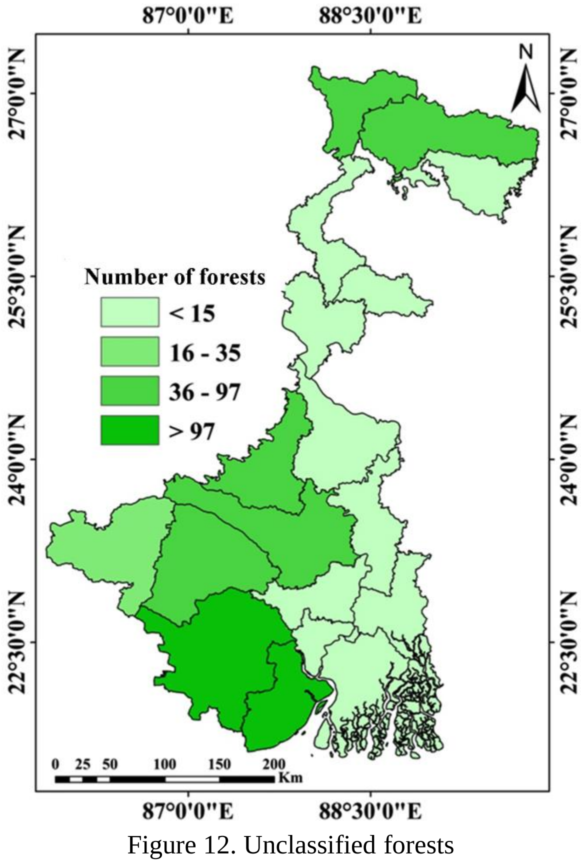

Figure 12. Unclassified forests

Murshidabad, Hooghly, North 24 Parganas and South 24 Parganas are observed with a relatively low number of tourist destinations (<5) (Figure 13). District-wise number of tourist destinations are classified into 4 classes which are <3 (14.14% area), 4 to 5 (16.62% area), 6 to 7 (63.61% area) and >7 (5.62% area). With increasing tourist destinations, ecotourism potentiality is positively oscillated (Meseguer *et al.*, 2021). Here, tourist destinations are reclassified into 4 groups, and following the above suggestion, previously mentioned classes are coded as 2, 4, 6 and 8, respectively.

2.5.3.5 District Wise Average Duration of Stay (days)

Figure 14 represents the district-wise average duration of stay (days). Coochbehar, West Medinipur and Howrah districts are noticed with the highest duration of stay. The average duration of stay varies between 1.13 days to 1.18 days at Birbhum, Nadia, Bankura, Maldah, Darjeeling, North Dinajpur, South-Dinajpur, Murshidabad and South 24-Parganas districts. Purulia, Barddhaman, Hooghly, North-24 Parganas and East Medinipur districts have the lowest duration (less than 1.12 days). Overall, the average duration of stay is classified into 4 categories i.e., <1.12 days (43.62% area), 1.13 days to 1.15 days (31.78% area), 1.16 days to 1.18 days (11.91% area) and >1.18 days (12.68% area). Later, those classes are reclassified into 4 groups with 2, 4, 6 and 8 weightages. The average duration of stay at a particular tourist place is positively related to ecotourism potentiality (Barros and Machado, 2010). Following this rule, weightages are assigned, and as the class value increases, ecotourism potentiality also increases and vice-versa.

2.5.3.6 Number of Accommodation Units

Figure 15 represents the number of accommodation units of West Bengal. Availability of different accommodation units are classified into 4 groups which are <52.83 (42.01% area), 52.84 to 144.17 (34.15% area), 144.18 to 238.58 (9.89% area), >238.58 (13.95% area). The number of accommodation units is high in Darjeeling, East Medinipur, Barddhaman, Hooghly and Howrah districts (>144.18). The number of accommodation units varies from 52.84 to 144.17 at Jalpaiguri, Murshidabad, North-24 Parganas and South 24 Parganas districts. Rest districts (i.e., Bankura, Purulia, West Medinipur, Hooghly, Nadia, North Dinajpur, South Dinajpur and Maldah) are noticed with a relatively smaller number of accommodation units. The number of accommodation units directly relates to tourism potentiality (Souza *et al.*, 2019; Nikoletta and Servidio, 2012). So, the above classes are recoded with

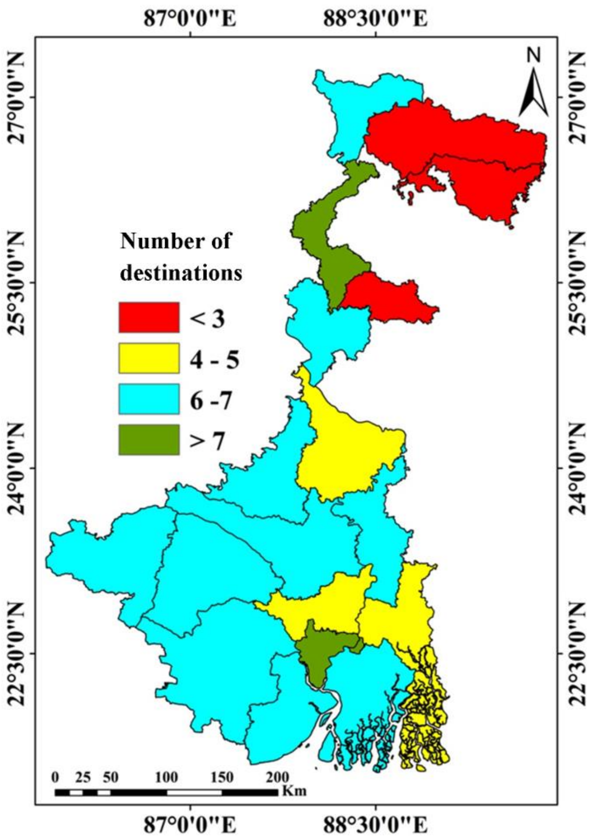

Figure 13. Tourist destinations

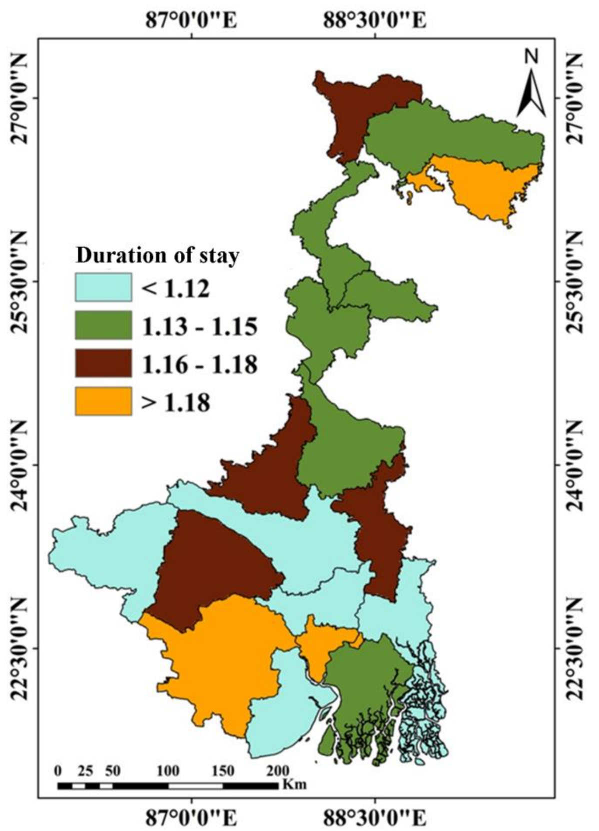

Figure 14. Average durations of stay

1, 3, 5 and 7, respectively, and as the class value increases, priority increases which signifies that the tourism potentiality increases with increasing accommodation units.

2.5.3.7 Occupancy Rate

District-wise occupancy rates (%) are illustrated in figure 16. The lowest occupancy rate is found in Jalpaiguri and Purulia districts. The occupancy rate (%) (>23%) is high in Bankura, Barddhaman, Nadia, North Dinajpur, South Dinajpur, Coochbehar, Hooghly, Howrah, North-24-Parganas and South 24-Parganas districts. Occupancy rates (%) are classified into 4 classes' i.e., <17 (14.73% area), 18 to 22 (33.62% area), 23 to 31 (37.46% area) and >31 (14.17% area). Ecotourism potentiality is positively vibrated by the occupancy rate (%). Following the above recommendation, the occupancy ratio is reclassified and prioritized with different weightages (1,3, 5 and 7, respectively). As the class value increases, priority also increases and vice-versa (Pinho and Marques, 2019; Ranasinghe *et al.*, 2020).

2.5.3.8 Road Densities

The road density map is illustrated in figure 17. Within the West Bengal, road density varies from 0.4 to 316.88 which are classified into 4 classes i.e., <18.96 (80.34% area), 18.97 to 76.61 (16.49% area), 76.62 to 197.70 (2.60% area), greater than 197.71 (0.57% area). Ecotourism potentiality is positively influenced by road densities (Bethapudi, 2013). So, in this research, road density is reclassified into 4 classes (i.e., 2, 4, 6 and 8 respectively), and as the class value increases, ecotourism potentiality also increases and vice-versa.

2.5.3.9 Road Proximity

The road proximity map is illustrated in figure 18. Overall, the road proximity of West Bengal varies from 0 to 0.90. Howrah, Hoogly, Kolkata, Barddhaman, Birbhum, Darjeeling, Jalpaiguri and Coochbehar districts have relatively high road proximity values. With relatively low road proximity values, Purulia, Bankura, East Medinipur, West Medinipur, North and South Dinajpur are identified. Here, road proximity is classified into 4 groups i.e., <0.15 (30.39% area), 0.16 to 0.31 (32.13% area), 0.32 to 0.49 (24.37% area) and >0.49 (13.11% area). Later, it is recoded as 2, 4, 6 and 8 respectively, according to their priorities (Khadaroo and Seetanah, 2008). If road proximity increases, it will be easy for tourists to reach a particular tourist spot. Ecotourism potentiality is enriched positively by road proximity (Ambecha *et al.*, 2020; Khalil, 2017).

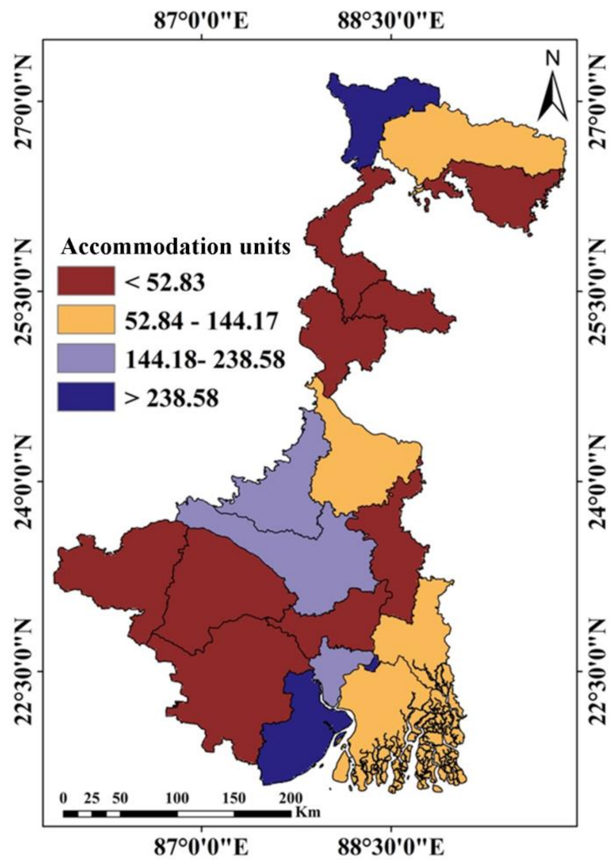

Figure 15. Accommodation units

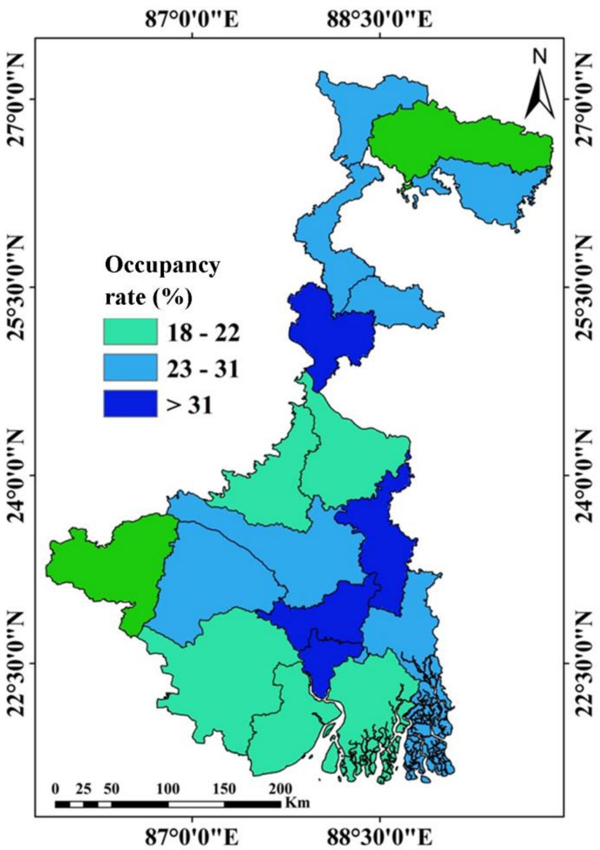

Figure 16. Occupancy rate

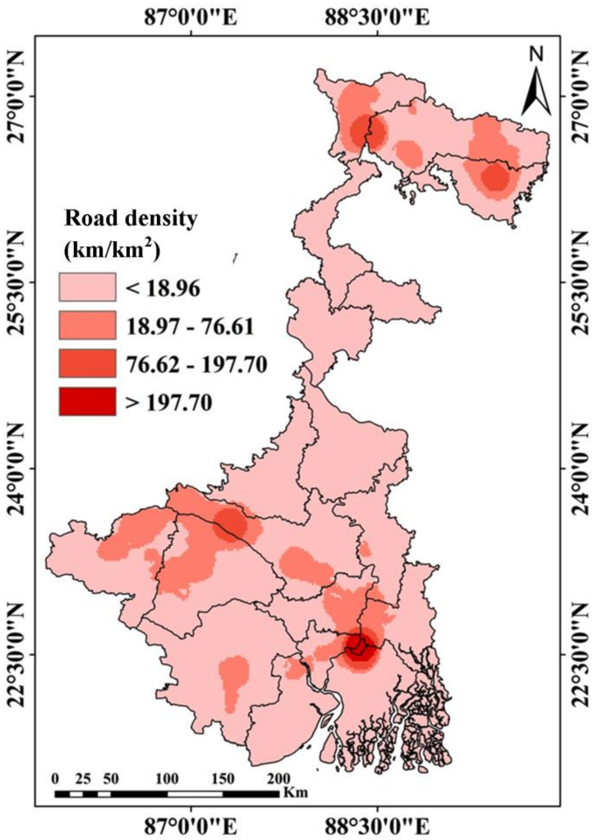

Figure 17. Road density

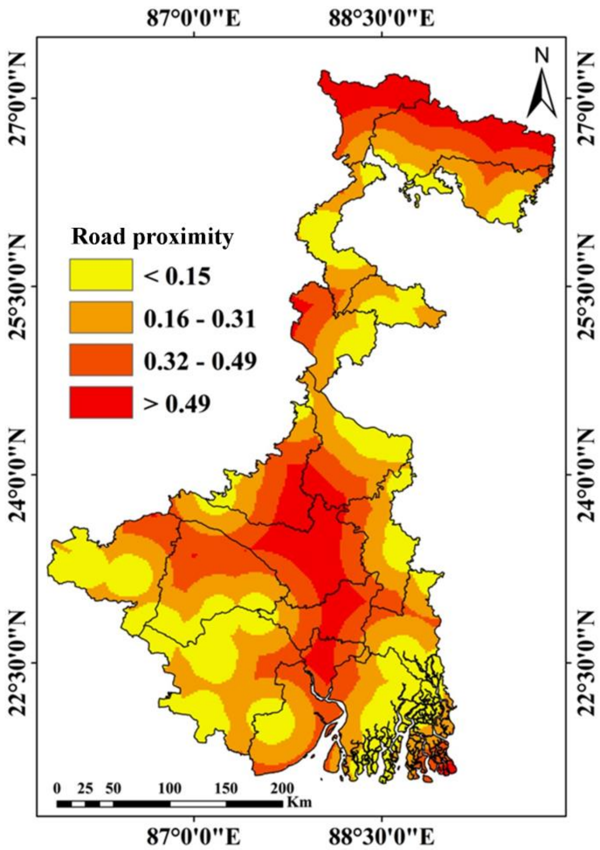

Figure 18. Road proximity

3 ECOTOURISM POTENTIAL ZONES

All the broad variables (i.e., P, E and ASI) are linearly added, and the ETPZs are estimated (Figure 19).

3.1 High Potential Zone

About 61.65% area is identified with high ecotourism potentiality. It is concentrated in Bankura, Purulia, West Medinipur, East Medinipur, Barddhaman, Birbhum, Howrah, South-24 Parganas, Kolkata, Darjeeling and Jalpaiguri districts. The notable features of this section are as follow:

- Darjeeling, Jalpaiguri, Birbhum, Bankura and West Medinipur are observed with moderate slope (> 89 degrees) (Figure 3).
- This section has a moderate relief (Figure 5) (51 m to 1000 m relief) value and a high aspect (>181 degrees) value (Figure 4).
- This region has a high drainage density (>8.05 km/km^2) (Figure 6).
- Population density (<500 persons/sq km.) (figure 8) and population growth rate (<12.59 %) (figure 9) are relatively less in these sections of the study region.
- This section is having a relatively high number of reserved forests (>113 no.s) (Figure 10), a relatively high number of protected forests (>55 no.s) (Figure 11), a relatively high number of unclassed state forests and others (>36 no.s) (Figure 12).
- The average duration of stay (>1.13 days) (Figure 14) is relatively high in these portions.
- A high number of accommodation units (>52 days) (Figure 15) are observed in these portions of the study region.
- Similarly, these sections experience higher occupancy ratios (Figure 16) (>18), higher road densities (Figure 17) (>19) and higher road proximities (Figure 18) (>0.32).
- As a combination of the above scenarios, the 100% area of Bankura, Birbhum, Darjeeling, East Medinipur, Howrah, Kolkata and South-24 Parganas, 94% area of Jalpaiguri, 86% area of Barddhaman and 94% area of West Medinipur are identified with high ecotourism potential zone (Figure 19).

Apart from the above factors, these portions (except Kolkata, Howrah and South-24 Parganas) are also less affected by urbanization (Som and Mishra, 2014; Guin and Das, 2015) and environmental pollution (Ghosh, 2009). On the other hand, Kolkata, Howrah, and South-24 Pargana have relatively flat terrain and possess a high number of tourist spots. Another notable fact in this section is the existence of Mangrove Forests. Densities of Mangrove (Reserved forests and protected forests) help increase the ecotourism potentiality values in these portions (Rahman, 2010).

3.2 Moderate Potential Zone

17.86% area is observed under the moderate ecotourism potentiality. North Dinajpur, Maldah, Murshidabad, Nadia, Barddhaman, and Purulia are spotted with moderate ecotourism potentiality. Features of these portions are revealed as follow:

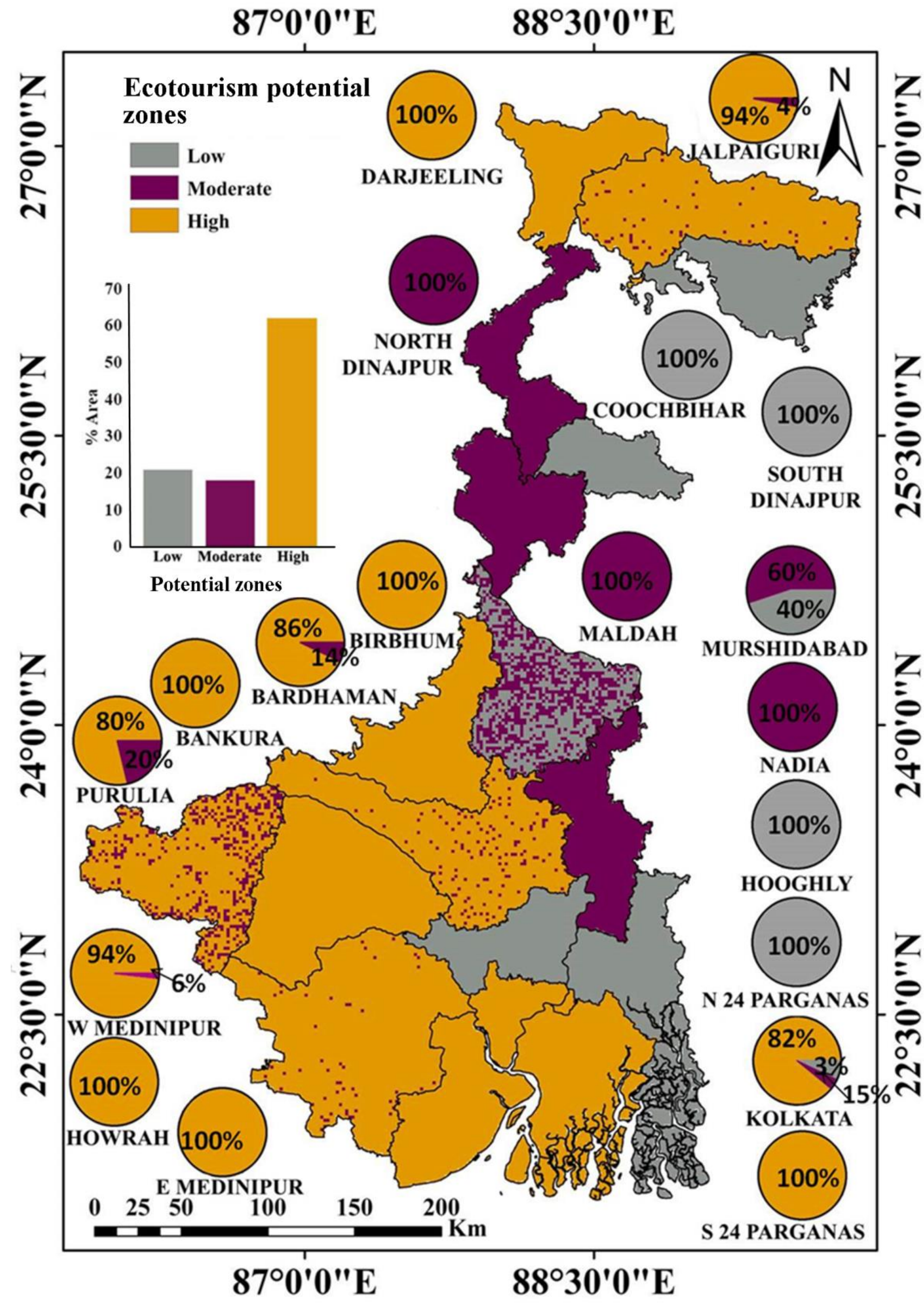

Figure 19. Ecotourism Potentiality Zones

- North Dinajpur, Maldah, Murshidabad, Nadia, Barddhaman and Purulia are located in flat terrain (Figure 5) and moderate aspect (90-180) (Figure 4).
- These portions also have a moderate to low slope (Figure 3), low rainfall (Figure 7) and low drainage density (Figure 6).
- Population densities (Figure 8) in these portions vary from 500 to 1000 persons/sq km. Population growth rates (Figure 9) in these sections range from 1 to 12.59%.
- The number of reserved forests (Figure 10), protected forests (Figure 11) and unclassified forests are also minimum (figure 12) in these portions of the study region.
- Except for North Dinajpur, the rest portions are observed with 3 to 5 destinations (Figure 13).
- The average duration of stay (figure 14) in these portions is 1.13 to 1.15 days which is moderate in nature.
- The number of accommodation units (Figure 15) in these portions varies from 52.84 to 144.17.
- The occupancy rates (Figure 16) are also moderate in these sections of the study region (18 to 31%).
- Road densities (Figure 17) are low (<18.96 km./ km^2) but proximity to road (Figure 18) is moderate (0.16 to 0.31) in these portions.
- With a combination of the above factors, 100% area of North Dinajpur, Maldah, Nadia, 4% area of Jalpaiguri, 14% area of Barddhaman, 20% area of Purulia and 60% area of Murshidabad are noticed with moderate green tourism potentialities (Figure 19).

Apart from the other features, these portions are noticed with several historical monuments and palaces set in a conventional natural setting that increases the value of ecotourism (Krakauer, 2014). However, these portions also face some adversities, including low rainfall (mm.), relatively high population densities, and population growth rates (West, 2014). These portions are highly enriched by traditional art and crafts (Sinha, 2017) help to stimulate the ecotourism potentialities in these portions.

3.3 Low Potential Zone

20.48% area of the GWB is recognized as the low ecotourism potentiality. Coochbehar, South-Dinajpur, Hooghly, Murshidabad and North-24 Parganas districts are identified with low ecotourism potentially. Characteristics of low ecotourism potential zone are exhibited as follows:

- Relatively flat relief with low slope (<89.80 degree) (Figure 3), low aspect value (<180) (Figure 4), flat terrain (Figure 5) and drainage density (<8.05) (Figure 6) are noticed in these portions of the study region
- Except for the Coochbehar district, this section is seen with small amount rainfall (<1800mm.) (Figure 7).
- A relatively low number of reserved forests (<43 no.) (Figure 10), protected forests (<8) (Figure 11), and unclassified forests (<16) (Figure 12) are noticed in these portions of the study region.
- Population density (>500 persons/km^2) (Figure 8) and population growth rate (>12 %) (Figure 9) are also generally high in this section which generally discarded the ecotourism potentiality.
- District-wise number of tourist destinations is also less in these portions (Figure 13).
- Except for Coochbehar, this section has a low average duration of stay (1.13 to 1.15 days) (Figure 14).
- This section is also noticed with a relatively small number of accommodation units (<52.83) (Figure 15).
- Occupancy rates are moderate (18-31) in these sections (Figure 16).
- Road densities in this section is also very low (<18.96) (Figure 17).
- Road proximities in this section are also low (<0.31) (Figure 18).
- Ultimately, with the help of above combinations, 100% area of Coochbehar, South-Dinajpur, Hooghly, North-24 Parganas and another 40% area of Murshidabad district is noticed with low ecotourism potentiality (Figure 19).

These portions are severely affected by urbanization (Som and Mishra, 2014; Guin and Das, 2015) and environmental pollution (Ghosh, 2009). According to Dutta and Gupta (2021), South-Dinajpur, Hooghly, Murshidabad and North-24 Parganas districts are the hotspot of high-level air pollution. Using the WRF-CHEM model, the authors have discovered an increase in air temperature of 0.80 to 1.20 ºC in this tract. Eight distinct land use classes primarily dominate in these sections of West Bengal, and pollution sources range from industrial emissions to domestic pollution and the burning of biomasses (Sudha *et al.*, 2003; Dutta and Gupta, 2021). Thereafter, considering the above perspectives, it can be asserted that the above findings are justified and acceptable.

4 CONCLUSION

In summary, Analytic Hierarchy Process (AHP) and weighted linear algorithms are utilized to restrict the ecotourism potentiality zone in space by considering 3 sustainable tourism parameters and 16 indicators. Those three parameters are physical (P), social (S) and availability of scenic beauty and infrastructures (ASI). Relief, slope, aspect, drainage density and rainfall are merged under physical (P), population density and population growth rate are integrated under social (S), and the total number of reserved forests, protected forests, unclassified forests, tourist spots, accommodation units, the average duration of stay, occupancy rates, road density and road proximity are incorporated under availability of scenic beauty and infrastructures (ASI). A 4-step procedure has been followed to do the research. At the first step, a simple hierarchical structure has been outlined, in the second step, pair-wise comparison matrices are formed; at the third stage, weighted linear algorithm technique is utilized to get the ecotourism potentiality zone, and at the last stage, ecotourism potentiality map is classified into high, moderate and low categories by following the principle of Dominant and Distinctive Function (DDF). As a result, about 61.65% area is marked with the high ecotourism potentiality, 17.86% area is observed with the moderate ecotourism potentiality, and 20.48% area is identified as the low ecotourism potentiality.

This study presents an integrated approach to denote the ETPZs in space. Moreover, it helps to develop a suitable methodology for potential ecotourism zone analysis. Thus, the study can be a helpful tool for planners and decision-makers to strategize local level planning procedures to develop the ecotourism in West Bengal. Further, the research can be extended through the inclusion perceptions of local people about the ecotourism.

ACKNOWLEDGMENTS

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ABBREVIATIONS

ADS: Average Duration of Stay; **AS**: Aspect; **ASI**: Availability of Scenic Beauty and Infrastructures; **DD**: Drainage Density; **OR**: Occupancy Rate; **P**: Physical; **PD**: Population Density; **PF**: Protected Forest; **PGR**: Population Growth Rate; **PR**: Precipitation; **RD**: Road Density; **RF**: Reserved Forest; **RL**: Relief; **RP**: Road Proximity; **S**: Social; **SL**: Slope; **UCF**: Unclassified Forests.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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