Journal of Geographical Studies
Homepage: www.gathacognition.com/journal/gcj5
http://dx.doi.org/10.21523/gcj5

Original Research Paper

Detection and Delineation of Potential Areas for Tourism Activities in Coastal Zone of Ratnagiri District, Maharashtra (India)

Sanjay B. Navale[1*], Vijay S. Bhagat[2]

1. Department of Geography, S. N. Arts, D.J.M. Commerce and B.N.S. Science College, Sangamner- 422605, District- Ahmednagar, Maharashtra (India).
2. Post-graduate Research Centre in Geography, Agasti Arts, Commerce and Dadasaheb Rupwate Science College, Akole- 422601, District- Ahmednagar, Maharashtra (India).

Abstract

Tourism is a device of economic development in developed, developing, and even in underdeveloped countries. The AHP based MCDA techniques used for detection and delineation of the tourism potential zones in the coastal area of Ratnagiri district in Maharashtra (India). The conventional and satellite data viz. ASTER data has been used for spatial analysis in GIS software. Seacoast, elevation, slope, river, LULC, available amenities, accessibility and connectivity, cultural and historical places, and density of settlements used as the criterions for detection of potential zones for tourism activities. The experts' opinions, literature survey and fieldwork used as the source of information for the selection of criterions and determination of ranks. The weighted overlay technique used to find the comparative levels of tourism potentials: very high, high, moderate and less potentials for tourism. About 13% of TGA shows comparatively very high tourism potential, 25.80% shows high, 54.62 % shows moderate, and 6.57 % shows less tourism potential. The overall accuracy of the categorized map estimated about 89.60%. The thematic maps viz. amenities and settlement were processed using inverse distance weighted (IWD) interpolation technique. Therefore, some areas from the category, 'high potential' merged in the category, 'moderate potential' and reduced the producer's accuracy of the classified map. The sandy beaches, lowland area with a gentle slope, river landscape features, road network, cultural and historical places, ideal size of settlements and number of amenities are attractions of tourists in the region. The technique used in this study can be an effective apparatus for precise analysis of site suitability for tourism activities.

Article History

Received: 29 November 2021
Revised: 25 December 2021
Accepted: 26 December 2021

Keywords

Analytic Hierarchy Process;
AHP;
Coastal Area;
Tourism;
Tourism Potential Area;
Inverse Distance Weighted;
Weighted Overlay.

Editor(s)

M. A. Siddiqui

1 INTRODUCTION

Tourism is a device of economic development in developed, developing, and even in underdeveloped countries (Gupta and Dutta, 2017). The share of tourism activities and service sector in GDP of India was 6.7% in 2018 (WTTC, 2019) and the tourism industry contributed 1.7 trillion USD to GDP of the world in 2019 (WTO, 2019). Tourism activities support the economy of any country, significantly assisting the people (Rio and Nunes, 2012; Botero *et al*., 2014; Garcia and Fernandez, 2018) and playing a significant role in the development of the rural economy (Bel *et al*., 2014). Tourism activities are a significant tool for economic development for providing many opportunities including: 1) employment to local youth in the field of medical tourism, tourism markets, etc., and 2) income from a small businesses like hotels, resorts, stores as well as payments from leased lands, etc., (Rabbany *et al*., 2013; Hughes and Scheyvens, 2018; Fadafan *et al*., 2018; Mazzola *et al*., 2019; Thama, 2019; Yuwono *et al*., 2021). This helps to improve the standard of living of local people and increase the revenue to the local self-governments, etc. This is a unique vital activity for continuous change in culture,

* Author's address for correspondence
Department of Geography, S. N. Arts, D.J.M. Commerce and B.N.S. Science College, Sangamner- 422605, District- Ahmednagar, Maharashtra (India).
Tel.: +91 9960101456
Emails: navalesanju1979@gmail.com (*S. Navale* -Corresponding author); kalpvij@gmail.com (*V. Bhagat*).

https://doi.org/10.21523/gcj5.21050203

healthy lifestyle, the wellbeing of human society (Pope, 2018; Damijanic, 2019). This industry supports and promotes agronomy and local handmade production in rural areas (Nooripoor *et al*., 2020).

Marine and coastal tourism are one of the significant fast-growing largest industrial sectors across the world (Hall, 2001; WTO, 2001; Phillips and House, 2009; Chen, 2010; Williams and Khattab, 2015; Chen and Bau, 2016; Nunes *et al*., 2020). Beaches at coastal lines are significant assets for tourism, create prospective appreciated financial assistance to a visitor and most important tourist destinations (Botero *et al*., 2014; Stanchev *et al*., 2015; Chen and Bau, 2016). In the coastal area, tourists' attraction points are sandy beaches, landscape features, rocky platforms, cliffs, mangrove forests, lagoons, caves, sea water, marine biodiversity, cultural and historical places with scenic beauty (Stanchev *et al*., 2015; Cletus and Okpoko., 2015; Semeoshenkova *et al*., 2016). However, the negative influences of the rapidly growing coastal tourists' activities on the coastal environment observed across the world (Klein *et al*., 2004; Roca *et al*., 2009). Therefore, the scholars like Lemos *et al*. (2011), and Thakur *et al*. (2020) have recommended the strategic environmental assessment (SEA) of tourism activities since 1990 to solve the problems related to the degradation of the coastal environment and to motivate the tourism activities. The sustainability analysis is important for assessments for planning and monitoring the tourism in any region (Lacitignola *et al*., 2007; Mikuli *et al*., 2015). Therefore, the detection and delineation of potential sites for coastal tourism are helpful for the planning, management, and development of tourism in the coastal regions (Liaghat *et al*., 2013; Wanyonyi *et al*., 2016; Batman, 2019; Ronizi *et al*., 2020).

Fennell and Ebert (2004), Kumara and Hussain (2014) and Raha *et al*. (2021) have been reported the usefulness of statistical techniques and methods with the precise logical ground for analysis of different services including transportation, communication, tourism, etc. Many scholars like Saaty (1977), Wind and Saaty (1980), Saaty (1983), Saaty (1990), Bunruamkaew and Murayama (2011), Taylor and Hoffman (2014), Zolekar and Bhagat (2015), Wanyonyi *et al*. (2016), Ghamgosar *et al*. (2016), Gumusay *et al*. (2016), Lin and Pussella (2017), Gaikwad and Bhagat (2017), Gaikwad and Bhagat (2018), Hoang *et al*. (2018), Fadafan *et al*. (2018), Serio *et al*. (2018), Sahani (2019), Yun *et al*. (2019), Zabihia *et al*. (2020), Mansour *et al*. (2020), Guerrero *et al*. (2020), Yuwono *et al*. (2021) and Raha *et al*. (2021) have used Analytic Hierarchy Process (AHP) techniques for detection of suitable and potential sites for agriculture, watershed management, tourism, etc. The AHP technique is useful for the analysis of land suitability and ecological carrying capacity of the land for the identification of potential areas for tourism (Ebrahimi *et al*., 2019; Mansour *et al*., 2020) especially for ecotourism (Bunruamkaew and Murayama, 2011) in coastal zones (Liaghat *et al*., 2013; Pourebrahim *et al*., 2014; Chen and Bau, 2016; Hoang *et al*., 2018). The researchers have reported the limitations of the AHP technique for precise identification of potential sites for tourism based on different criterions, variation in definition of sub-criterions and assigned weightages and unavailability of firsthand socioeconomic data (Murali *et al*., 2013; Brilha, 2016; Rocha *et al*., 2020; Guerrero *et al*., 2020; Mooser *et al*., 2021). Therefore, the present study performed based on criterions selected and reclassified sub-criterions using information gathered through wide literature review and fieldwork for application of AHP based multi-criteria decision techniques for precise identification and delineation of potential areas for tourism activities in coastal area. This study focused on land suitability analysis for tourism activities in the coastal zone of Ratnagiri district using the AHP and weighted overlay techniques in Geographical Information System (GIS). Spatial information about multiple criterions including seacoast, elevation, slope, river, land use land cover (LULC), significant cultural and historical places, number of amenities, the density of settlements, accessibility, and connectivity used in the decision-making process (Hoang *et al*., 2018; Mansour *et al*., 2020). The results of the study will be helpful for planning and monitoring the tourism activities in the region. The techniques and methods used in the study can be useful for detection and delineation of potential areas for tourism activities in different environmental conditions globally.

2 STUDY AREA

The coastal zone of Ratnagiri district (2989 km^2) is the part of western Maharashtra along the Arabian Sea extended between 16º 29′ 32″ and 18º 01′ 16″N and 73º 01′43″ and 73º 31′ 24″E (Figure 1). This is a narrow strip with 10-15km width and nearly 173 km north-south length with distribution of about 85% TGA in Sahyadri hills. All rivers are originating in the Sahyadri ranges at the East of the region and flow towards the Arabian Sea at the West. Vasishthi is the most important river flowing through Guhagar, Dapoli, Chiplun, and Ratnagiri tahsils. Temperature ranges from 25 to 34ºC with an average of 31.3ºC and annual variations from 25.1ºC in January and 28.8ºC in May. The average rainfall is 3118 mm with maxima in Mandangad tahsil (3500mm) located in Sayhadri ranges. However, the rainfall along the coastline is between 2500 to 3200mm. The yellowish-red soils are suitable for the mango plantation observed in the region. Alluvial soils are observed in the foothill zones near to the coastline and useful for the coconut plantation. The fishery is one of the major occupations of the people in the region. The total population is 679862 (2011) with 318702 males and 361160 females. The population density is 230 person/km^2 (2011) with 71.35% literacy. The sex ratio (1133 females / 1000 males) (2011) is significantly more compared to the state of Maharashtra (922 females/1000 males). The working population is 72.86% with marginal works (26.65%) and a total working population (46.54%). The linear type settlements observed in the region. The Marathi and

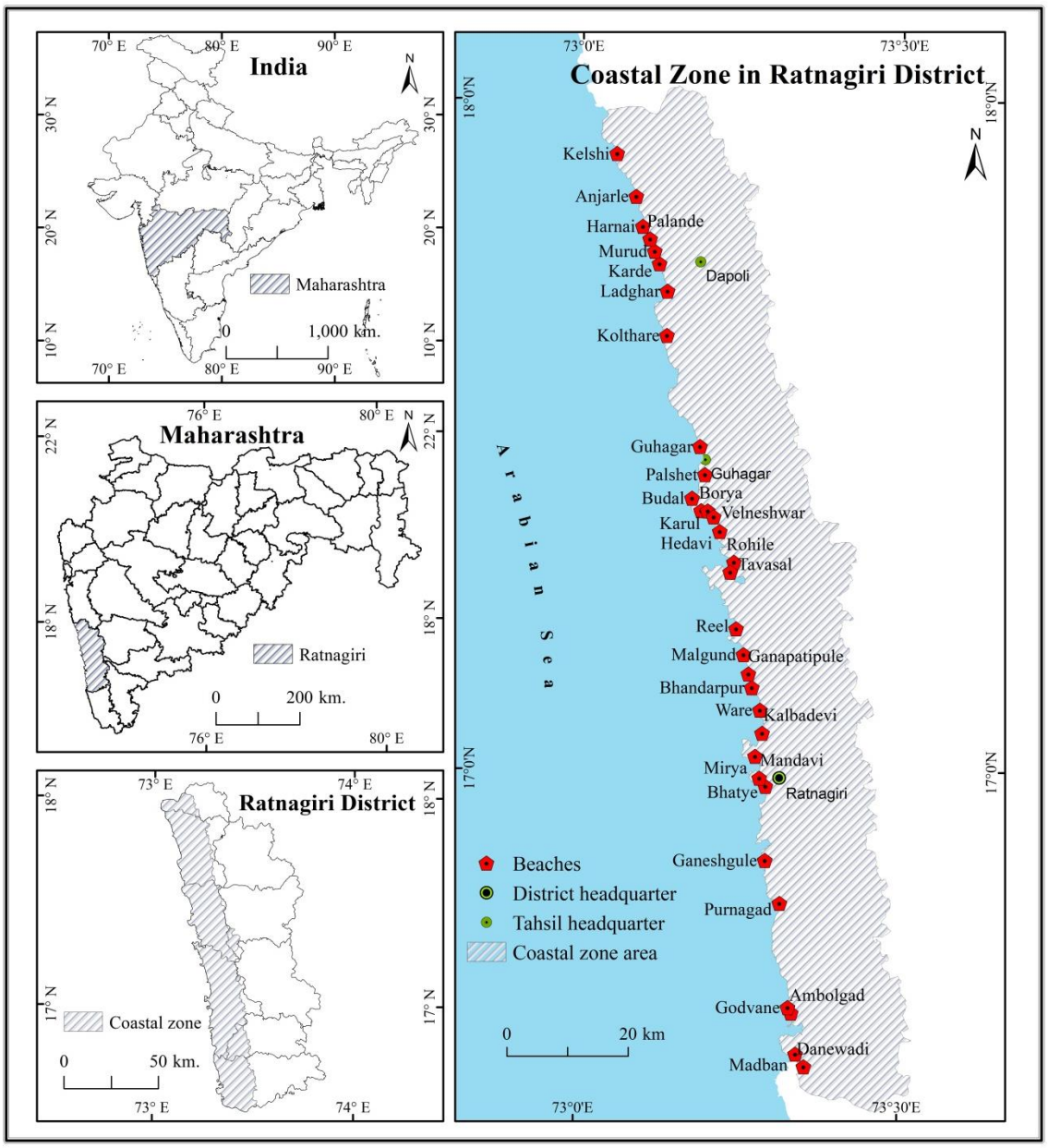

Figure 1. Study area: Coastal zone in Ratnagiri district, Maharashtra (India)

Kokani are the main spoken languages. The morphological features like beaches (Ganpatipule, Kelshi, Anjarle, Are Ware, Malgund, Madhaban, Guhagarh, Velas, Hedvi, Ambolgarh, etc.), cliffs (Kolthare, Velneshwar, Jaygad), headlands, creeks (Kalbadevi Creek, Bhatye Creek, Purnagad Creek, Rajapur Creek, etc.) are the main attraction of tourists. The tourists are mostly visiting some of the cultural and historical places viz. Ganpatipule, Lokmany Smark, Keshvsut Samrk, Dashbhuj Ganpati, Fort, Jetty, Kuda Buddhist Cave, etc. Some institutes including Konkan Krishi Vidyapeeth, Coconut Research Center, Marine Aquarium, and Museum are also visiting places of academicians. Some tourists are visiting the region in the season of Ganpati festival, Holi festival, Turtle festival, Katal Shilpa festival, Anjarle festival, Alphonso mangoes festival, etc.

3 METHODOLOGY

AHP base multi-criteria analysis performed for detection and delineation of potential areas for tourism in the coastal zone of Ratnagiri district. The physiographic and sociocultural criterions selected for the analysis of potential areas. The study processed through seven steps: 1) selection criteria, 2) ranking, 3) pairwise comparison, 4) calculation of weights, 5) determination of scores, 6) weighted overlay analysis, and 7) accuracy assessment.

3.1 Data

The topographic maps (1:50000) procured from Survey of India (SOI) (Hedge and Reju, 2007) and used to prepare the maps showing river network, seacoast, accessibility and connectivity, cultural and historical places, and density of settlements for determination of site suitability for tourism. Census data (Census, 2011) used to represent the number of amenities for the identification of areas with tourism potentials. The ASTER DEM (30m) data used to prepare the elevation and slope maps. The Landsat-8 ETM+ data at 30m resolution (path 147 and row 48) data used to identify the LULC analysis. This data has been widely used for detection of the potential areas for coastal tourism, eco-tourism, agriculture, irrigation, watershed management, built-up area, etc. (Murali *et al*., 2013; Jayappa *et al*., 2014; Zolekar and Bhagat, 2015; Thakur *et al*., 2020) (Figure 2 and Table 1). This satellite data was acquired on 14th February 2019 in a cloud-free situation and downloaded from USGS GloVis website for the preparation of LULC map. GPS [Global Positioning System] was used for identification of sites for sample survey during the field visits arranged to collect the ground truth data about LULC, cultural and historical places, beach sites and locations, lagoons, creeks, stream, landscape features, sites aerial view, etc. All geospatial data was loaded and processed in Arc GIS (10.2), Global Mapper (13), and ERDAS 9.2 software [Earth Resource Development Application System].

3.2 Multi-Criteria Analysis (MCA)

The present study was used multi-criteria decision-making (MCDM) techniques i.e. AHP (Analytical Hierarchy Process), GIS (Geographical Information System), and Experts' opinions to detection of potential area for tourism in a coastal zone (Liaghat *et al*., 2013; Ebrahimi *et al*., 2019). The MCDM technique is a significant tool for identifying the potential sites for the planning and management of tourism (Bunruamkaew and Murayam, 2011; Mansour *et al*. 2020; Ronizi *et al*., 2020). This is a simple but definite learning composite phenomenon to improve the design of methods (Kiani *et al*., 2019) to provide a convenient and equitable manner to achieve the specific objective of the study (Raha *et al*., 2021). MCDM requires an arrangement of several fundamental procedures e.g. ranking, pairwise comparison, calculation of weights, determination of scores, weighted overlay analysis, and accuracy assessment with an evaluation of criteria maps. The combinations and influence of criteria in the detection of suitable sites for tourism activities based on appropriate decision-making variables facilitate the selection process of these sites for tourism development (Ghamgosar *et al*., 2016; Fadafan *et al*., 2018). The integrated ranking and scaling procedures performed for selected criteria are useful for the qualitative and measurable spatial attributes for the site suitability analysis for tourism (Mamun and Mitra, 2012; Bagdanaviciute, 2018). This technique is precisely

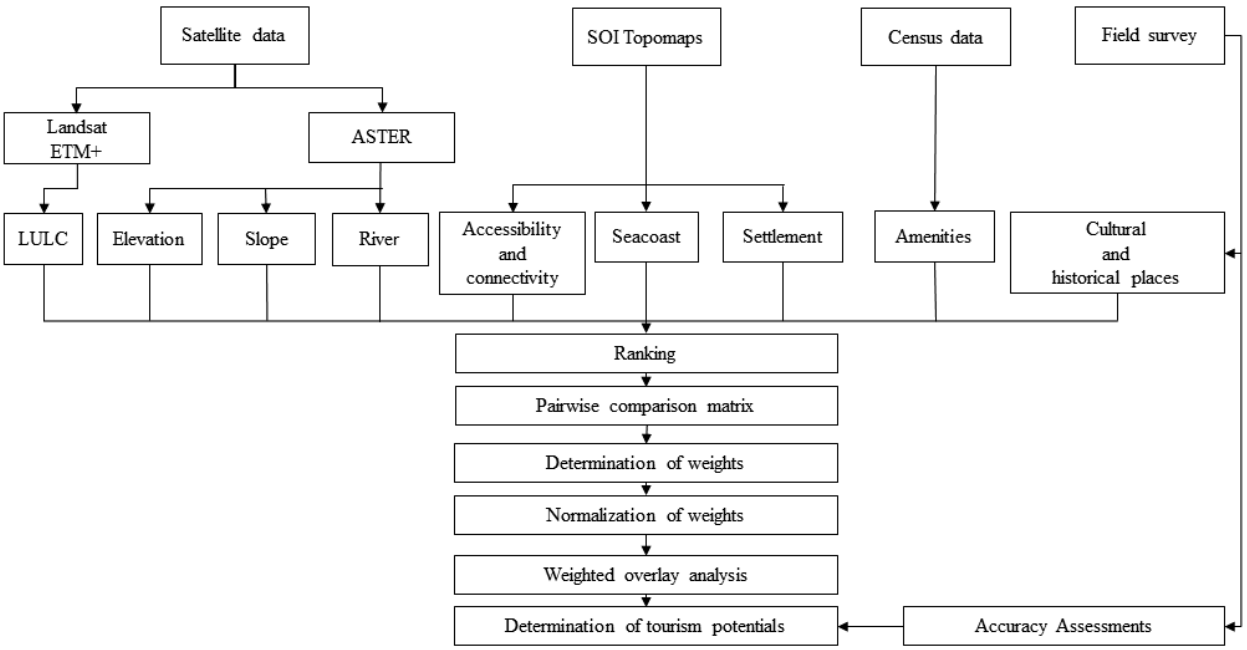

Figure 2. Methodology

applicable to determine the weights of selected criterions useful to identify potential sites of tourism (Sahani, 2019). Carrillo and Jorge (2017) have used this technique for the construction of composite indicators, either to determine the weights of criteria (Carrillo and Jorge, 2017). Therefore, MCDM technique was used for site suitability analysis for tourism in the coastal zone of Ratnagiri District.

The selection of criterions for multi-criteria analysis for detection of potential sites for tourism performed based on review of published research (Table 2) on the coastal tourism. The scholars have been used different criterions for detection and delineation potential sites for tourism including seacoast, elevation, slope, river, LULC, cultural and historical attraction, accessibility and connectivity, size of settlements, viability of services and amenities, etc.

Table 1. Sources of spatial datasets

Criterions	Data source	Spatial resolution
Seacoast	GPS data, SOI Topo-maps	1:50000
Elevation	ASTER data	30 m
Slope	ASTER data	30 m
River	ASTER data	30 m
LULC	Satellite image	30 m
Accessibility and connectivity	SOI Topo-maps	1:50000
Settlement	SOI Topo-maps	1:50000
Amenities	Census data (2011)	
Cultural and historical places	The filed survey, GPS data	

Table 2. Comparative weighted classes

Criterions	Comparative weighted classes				Authors
	Low (1)	Moderate (2)	High (3)	Very high (4)	
Seacoast	High hard rock cliff	Estuaries/ lagoons	Muddy	Sandy coasts	Lin and Pussella, 2017
	Mud	Coarse	Medium sand	Fine sand	Silva *et al*., 2013
Cultural and historical attraction	Local	Regional	National	International	Pralong and Reynard, 2005
	Inter local (2-1)	Interprovincial (4-3)	Nationwide (5-7)	International (8-10)	You-jun and Zheng-xin, 2009
	Province-wide attractive (1)	Region-wide attractive (4)	Nation-wide attractive (7)	World-wide attractive (10)	Hoang *et al*., 2018
	Site located less than 20 km from a recreational area or tourist attraction	Site located less than 15km from a recreational area or tourist attraction	Site located less than 10 km from a recreational area or tourist attraction	Site located less than 5km from a recreational area or tourist attraction	Brilha, 2016
Elevation (m)	< 550 m	550-650 m	650-750	> 750	Guerrero *et al*., 2020
	>6	> 3- <6	> 0 - < 3	< 0	Murali *et al*., 2013
	Low	Moderate	High	Very high	Pralong and Reynard, 2005
	5-30 m (Cliff)	31-60m (Cliff)	61-90m (Cliff)	>90m (Cliff)	Anfuso *et al*., 2017; Mooser *et al*., 2021
	0-100m	> 400m	100-300m	300-400m	Bunruamkaew *et al*., 2011

	Low elevation	Moderate elevation	High elevation	Very high elevation	Ambecha *et al*., 2020
	< 100m	> 400m	100 - 300m	300 - 400m	Wanyonyi *et al*., 2016
	1400-1500m	1501-2300m	2301-3200m	3200-3680m	Asmamaw and Gidey, 2018
Slope	25-35%	15-25%	3-15%	0-3 %	Guerrero *et al*., 2020
	Very steep (>20º)	Slightly high steep (5º - 20º)	Moderate steep (2º-5º)	Low steep (<2º)	Silva *et al*., 2013
	< 5º (Beach face)	5º -10º (Beach face)	10º -20º (Beach face)	20º -45º (Beach face)	Anfuso *et al*., 2017
	> 1º	> 0.2º - < 1º	> 0.1º - < 0.2º	> 0º - 0. º <	Murali *et al*., 2013
	> 35º	25º -35º	5º -25º	0º -5º	Bunruamkaew *et al*.,2011
	1-2(%)	0.5-1(%)	0.1-0.5(%)	<0.1(%)	Lin and Pussella, 2017
	Gentle Slope	Moderate slope	Steep slope	Highest Steep slope	Ambecha *et al*., 2020
	35%	25%	0-25%	0-5%	Wanyonyi *et al*., 2016
	>35º	25º-35º	5º-25º	0º-5º	Asmamaw and Gidey, 2018
Distance from River	> 6km	6km	3km	1km	Ambecha *et al*., 2020
	150-200 m	100-150 m	50-100 m	< 50 m	Rocha *et al*., 2020
Land use land cover (LULC)	Agriculture, Forestry, urban, Non vegetated area	Pasture	Grassland	Forest, Carredo, water	Guerrero *et al*., 2020
	Built-up area	Open grassland and shrub land , cultivated land	Closed grassland	Lake and dense forest	Asmamaw and Gidey, 2018
	Coastal sand	Forest	Agriculture	Urban and industrial infrastructures	Rocha *et al*., 2020
	Barren land	Vegetated land	Agriculture / Fallow land	Urban, ecological sensitive region	Murali *et al*., 2013
	Not suit	Marginal	Moderate	High	Bunruamkaew *et al*., 2011
	Meadowland, sparsely brushwood (1-3)	Only brushwood, meadowland (3-4)	Lonely greenwood, meadowland (5-7)	Greenwood, brushwood, meadowland (7-8)	Cetin *et al*., 2018
	Forest	Shrubs	Agriculture/ marshy land	Built-up	Lin and Pussella , 2017
	Urban	Bare land	Vegetated area	Forested area	Wanyonyi *et al*., 2016
Accessibility and connectivity	1500m	750-1500m	350-750m	< 350m	Guerrero *et al*., 2020
	2km buffer	1km buffer	500m buffer	250m buffer	Murali *et al*., 2013
	Less than 50m	between 50 and	between 200 and	more than 500m	Pralong and

		200 m	500m		Reynard,2005
	Less than 1km of track	By a local road	By a road of regional importance	By a road of national importance	Pralong and Reynard, 2005
	No buffer zone/ heavy traffic	No buffer zone/ light traffic	Parking lot visible from coastal area	Parking lot not visible from coastal area	Anfuso *et al*., 2017
	>60 km (1)	>40-60 km (4)	20-40 km (7)	<20 km (10)	Hoang *et al*., 2018
	Less than 1km from a road accessible by bus	Site accessible by bus but through a gravel road	Less than 500 m from a paved road	Less than 100 m from a paved road and with bus parking	Brilha, 2016
	> 45km (Accessibility)	30-45km (Accessibility)	15-30km (Accessibility)	0-15km (Accessibility)	Bunruamkaew *et al*., 2011
	Areas within 10 km buffer around major roads	Areas within 5 km buffer around second main roads	Areas within 2 km buffer around third main roads	Areas outside of any buffers around all roads	
	Cableway, railway, ferryboats, balloon, airplane, parachute, etc.	Vehicle availability at specific hours	Vehicle availability	Walking distance	Cetin *et al*., 2018
	>6km	6km	3km	1km	Ambecha *et al*., 2020
	>30km (Cultural sites)	20-30km (Cultural sites)	10-20km (Cultural sites)	0-10km (Cultural sites)	Wanyonyi *et al*., 2016
	2 km Buffer	5 km Buffer	10 km Buffer	Area outside	
	>500m (Accessible by private transport but no service and facilities)	< 500m (Accessible by private transport but limited service and facilities)	(Accessible by public transport but limited service and facilities-semi urban)	(Accessible by public transport and safety service and facilities- urban area)	Bagdanaviciute *et al*., 2018
	Narrow road, only pedestrian, no vehicle access possible, bad road condition	Moderate road, vehicle allowed, bad road condition / Narrow road vehicle allowed, good condition	Wide road, vehicle allowed and moderate road condition	Wide road , vehicle allowed and good condition	Mamun and Mitra, 2012
Settlement (size)	<50000	>50000- <100000	>100000- <20000	> 200000	Murali *et al*., 2013
	Heavy tourism and/ or urban	Light tourism and/or urban and/or sensitive	Sensitive tourism and/ or urban	Historic and/or none	Anfuso *et al*., 2017
	100 inhabitants/km^2	100-250 inhabitants/km^2	250-1000 inhabitants/km^2	More than 1000 inhabitants/km^2	Brilha, 2016
	>1000m (Urban)	500-1000m (Urban)	300-500m (Urban)	<300m (Urban)	Guerrero *et al*., 2020
	Urban settlements (>10000)	Small towns (1001-10000)	Unincorporated communities (1-1000)	Absence of permanent settlement (0)	Bunruamkaew *et al*., 2011

	Up to 200 km (100,000)	Up to 100 km (100,000)	Up to 50 km (100,000)	Up to 20 km (100,000)	Cetin *et al*., 2018
	0-25 (inhabitation/ km^2	25-100 (inhabitation/ km^2	100-250 (inhabitation/km^2	>250 (inhabitation/ km2	Bagdanaviciute *et al*., 2018
Amenities	Absence of one or more of the basic facilities	Presence of all basic facilities, but poorly managed	Presence of all basic well managed facilities	Presence of all basic and important facilities	Semeoshenkova *et al*., 2016
	Availability of potable water-source	Availability of potable water-well	Availability of potable water-artesian well	Availability of potable water-general network	Silva *et al*., 2013
	Public sanitation system-Absent	Public sanitation system-To the sediment	Public sanitation system- General network	Public sanitation system-Treatment	
	Public transport distance->100m	Public transport distance-100m	Public transport distance-50m	Public transport distance -Next beach	
	Street lighting-absent	Electric generator	Electrical network 50%	Electrical network 100%	
	Street lighting-absent	-	Street lighting-little	Street lighting-adequate	Sousa *et al*., 2014
	Public bathrooms-absent	--	Public bathrooms - little	Public bathrooms - adequate	

Asmamaw and Gidey (2018) and Guerrero *et al*., (2020) have been showed the elevation >750m with very high potentials, 650-750m with high potential, 550-650m moderately potential and <550m with less potential of tourism Brazil and Ethiopia. The scholar like Bunruamkaew and Murayama (2011) and Wanyonyi *et al*. (2016) have suggested the elevation 300-400m as more suitable sites for tourism than the land with elevation of 0-100m in Kwale from Kenya. However, flat lands are more favorite sites for tourism in the coastal zones e.g. low elevation (<0) than the higher elevation (>6) (Murali *et al*., 2013). Further, Pralong and Reynard (2005) have reported that higher elevated sites are more suitable than the lowlands for these activities. However, Ambecha *et al*., (2020) have found out the coastal sites are more suitable for tourism. Therefore, variations in elevation considered as a criterion of the analysis of tourism potentials in coastal region.

The scholars have used slope of the land as the criterion for site suitability analysis (Silva *et al*., 2013; Murali *et al*., 2013; Guerrero *et al*., 2020). Some of the scholars have reported steep slopes as more suitable lands for tourism. However, coastal flat lands (<2°) are more suitable than the steep slopes (>20°) in coastal region (Silva *et al*., 2013). Further, the scholars like Wanyonyi *et al*. (2016), Lin and Pussella (2017), Asmamaw and Gidey (2018) have taken into consideration the gentle slopes as a criterion for the analysis of tourism sites in coastal region. Therefore, slope is significant criterion for site suitability analysis of tourism potential in the study area.

Lin and Pussella (2017) have suggested the assessment criterions for the analysis of beach tourism development with considering the sandy beaches as attraction points of tourists then the features like muddy beaches, lagoons and cliffs on shoreline in Shri Lanka. The fine sand coasts are more suitable than mud and coarse sand coast to the beach tourism activities (Silva *et al*., 2013). Therefore, the features at seacoasts selected as criterion for the analysis of potential sites for tourism activities.

Some of the scholars have analyzed the distance from river channel to find the potential sites for tourism (Ambecha *et al*., 2020; Rocha *et al*., 2020). have classified the distance from the river into four major categories: very high (1km), high (3km), moderate (6km) and low (>6km) tourism potential of tourism in Ethiopia. Further, Rocha *et al*. (2020) have also classified this distance into four categories of tourism potentials i.e., < 50m (very high), 50-100m (high), 100-150m (moderate) and 150-200m (low) in Portugal. Therefore, the distance from the river channels considered as a criterion for analysis of tourism.

Some of the scholars have analyzed the LULC for the detection of potential sites for tourism development (Bunruamkaew and Murayama, 2011; Wanyonyi *et al*., 2016; Lin and Pussella, 2017; Cetin *et al*., 2018; Guerrero *et al*., 2020) have classified the LULC for

detection of prospective regions for ecotourism criterions including: 1) forest, Cerrado (tropical savanna ecoregion, Brazil) and water aspects as very highly suitable, 2) grassland as highly suitable, 3) pasture as moderately suitable, and 4) agriculture, forestry, urban and non-vegetated areas as less suitable. Asmamaw and Gidey (2018) have assessed LULC for the analysis ecotourism sites: 1) lakes and dense forest as highly suitable, 2) closed grassland as moderately suitable, 3) open grassland and shrub land, cultivated land as less suitable, and 4) built-up land as not suitable. Roach *et al*. (2020) have reported: 1) the urban and industrial infrastructures as extreme suitable, 2) agriculture as high suitable, 3) forest as moderately suitable, 4) coastal sand, water bodies, sparse vegetation, swamp or bare rock as less suitable category of LULC for tourism development. Murali *et al*. (2013) have analyzed the LULC for determination of site suitability of urban and ecological sensitive regions as very high tourism, agriculture/fallow lands as higher tourism, vegetated land or open spaces as moderate tourism, and barren land and less suitable for tourism. Therefore, LULC considered as a criterion for the analysis of tourism potentials in coastal region

The distribution of cultural and historical aspects is useful for site suitability analysis of tourism development with gradation regional influence like 1) international sites as very high suitable, 2) national sites as high suitable, 3) regional sites as moderate suitable, and 4) local sites less suitable for the tourism development (Pralong and Reynard, 2005; You-jun and Zheng-xin, 2009). 1) World-wide sites show very high potential of attraction, 2) nation-wide sites show high potential of attraction, 3) region-wide sites show moderate potential of attraction, and 4) province-wide sites show less potential of attraction for the tourists. Brilha (2016) has studied the attraction of tourist towards the cultural and historical places and classified into four major categories: 1) <5 km as very highly suitable, 2) <10km as highly suitable, 3) <15km as moderately suitable and 4) <20km as less suitable for the tourism development. Therefore, distribution of cultural and historical places are considered as a criterion for the analysis of tourism potentials in the coastal region.

Some of the scholars have analyzed the accessibility and connectivity for determination of potential sites for tourism development (Bunruamkaew and Murayama, 2011; Mamun and Mitra, 2012; Wanyonyi *et al*., 2016; Brilha, 2016; Anfuso *et al*., 2017; Hoang *et al*., 2018; Cetin *et al*., 2018; Bagdanaviciute *et al*., 2018). Guerrero *et al*., (2020) have found that the touristic attractions vary according to the accessibility and connectivity of the region and categorized into major four classes including: 1) tourist places near to the road (< 350m) show very high tourist attractions, 2) distance between 350 to 750m shows high tourist attractions, 3) distance between 750-1500m shows moderate tourist attractions, and 4) distance more than 1500m shows less tourist attractions. Murali *et al*. (2013) have suggested the road network as significant criterion for site suitability analysis of tourism and classified these regions with 1) 250m buffer as very high suitable, 2) 500m buffer as high suitable, 3) 1km buffer as moderate suitable and 4) 2km buffer as less suitable for tourism activities. Pralong and Reynard, (2005) have analyzed the site suitability for the tourism development and classified into four categories with regional view as national (very high), regional (high) and local roads (moderate) and <1km track (low). Ambecha *et al*. (2020) have considered the distance from the tourist places as most significant aspect for the tourism attraction and classified into four classes: 1) place on 1km distance as very high attraction point, 2) place on 3km as high attraction point, 3) place on 6km as moderate attraction point and 4) place on >6km distance as less attraction of tourist point. However, the scholars like Mamun and Mitra (2012) have used the density of road network as indicator of connectivity and accessibility and used as criterion for site suitability analysis for tourists places Murshidabad district, West Bengal, India. Therefore, density of road network was used as a criterion for analysis of the tourism potential in the study area.

Bunruamkaew and Murayama (2011) have found the significance of the size of settlement as in process of tourist activities and used this criterion for determination of site suitability as: 1) very high for absence of permanent settlement, 2) high for unincorporated communities, 3) moderate for small towns, and 4) less suitability for urban settlements. However, Anfuso *et al*. (2017) gave more significance for urban areas for tourists' point of view. Further, Brilha (2016) and Bagdanaviciute *et al*. (2018) have classified the settlements into four main categories as >1000 inhabitants/km^2 (very high potential), 250-1000 inhabitants/km^2 (high potential), 100-250 inhabitants/km^2 (moderate potential) and 100 inhabitants/km^2 (less potential) to show the potentiality of different sites according to size of settlements for tourism purposes. Cetin *et al*. (2018) have used relationships between size of population and distance of buffer zone for this purpose as: 1) very highly suitable area having 100000 population in buffer of >20km, 2) highly suitable area having same population within > 50km buffer, 3) moderately suitable land of 100km buffer and 4) less suitable land up to 200km buffer. Murali *et al*. (2013) have reported the land having population size> 200000 as more suitable than land having population <50000 (low) for tourism purposes. Therefore, density of settlements considered as a criterion of the analysis of tourism potentials in coastal region.

Semeoshenkova *et al*. (2016) have used amenities and services as criterions for analysis tourism potential and classified into four categories i.e. presence of all basic and important facilities (very highly suitable), presence of all basic facilities but poorly managed (highly suitable), presence of all basic facilities (moderately suitable) and absence of one or more of the

basic facilities (less suitable). Silva *et al*. (2013) and Sousa *et al*. (2014) have consider the number of amenities including availability of water, public sanitation system, public transport distance, electrification (100%), street lighting, adequate public bathrooms, for detection of potential sites for tourism.

Thus, nine criterions i.e. elevation, slope, seacoast, river, LULC, accessibility and connectivity, density of settlements, number of amenities, cultural and historical places were selected and used for detection of potential sites for tourist activities in the selected study region using AHP technique.

Further, the scholars like Moreno (2010), Falk (2014), Romero *et al*. (2019) have used that temperature as a significant criterion for analysis of beach tourism in temperate zone. Ridderstaat (2014) has reported that the beach tourism is possible in the destinations of comfortable temperature. The distribution of rainfall also reported as significant factor of tourism development (Ogbuene, 2011). However, Jeuring and Becken (2013), Fitchett *et al*. (2017) have reported negative effects of the heavy rainfall on tourism activities. The present study focused on detection of tourism potential in micro-region and the region shows minor variations in spatial distribution of rainfall and temperature. Therefore, the climatological criterions including rainfall and temperature not considered in the analysis. The natural diversity and landscape features are the major attraction points for tourists (Ha and Yang, 2019; Batman *et al*., 2019). The tourists are visiting the natural features for enjoy (Bunruamkaewa and Murayama, 2011). The region is coastal zone and therefore, landscape feature on coastlines including cliffs, platform and headland not specially points in the present analysis. Further, the tourism safety is important for tourist and play vital role in development of tourism industry (Chen *et al*., 2017).

3.3 Criterions

Nine criterions i.e. elevation, slope, seacoast, river network, LULC, accessibility and connectivity, density of settlements, number of amenities, cultural and historical places were used for detection of potential area for tourism activities in study region using MCDM based AHP technique.

3.3.1 Seacoast

The beach tourism is unique and dynamic business across the world (Butowski, 2018) and fresh, comprehensive and sandy coastlines (Klein *et al*., 2004) are major destinations for the tourism development (Monavari *et al*., 2012) with enhancement of beauty and entertaining activities e.g. sandy beach, landscape features, sand bar, lagoon, headland, cliff, cave, spit bar, tombolo, etc.

Pralong and Reynard (2005) have studied the morphological sites particularly landscape evolution as the major attraction point for tourist which give more income to the local people without environmental disturbance. Mooser *et al*. (2018) have reported most attractive landscape features along the coastlines such as headlands, cliff, caves, rocky, sandy beaches, etc.

The scholars like Kale (2015), Brilha (2016) have analyzed the potentials and diversity of geo-tourism. This activity focused on tourism of the natural surroundings, especially emphases on landscape (Kale, 2015). Geo-diversity tourism relates with the pictorial attractiveness of the geographical existence (Brilha, 2016). The landscapes in adjoining region of seacoasts show higher visual standards for tourism activities (Tomic *et al*., 2018). Batman *et al*. (2019) have suggested natural surroundings without landscape uniformity for tourism. Further, Priskin (2001) has described the prospective ecotourism locations Western Australia (Ambecha *et al*., 2020). Lin and Pussella (2017) have found that sandy coasts more suitable than the headland, cliff and rocky coast for tourism. Coastal swamplands are also suitable for various tourism amenities (Belsoy *et al*., 2012). Photography of sun at shoreline including natural landscape features is fundamentally potential sources for tourism development (Pereira *et al*., 2019). Therefore, analysis of natural landscapes is significant to establish the natural bases for development of tourism activities with eco-friendly approach. Coastal areas are significant regions for human settlements and tourism activities (Lin and Pussella, 2017) for financial support to local people (Chen and Bau, 2016). These activities can meet the forever-accumulative recreational requirements of town residents (Asur, 2019). However, Rangel-Buitrago *et al*. (2017) have reported problems like land degradation in this region due to this activities.

The map showing seacoast was prepared using topographic (SOI) maps, Google earth data and field data. The seacoast tourism potential was calculated in Arc GIS 10.2 and classified into four categories i.e. headland-cliff (0.39 % area) less suitable for tourism, beach/rocky coast-blackish (0.39 % area), rocky/sandy beach-black and white sandy/rocky beach with including especially (headland, cliff, sand bar and tombolo) (54.38 % area) very highly suitable for tourism (Figure 3).

The seacoast characteristics: 1) headland and cliffs given low weightage 1, 2) sandy beaches, rocky coast with estuaries or lagoons given weightage 2, 3) rocky and muddy sandy beaches with blackish sand given weightage 3 and 4) white sandy beaches, sand bars, tombolo, etc. given weightage 4.

3.3.2 Cultural and Historical Places

Cultural heritage is more significant as traditional shoreline locations having scenic view for the tourists (Lacher *et al*., 2013). Prehistoric and cultural traditions are the most attractions for them (Escobar *et al*., 2020). Cultural heritages represent human tradition in the particular area including archaeological indications, historical forts, other buildings, etc. within the region. It is the symbol of human history and time considering the

geographic and geological learning situations (Reynard, 2009). The presence of the cultural heritage is a past period distinctive physical cultural record indicating the challenges about climate changes impact on shoreline with surrounding natural resources (Li *et al*., 2021). Coastline service sector has built on a distinctive source combination of terrestrial and sea offering amenities such as marine, seashores, vegetation, landscape feature and differentiated artistic with historic heritage along the shoreline support the coastal tourism development (Cletus and Okpoko, 2015). The cultural heritage including folks, traditional clusters, homelands, and its value historic, artistic, trade and industry buildings, regions, ballet, fare, clothes, events, ethics, daily life and arts (Ismail *et al*., 2014) for attraction of tourism. The terrains of coastal zone are habitually attractive for the development of tourism amenities and services i.e. residential building, hotel, hospital, restaurant, security organization, etc. (Nikiforov *et al*., 2018). Pralong and Reynard (2005) and You-jun and Zheng-xin (2009) have found that international cultural and historical heritage very high suitable for coastal tourism, national places are high suitable for tourism and local heritage less suitable to the tourism. Therefore, cultural and historical heritage tourist sites considered as higher potential of coastal tourism development in the region.

About 3.40% TGA is classified in cultural and historical attraction proximity >5km distributed in the Western part along with the seacoastline, 7.03% TGA within the 3-4km, 8.66 % TGA within 2-3km, and 80.92% TGA within the <1km. Coastal side area having high value representing the high tourism potentials (Table 4 and Figure 4). Here, the cultural and historical attraction proximity is reclassified into four categories and assigned weights of 1, 2, 3 and 4, respectively.

3.3.3 Elevation

Ambecha *et al*., (2020) have noticed elevation as the prime factor of attraction point of view from tourism scenery landscapes. The relief disparity shows significant impact on scenic landscape (Maharashtra state gazetteers, 1962). Absolute relief represents the highest elevation of topography and plays a fundamental role in tourism development (Mirzekhanova and Fetisov, 2008). Therefore, the analysis of elevation is useful to point out the potential sites for tourism. Mirzekhanova and Fetisov (2008) have found and recommended favorable height up to 300m and unfavorable above 300m for tourism development. Guerrero *et al*. (2020) have notified that elevation of landscape less than750m has beauty that is more scenic. The higher elevation of land shows significant scenic value for tourism activities (Pralong and Reynard, 2005). However, some of the scholars have noted less elevation as favorable landscape for tourism viz. Cetin (2016) has reported the lowland topography is favorable for various tourism activities. Highest elevation suggested as more suitable for ecotourism (Ambecha *et al*., 2020). The present study area is the coastal zone and coastline has more attraction of tourists. At some places, lowlands show high risk at the coastal area including natural calamities like tsunami, floods, landslides, etc., (Murali *et al*., 2013). Therefore, the disparity in elevation of the study analyzed to identify the potential sites for tourism.

Table 3. Suitability levels: Seacoast characteristics

Suitability levels	Seacoast characteristics	Area	
		(km^2)	(%)
Low suitable	Headland and cliffs	125.62	54.38
Moderately suitable	Sandy beaches, rocky coast with estuaries or lagoons	103.55	44.83
Highly suitable	Rocky and muddy sandy beaches with blackish sand	0.91	0.39
Very highly Suitable	White sandy beaches, sand bars, tombolo, etc.	0.91	0.39

Table 4. Suitability levels: Cultural and historical attraction proximity

Suitability levels	Classes (km)	Area	
		(km^2)	(%)
Low suitable	>5	101.66	3.40
Moderately suitable	3-4	210.04	7.03
High suitable	2-3	258.73	8.66
Very high suitable	< 1	2418.57	80.92
Total		2989.00	100.00

Figure 3. Suitability levels: Seacoast

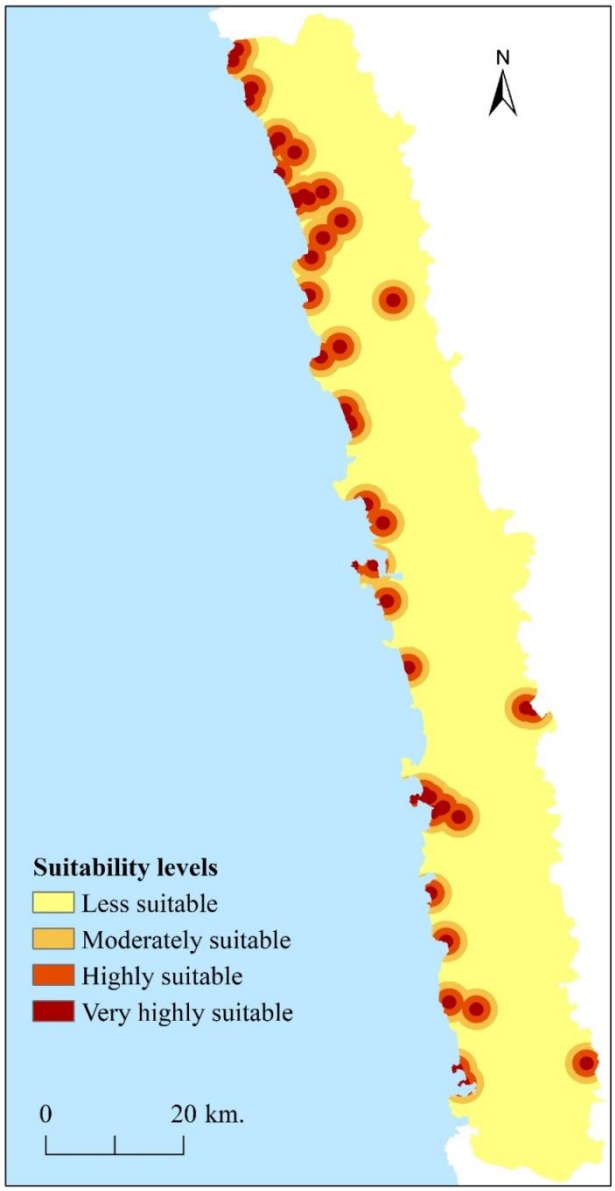

Figure 4. Suitability levels: Cultural and historical places

The maps showing distribution of elevation in Ratnagiri Coastal Zone (RCZ) was prepared using Cartosat DEM data (Figure 3). The height varies from 0m at coastline to 413m at Sawari village (Mandangad Tahsil). The map classified into four categories based on the comparative weighted class values as lowland (4), moderate land (3), highland (2) and very highland elevation (1). The area was estimated 19.42% TGA into lowland, 29.06 % TGA into moderate, 33.47% TGA area into high and 18.05% TGA area in very highlands. In the study area, the coastal area has higher attraction of tourists compare to other land classes therefore, the costal lowland has been give higher weightage (4) for AHP analysis. Further, the class of moderate elevation has given weightage 3, high elevation given weightage 2 and very highlands given weightage 1 for AHP analysis (Table 5 and Figure 5). Therefore, coastline areas including beaches (Chen and Bau, 2016), headlands, lagoons, creek, cliffs, etc. have more attraction of tourism.

3.3.4 Slopes

The slope refers to the degree of gradient of a landform (Sundriyal *et al*., 2018). Slopes indicate convince for tourists, accessibility to cultural locations, distance from road and rail network (Wanyonyi *et al*., 2016), aquatic spring, distance from the landscape features, vegetation, wild life and territory (Abed *et al*., 2011) are significant to find out scenic beauty (Guerrero *et al*., 2020). Therefore, the slope is one of the important indicators to find the potential sites for tourism (Ambecha *et al*., 2020). The scholars like Anfuso *et al*. (2017), Lin and Pussella (2017) have focused on steep slopes (vertical 90º) as suitable category including headlands and the cliff features. However, Bunruamkaew and Murayama (2011) and Asmamaw and Gidey (2018) have reported

almost gentle slope (0-5º) as favorable category for tourism. Further, Asmamaw and Gidey (2018) have reported the slope >35º as not suitable land for tourism development. The places in hilly areas are most attractive points for various tourism activities like visits to hill station and identified botanical regions, trekking, watching and film making of wild life, horse-riding, caving and adventure, (Cetin and Sevik, 2016) rafting, tableland tourism (Batman *et al*., 2019), walking and driving, etc. (Rutherford, 2014). Coastal lowland areas are mostly suitable for development of tourism activities at sandy beach, rocky beach, coastal landform, cliff, headland inlet, lagoon, sand spits, etc. (Hegde and Reju, 2007). Slope analysis of coastal area is more significant for construction of human settlement and its related land mapping (Bagheri *et al*, 2013). The study related to analysis and identification of tourism potential area of coastal zone of Ratnagiri district. Therefore, coastline area has more importance as tourism landscape in the region (Batman *et al*., 2019). The slope map was prepared using Cartosat DEM data with slopes variation from almost flat (0º) to steep slope (90º). The slopes reclassified into four weighted comparative classes as gentle slopes (4), moderate slopes (3), steep slopes (2), and very steep slopes (1). About 29.07% TGA is classified in the class showing slope < 5º distributed in the western part along with the sea coastline, 69.90% within the class of 5 to 25º, 0.98% within 25 to 35º and 0.05% within slope > 35º. Coastal sides having higher values represent the high tourism potentials (Sahani 2019; Ambecha *et al*., 2020) (Table 6 and Figure 6).

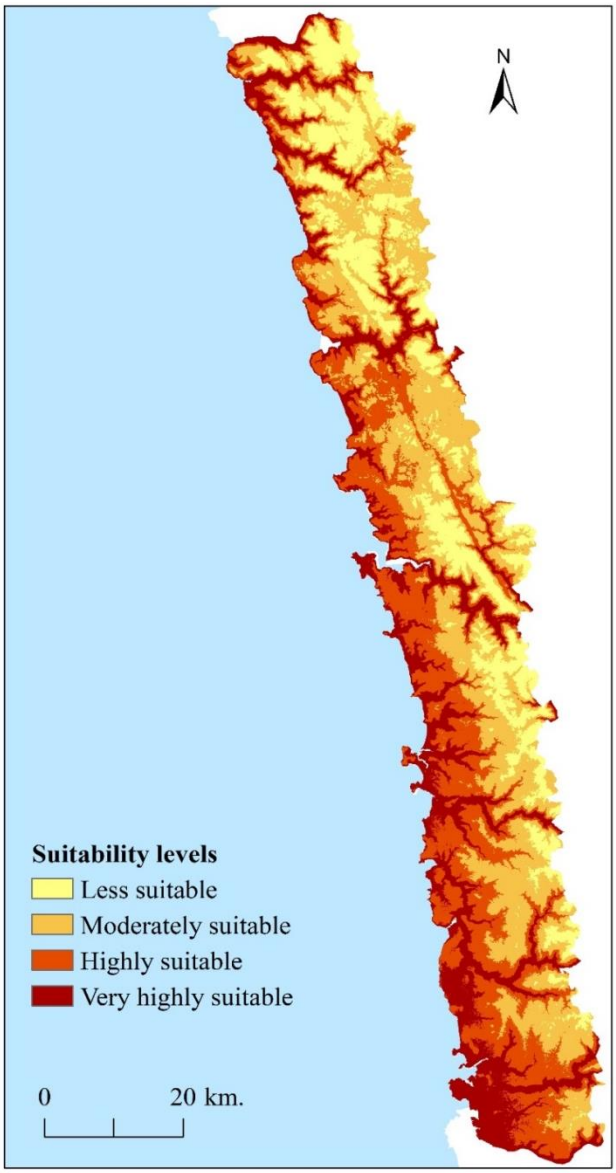

Figure 5. Suitability levels: Elevation

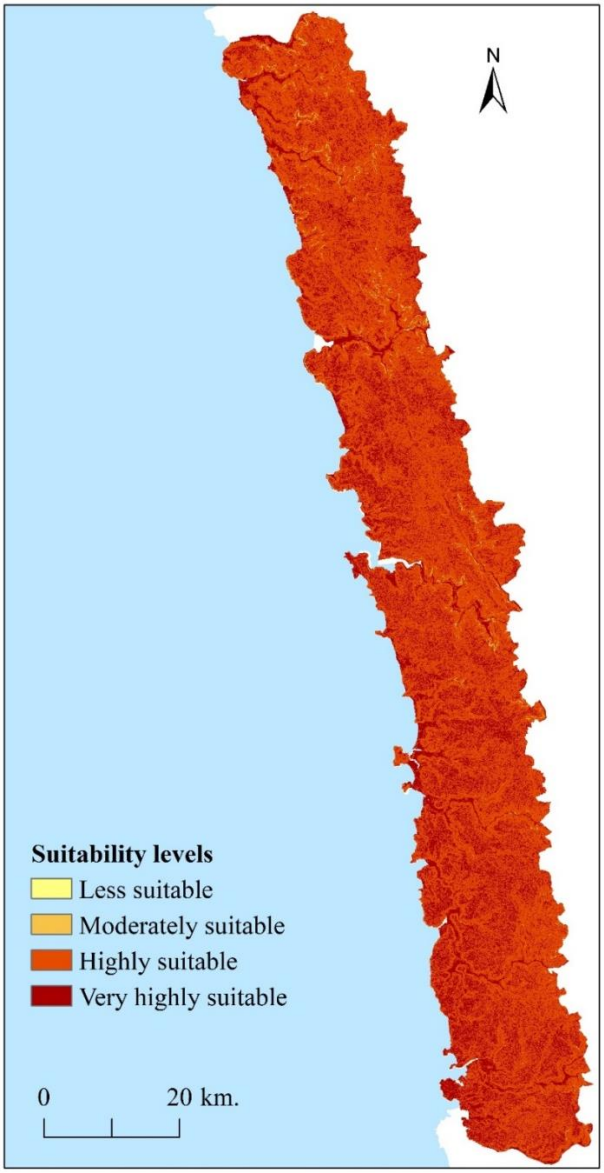

Figure 6. Suitability levels: Slope

Table 5. Suitability levels: Elevation

Suitability levels	Elevation (m)	Classes	Area	
			km^2	%
Very highly suitable	Lowland	< 59	580.38	19.42
Highly suitable	Moderate elevation	60-126	868.62	29.06
Moderately suitable	Highland	127-193	1000.49	33.47
Less suitable	Very highland	> 193	539.51	18.05
Total			2989.00	100

Table 6. Suitability levels: Slope

Suitability levels	Slope classes	Slope (°)	Area	
			km^2	%
Very highly suitable	Gentle slope	< 5	868.79	29.07
Highly suitable	Moderate slope	5-25	2089.46	69.90
Moderately suitable	Steep slope	25-35	29.20	0.98
Low suitable	Very steep slope	> 35	1.55	0.05
Total			2989.00	100.00

3.3.5 Rivers

Rivers play the significant role in formation of view point tourists as pilgrim attraction including birthplace of many saints, poets and philosophers, land of spirits and divinity, (Jaswal, 2014) historical places, traditional locations, morphological attraction such as river oxbow lakes, waterfalls, hot springs, delta, etc. (Sepahi *et al*., 2015). Tourists are currently competent to holiday parts of river circular track (Tomic *et al*., 2018) using both sides of the river banks as the most appropriate starting point including boating, colorful sunny museum ferry (Hsu *et al*., 2009), side view of river bank, etc. The river morphometric study shows an imperative part in scenery feature and tributary actions such as progress of the hydro-tourism (Rahman and Rindam, 2017). The places of aquatic sources on rivers are more suitable for tourists' attractions and leisure (Aklıbasında and Bulut, 2014). Aklıbasında and Bulut (2014) have been reported the water resource as the attraction of tourist considering the 0-300m distance from river site scenic value. Further, Rocha *et al*. (2020) showed four weighted classes of distance from river channel as 150-200m into low potential, 100-150m moderate potential, 50-100m higher potential and < 50m distance from river show higher potential of tourism development. They gave more weightage for nearness to the river for selection of suitable sites for tourism. Therefore, in the present study, lands near to the river channel considered as higher potential lands for tourism development.

The map showing distance from the river channel was prepared based on the drainage map prepared using topographic (SOI) maps. The distances were calculated using multiple ring buffer available in Arc GIS 10.2 and classified in four categories (Ambecha *et al*., 2020): distance <1km (20.77%), 1 to 3km (34.62 %), 3 to 6km (32.01%) and >6 km (12.60 %). The land near to the river channel (1km) has been given more weightage 4, 1 to 3km give 3, 3 to 6km 2 and for distance more than 6km given weightage 1 (Table 7 and Figure 7).

3.3.6 Land Use Land Cover (LULC)

The human population densities (Ellis *et al*., 2010), sprawl and service sector progressive actions are changing the present state of LULC varies the natural environment (Clark, 1982; Jaiswal *et al*., 1999; Chilar, 2000; Yuan *et al*., 2005; Yılmaz, 2009; Joshi *et al*., 2011; Luna and Robles, 2013; Rawat *et al*., 2013; Kaliraj *et al*., 2016). LULC is uneven distributed for the reason that of man-made events and natural disasters (Muttitanon and Tripathi, 2004; Lambin *et al*., 2003; Qiang and Lam, 2015; Khan *et al*., 2015). LULC variations due to a number of morphological processes, climatic and anthropogenic activities (Thakur *et al*., 2020) are indirectly influencing the human society on shoreline native people. The satellite data has become significant apparatus for studying LULC change (Szuster *et al*., 2011). The GIS is one of most significant apparatus for analysis of land suitability of seacoast area for future planning of housing, farming, industrial, hotel, lodging, transport, settlement, shoreline tourism, etc. (Bagheri *et al*., 2013). The assessment is necessary for accepting the LULC classes in a specific area and its assistance in accumulative or shrinking the exposure of a region (Murali *et al*., 2013). LULC is important for biodiversity protection and sustenance of travelers' events (Pisolkar and Chaudhary, 2016). The tourists' attractions are points in coastal zone and from this time provide a lot of chance for tourism development (Naik *et al*., 2018). Therefore, LULC analysis is the fundamental component to detecting for the potential lands for tourism development. Coastal zones are major

source of fish food, biodiversity, coastal landscape features and entertaining opportunities with vast challenges (Bernard and Rivaud, 2013). Murali *et al.* (2013) have recognized that barren land is less suitable for coastal tourism. Moderately suitable places are the sparsely vegetated areas and high suitable lands are in agricultural zones and fallow lands. Very highly suitable lands observed in urban and ecologically sensitive region. The LULC map was prepared in Arc GIS 10.2 and ERDAS software using Landsat 08 OLI satellite image (14/02/2019) and classified in four categories (Murali *et al*., 2013; Wanyonyi *et al*., 2016; Lin and Pussella, 2017) (Figure 8 and Table 8). Further, this LULC map was classified into four suitability levels: 1) barren and open lands (51.24%) are less suitable for tourism as assigned weightage 1, 2) the sparse vegetation (2.00%) and agriculture land (41.41 %) are moderately suitable and assigned the weightage 2, 3) the dense vegetation (0.10 %) and built-up area (1.92 %) is highly suitable and assigned the weightage 3 and 4) water bodies (2.32%) are very highly suitable for tourism development and assigned the weightage 4 (Figure 8 and Table 8).

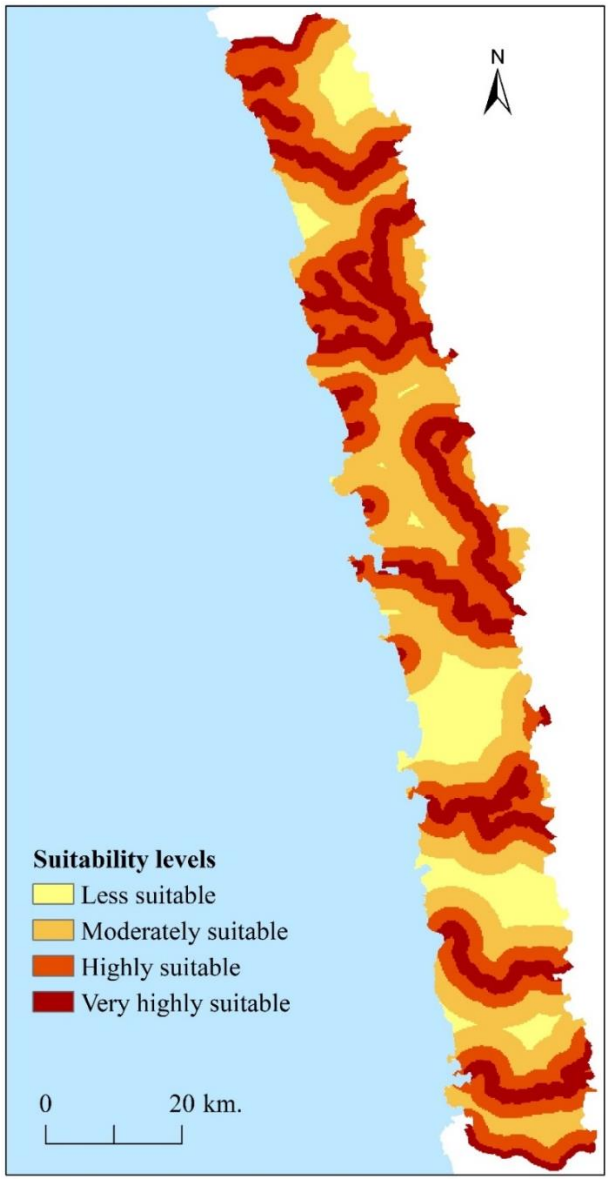

Figure 7. Suitability levels: Distance from river channel

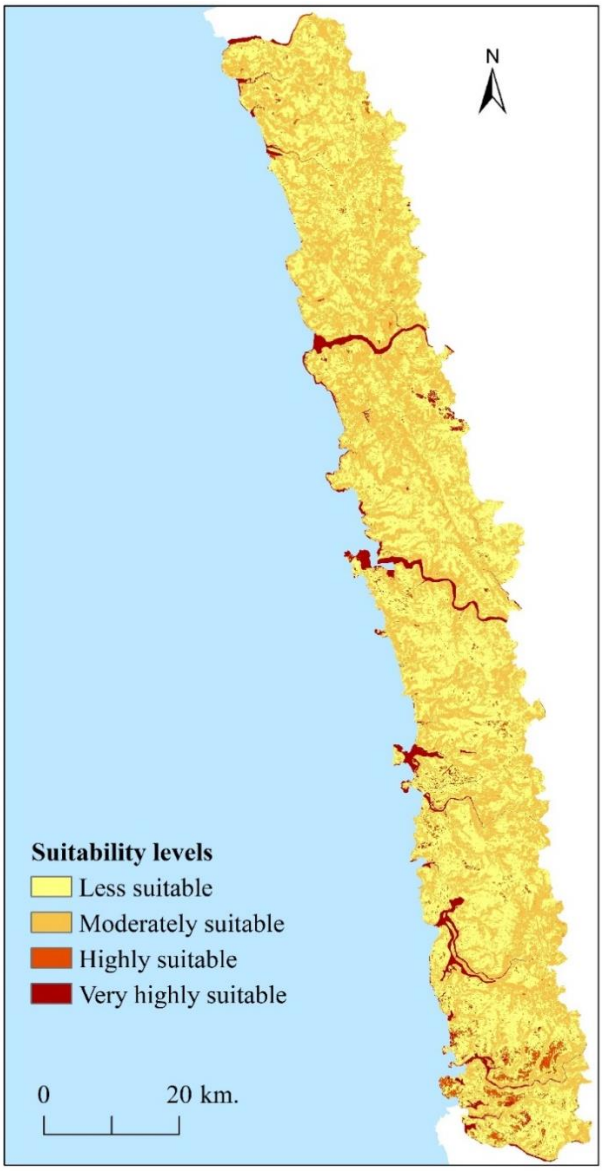

Figure 8. Suitability levels: LULC

Table 7. Suitability levels: Distance from river

Suitability levels	Classes	Area	
		km^2	%
Very highly suitable	< 1km	620.76	20.77
Highly suitable	1 to 3km	1034.69	34.62
Moderately suitable	3 to 6km	956.78	32.01
Less suitable	> 6km	376.76	12.60
Total		2989.00	100.00

Table 8. Suitability level: LULC

Suitability levels	Classes	Area	
		km^2	%
Less suitable	Barren land / open land	1561.43	52.24
Moderately suitable	Sparse vegetation	59.86	2.00
	Agriculture	1237.7	41.41
Highly suitable	Dense vegetation	3.13	0.10
	Built-up area	57.5	1.92
Very highly suitable	Water body	69.38	2.32
Total		2989	100

3.3.7 Accessibility and Connectivity

Accessibility and connectivity are important components of the tourism industry and development of tourist sites (Prideaux, 2000; Cejas and Sanchez, 2010; Kovacic and Milosevic, 2016; Virkar and Mallya, 2018; Khadaroo and Seetenah, 2008; Taye *et al*., 2019). The tourism and transportation networks have close associated movements of tourists (Hacia, 2019). It is essential to provide various facilities and services to tourists at the time of traveling and stay at tourist places (Cetin, 2016). The innovative technologies in the transport sector are useful for tourism development in any region (Mammadov, 2012) and infrastructures supporting to the tourism value of the particular tourist sites (Cocean and Cocean, 2016). The development of the international tourism in any nation requires well network system including road, railway, metro as well as shipping (Albalate and Bel, 2009; Kubalikova and Kirchner, 2015). However, the transport cost inversely effects the development of the tourism sector and the selection of travelling mode (Kim and Lee, 2016). Therefore, transport network and connectivity analyzed to understand the tourism potential in the region.

Bunruamkaew *et al*. (2011) and Pralong and Reynard (2005) have delineated suitable areas based on buffer zone from roads for tourism. In the present study, the road density map was prepared (Figure 9) to find the potential areas for tourism in the coastal zone of Ratnagiri district. The road densities vary from 1.25 to 0.52 and categorized into four classes (Table 9).

3.3.8 Density of Settlements

Settlements are naturally attractive, pulling factor of tourists and have more tourism potential (Bunruamkaew, 2012). Historic and ancient settlements in coastal region are the significant corridor for tourism (Ertas, 2017; Batman, 2019). The shoreline settlements show the cultural integration of arts, traditions, festivals, etc. (Asur, 2019) and helping for preserving their traditional architectural designs (Prabawa and Gunawarman, 2020). About 11% world residents observed in shoreline area due to their various economic activities (Stanchev *et al*., 2015; Wijerathne and Senevirathna, 2020). The settlements are the nest of rural tourism which provide various facilities to the tourist including lunch, dinner and staying and shopping facilities, etc. (Hamzah *et al*., 2014; Lakshmi and Shaji, 2015; Trukhachev, 2015). The fish foods are main attraction of tourists and fisherman-families are providing the fish-food to the tourists (Setioko *et al*., 2011). These settlements are comfort zone for tourists during the time of travelling on shoreline (Merwe and Niekerk, 2013). However, the growth of settlement in this area shows negative impact on coastal environment (Buitrago *et al*., 2020) e.g. rapid growth of cities along the coast (Setioko *et al*., 2011), coastal destructions, litter, degradation of dunes, seacoast erosion, salinity near shore area, floods, beach pollution, sewage problem, crowd on roads, etc. (Snoussi *et al*., 2007). The density of households estimated based on number of households reported in census 2011. The Ratnagiri city region shows high household densities (>1138km^2.) as compared to the eastern hilly region (<242km^2). The estimated household density is classified into four classes: <242km^2 (1.14 % TGA), 242-690km^2 (1.56 %

area), 690-1138km^2 (37.05 % area) and >1138.01km^2 (60.25 % area). The map reclassified into main four comparative suitability classes and assigned 1 to 4 values for determination of the weight of these sub-criterions (Table 10 and Figure 10).

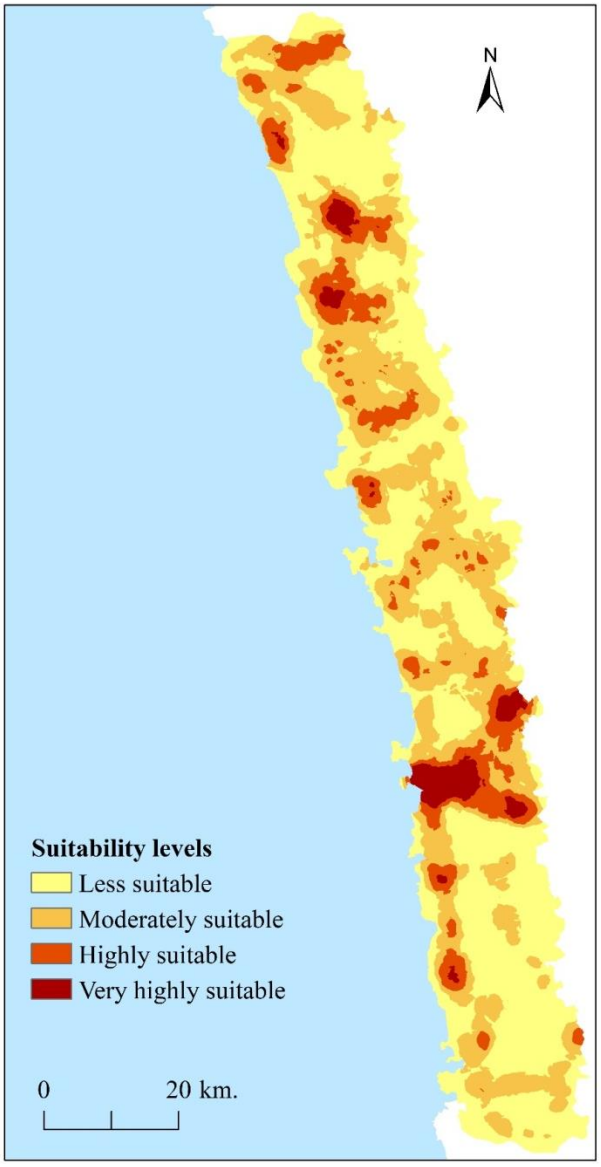

Figure 9. Suitability levels: Road density

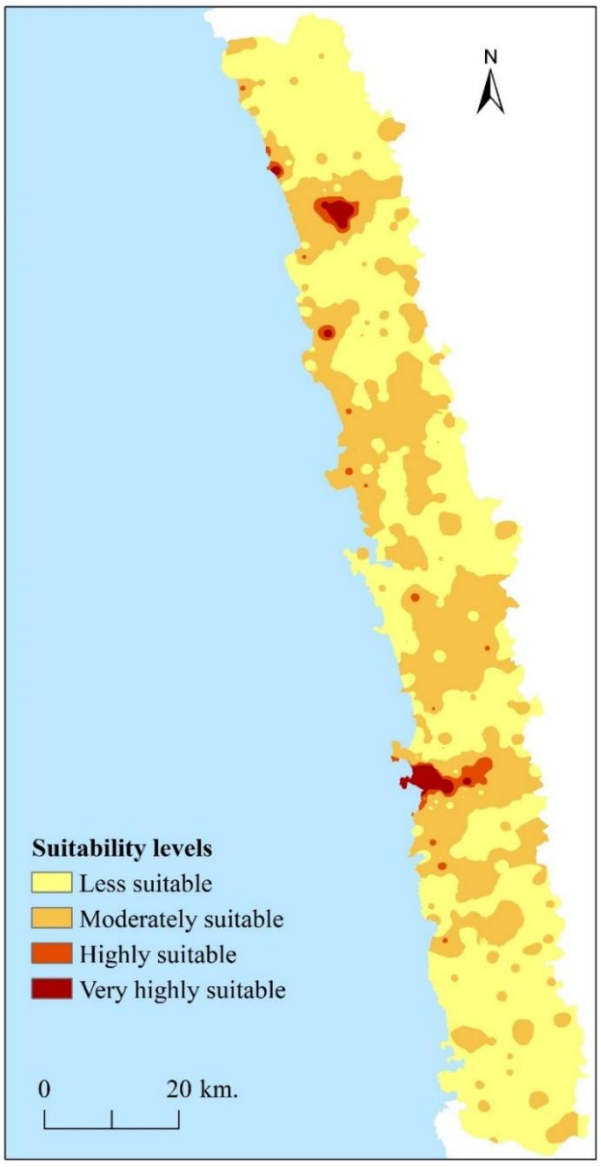

Figure 10. Suitability levels: Settlement densities

Table 9. Suitability levels: Road densities

Suitability levels	Class	Area	
		km^2	%
Low suitable	>1.25	101.01	3.38
Moderately suitable	1.24-0.81	334.83	11.20
High suitable	0.53 - 0.80	1039.07	34.76
Very high suitable	< 0.52	1514.09	50.66
Total		2989.00	100.00

Table 10. Suitability levels: Settlement densities

Suitability levels	Classes (households/ km^2)	Area	
		km^2	%
Low suitable	< 242	34.10	1.14
Moderately suitable	242-690	46.68	1.56
High suitable	690-1138	1107.36	37.05
Very high Suitable	> 1138	1800.86	60.25
Total		2989.00	100.00

3.3.9 Amenities

The basic amenities like medical, hospital, hotel, café, restaurants, water supply, electricity, entertainment, housing, safety and security at tourist places, parking facilities, libraries, bookstores and transport services, etc. are important for: 1) development of tourism activities (Lam and Xiao, 2000; Popichit *et al*., 2013; Manaf *et al*., 2015; Ruano, 2018; Luo *et al*., 2019), 2) income to local communities (Green, 2001; Jackson and Murphy, 2006; Lee *et al*., 2013; Yun, 2014), and 3) improvement in rural market (Ejiofor *et al*., 2012; Yun, 2014; Bel *et al*., 2014). The amenities and services are the more dynamic activities, which create the employment in the tourism sector (Nooripoor *et al*., 2020). The amenities are supporting for the movement of tourists and improving the tourists' satisfactions (Hermawan *et al*., 2019; Vuin *et al*., 2019). Therefore, the availability of basic amenities required 24 hours on travelling ways and tourist places (Ruano, 2018). The participations of local people can be helpful to improve the satisfaction of tourists and sustainability in development of tourism (Hamzah *et al*., 2014). Therefore, availability of amenities and services are studies based on census data (2011) and mapped to understand the spatial diversity and its relationship with tourism activities.

The number of available amenities mapped and reclassified into four categories: 1) amenities < 5 (3.38 %) are less suitable for tourism as assigned weightage 1, 2) 5 to 10 (11.20 %) are moderately suitable and assigned the weightage 2, 3) 10 to 15 (34.76 %) is highly suitable and assigned the weightage 3 and 4) > 15 (50.66%) are very highly suitable for tourism development and assigned the weightage 4 (Table 11 and Figure 11).

Table 11. Suitability levels: Amenities

Suitability levels	Classes	Area	
		km^2	%
Low suitable	< 5	3.28	0.11
Moderately suitable	5 to 10	2492.5	83.39
Highly suitable	10 to 15	442.8	14.81
Very highly suitable	> 15	50.37	1.69
Total		2989.0	100.00

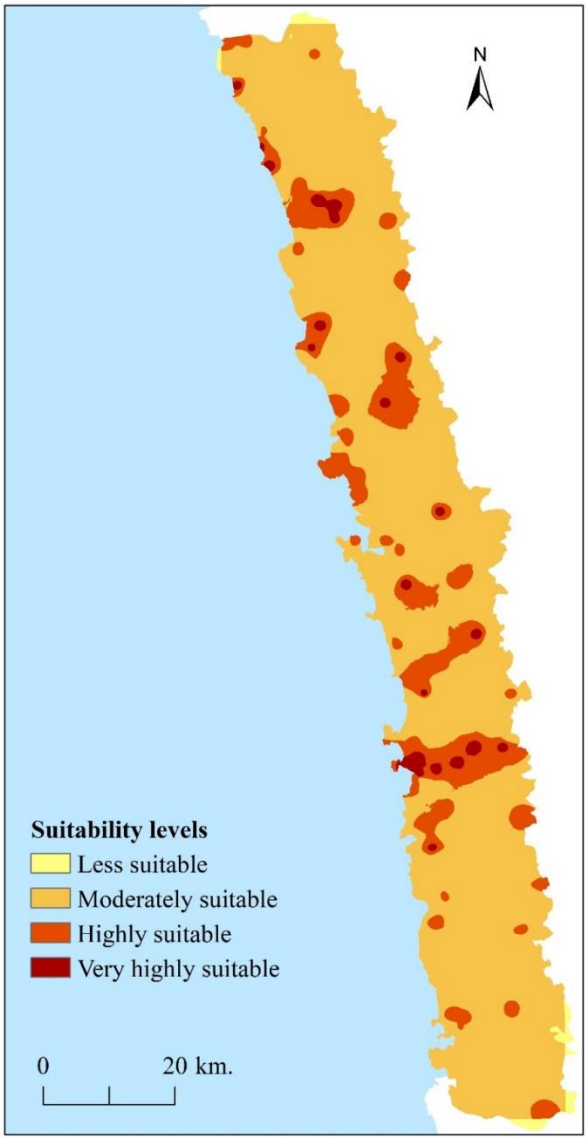

Figure 11. Suitability levels: Amenities

3.4 Analytic Hierarchy Process (AHP)

Prof. Thomas L. Saaty has introduced the AHP technique in 1960s to solving complex problems of decision-making (Bunruamkaew and Murayama, 2011; Zolekar and Bhagat, 2015; Gaikwad and Bhagat, 2017; Raha *et al*., 2021) of site suitability for planning and management of tourism activities (Sahani, 2019; Ambecha *et al*., 2020; Gyinaye *et al*., 2017). MCDM and geographical information system (GIS) are useful tools for suitability assessments to find the suitable sites (Malczewski, 2006) based on verifying the sustainability of judgment modifications (Ebrahimi *et al*., 2019; Boroushaki and Malczewski, 2010). AHP based hierarchical structure is mostly useful for complex spatial judgment with advanced confidence level (Wind and Saaty, 1980). Generally, scholars are using the AHP techniques due to the effective mathematical properties to determine the criterion weights through pairwise comparison and assigning score for sub-criterions (Mansour *et al*., 2020; Raha *et al*., 2021). Some of the scholars like Bunruamkaewa and Murayama (2011), Zolekar and Bhagat (2015), Ghamgosar *et al*. (2016), Gaikwad and Bhagat (2017), Navale *et al*., (2021) have used the AHP multi-criteria techniques for evaluation of suitable for land applications and tourism potentials. The researcher have used the this technique for arrangement of the data to identify the site suitability for specific tourism sites by using weighting overlay and calculated values for each criterion and sub-criterions (Asmamaw and Gidey, 2018; Ebrahimi *et al*., 2019; Yuwono *et al*., 2021). AHP is unique technique acquainted with prejudice and conflicts in biased decisions. Its conflicts can be verified and amended, resultant in an additional consistent final ranking (Hsu *et al*., 2009). Thus, it reduces the judging faults confined by particular mechanism (Gyinaye *et al*., 2017). It is additional flexible technique with complex accuracy in site suitability (Malczewski, 2006; Zolekar and Bhagat, 2015). The ranks of criterions chosen need inverted for additions and demarcation of criterions (Wijnmalen and Wedley, 2009). However, stated views about ranks and weights assigned to selected criterion in the present study shows prejudice decision unbiased by the defendant**.** Therefore, AHP technique has selected for robust decision of ranking and calculation of weights for selected criterions and assignments of the score for sub-criterion (Zolekar and Bhagat, 2015).

3.4.1 Ranking

Scholars likes Klein *et al*. (2004), Pourebrahim *et al*. (2014), Wanyonyi *et al*., (2016), Raha *et al*., (2021), etc. have used multi-criteria decision-making and pairwise comparison matrix for site suitability analysis. Computable and qualitative techniques have been commonly used for determination of ranks to the selected criterions for weighted evaluates (Gaikwad and Bhagat, 2018). Phillips *et al*. (2010) have studied experts' judgment and data collection for decent exercise and assessment. The expert's opinion is useful for analysis of data about selected criterion obtain from authentic literatures and professional with knowledge in the field (Bunruamkaew and Murayama, 2011; Chen *et al*., 2017). However, sometimes experts are not able to attain the query of research due to misunderstanding or shortage subject knowledge. Further, the specialist experts are able to getting the implication of expert decision in selection of criterions, determining the scores and weights in specific field of research. The appropriate assessments of selected criterions are depending on the judgment reviews from experts but certain cases (Gyinaye *et al*., 2017). However, the subjective expert opinion is a significant phase particularly in the situation of statistics inadequacy, ambiguity and contradiction (Murali *et al*., 2013).

The ranks of selected criterions assigned based on opinions collected from experts from the fields of tourism, ecotourism and agro-tourism. The questionnaires circulated to these selected experts to collect the judgments and opinions about hierarchy of influence of criterions selected for site suitability analysis of tourism in coastal region (Ergin *et al*., 2004). The experts' judgments were used for determination of ranks (1 to 9) of selected criterion. It shows the significance level of parameters. Forty-two experts from the field of tourism have selected for opinions of about ranks for asked criterion. Seacoast, cultural and historical attraction, elevation and slope have more influence on tourism sites in coastal zone and ranked 1 to 4, respectively. The criterions viz. river (rank 5), LULC (rank 6) and accessibility and connectivity (rank 7) strongly influencing on sites suitability for tourism. Density of settlements and amenities illustrate relatively less significance than other criterions (Table 12).

Table 12. Rank assigned to criterion

Criterions	Seacoast	Cultural and historical places	Elevation	Slope	River	LULC	Accessibility /connectivity	Densities of settlement	No. of amenities
Ranks	1	2	3	4	5	6	7	8	9

3.4.2 Pairwise Comparison Matrix (PCM)

The experts' opinions considered to determine the ranks of influencing criterions selected for the study (Murali *et al*., 2016). The MCDM technique and Pairwise Comparison Matrix (PCM) are significant for detection and delineation of potential sites for tourism development in the region. AHP technique was used for preparing the PCM for calculation of precise relative importance of the selected criterions in tourism activities (Bunruamkaewa and Murayamaa, 2011; Ebrahimi, 2019). The normalized weights for selected criterions calculated according to the significance of criterions in tourism (Brilha, 2016) for calculation of potential areas for tourism development (Saaty, 1987; Mansour *et al*., 2020). Ranks assigned (1 to 9) to the criterions show illustrative and mechanisms (Table 13).

3.4.3 Calculation of Weights

The calculation of weights is based PCM technique using the software AHP-OS (Analytic Hierarchy Process-Online System) according to the four steps: 1) judgment formation, 2) ranking, 3) normalized pairwise comparison matrix and 4) calculation of weights (Zolekar and Bhagat, 2015). The weights calculated using equation (1) Gaikwad and Bhagat (2018).

$$£c_i = \frac{w_c}{£w_s} \times 100 \quad (1)$$

$£c_i$ = Normalized influence of the criterion.

W_C = Sum of PCA values in row.

$£_{WC}$ = Total of PCA values all criterions.

The ranking of the selected criterions performed based on expert opinion used for calculation of weights in the PCM. The PCM cell values of each selected criterions was proceeded to find the cell values in normalized PCM (Table 13) (Zolekar and Bhagat, 2015). PCM calculates the precise weights of criterions influenced by consistency decisions of grades of the criterions. The consistency ratio (CR) calculates the consistency of the decision and simplifies the sympathy of conceivable inaccuracies (Saaty, 1977).

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \quad (2)$$

CR= Consistency ratio

CI= Consistency index

RI= Random index

The consistency ratio value <0.10 shows significant consistency and the value >0.10 shows inconsistencies **(**Saaty, 1977; Bunruamkaewa and Murayama, 2011; Zolekar and Bhagat, 2015; Mansour *et al*., 2020; Navale *et al*., 2021). The consistency index (CI) calculated as:

$$\mathrm{CI} = \lambda\max - \mathrm{n}/(\mathrm{n}-1) \quad (3)$$

The calculated CR value is 0.07 and significantly acceptable (more than tabulated CI value 0.10) showing consistency in the calculated values for selected criterions for analysis of tourism potentials in the region.

Table 13. Pairwise comparison matrix

Criterion	Seacoast	Cultural and historical places	Elevation	Slope	River	LULC	Accessibility /connectivity	Densities of settlement	No. of amenities
Seacoast	1/1	2/1	3/1	4/1	5/1	6/1	7/1	8/1	9/1
Cultural and historical places	1/2	2/2	3/2	4/2	5/2	6/2	7/2	8/2	9/2
Elevation	1/3	2/3	3/3	4/3	5/3	6/3	7/3	8/3	9/3
Slope	1/4	2/4	3/4	4/4	5/4	6/4	7/4	8/4	9/4
River	1/5	2/5	3/5	4/5	5/5	6/5	7/5	8/5	9/5
LULC	1/6	2/6	3/6	4/6	5/6	6/6	7/6	8/6	9/6
Accessibility/cone-ctivity	1/7	2/7	3/7	4/7	5/7	6/7	7/7	8/7	9/7
Densities of settlement	1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8	9/8
Amenities	1/9	2/9	3/9	4/9	5/9	6/9	7/9	8/9	9/9

Table 14. Normalized pairwise comparison matrix

Criterions	Seacoast	Cultural and historical places	Elevation	Slopes	River	LULC	Accessibility and connectivity	Densities of settlement	No. amenities	Sum	Weight	Influence (%)
Seacoast	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	45.00	0.35	35
Cultural and historical places	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	22.50	0.18	18
Elevation	0.33	0.67	1.00	1.33	1.67	2.00	2.33	2.67	3.00	15.00	0.12	12
Slopes	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	11.25	0.09	9
River	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	9.00	0.07	7
LULC	0.17	0.33	0.50	0.67	0.83	1.00	1.17	1.33	1.50	7.50	0.06	6
Accessibility and connectivity	0.14	0.29	0.43	0.57	0.71	0.86	1.00	1.14	1.29	6.43	0.05	5
Densities of settlement	0.13	0.25	0.38	0.50	0.63	0.75	0.88	1.00	1.13	5.63	0.04	4
Amenities	0.11	0.22	0.33	0.44	0.56	0.67	0.78	0.89	1.00	5.00	0.04	4
Sum	2.83	5.66	8.49	11.32	14.14	16.97	19.80	22.63	25.46	127.30	1.00	100

3.4.4 Determination of Score for Sub-Criterions

The scholars like Pralong (2005), You-jun and Zheng-xin (2009), Bunruamkaew *et al*. (2011), Mamun and Mitra (2012), Murali *et al*. (2013), Silva *et al*. (2013), Wanyonyi *et al*. (2016), Semeoshenkova *et al*. (2016), Brilha (2016), Lin and Pussella (2017), Anfuso *et al*. (2017), Asmamaw and Gidey (2018), Cetin *et al*. (2018), Bagdanaviciute *et al*. (2018), Hoang *et al*. (2018), Ambecha *et al*. (2020), Guerrero *et al*. (2020), Rocha *et al*. (2020) and Mooser *et al*. (2021) have assigned the score for sub-criterions of the selected criterions for determination of suitable sites for different purposes. In the present study, the score values assigned for sub-criterions varied from 1 to 4. Here, all thematic maps were reclassified within four categories and assigned score values from 1 to 4 according to the suitability levels of classified categories. The score value 1 is assigned for less suitable category, 2 for moderately suitable category, 3 for highly suitable category and 4 for very highly suitable category created in the reclassified maps including seacoast, elevation, slope, river, LULC, accessibility and connectivity, cultural and historical attraction, density of settlements and number of amenities (Table 15).

Table 15. Weightages and scores

Criterions	Weightage	Influence	Class	Sub-criterions	Area (km^2)	scores
Seacoast	0.35	35	Low suitable	Headland ,cliff	125.62	1
			Moderately suitable	Beach/rocky coast, blackish	103.55	2
			Highly suitable	Rocky/sand beach, black	0.91	3
			Very highly suitable	White sandy/rocky beach, sand bar, tombolo	0.91	4
Cultural and historical places	0.18	18	Low suitable	> 5 km		1
			Moderately suitable	3 -4 km		2
			High suitable	2-3 km		3
			Very high suitable	< 1 km		4
Elevation	0.12	12	Very highly suitable	Lowland (<59)	580.38	4
			Highly suitable	Moderate elevation (60-126)	868.62	3
			Moderately suitable	Highland (127-193)	1000.49	2
			Low suitable	Very highland (>193)	520.81	1
Slope	0.09	9	Very highly suitable	Gentle slope (<5)	868.79	4
			Highly suitable	Moderate slope (5-25)	2070.41	3
			Moderately suitable	Steep slope (25-35)	29.2	2
			Low suitable	Very steep slope (<35)	1.55	1
River	0.07	7	Very highly suitable	< 1km	620.76	4
			Highly suitable	1 to 3 km	1014.98	3
			Moderately suitable	3 to 6 km	956.78	2
			Low suitable	> 6km	376.76	1
LULC	0.06	6	Less suitable	Barren land / open land	1542.72	1
			Moderately suitable	Sparse vegetation	59.86	
				Agriculture	1237.7	2
			Highly suitable	Dense vegetation	3.13	
				Built-up land	57.5	3
			Very highly suitable	Water body	69.38	4
Accessibility and connectivity	0.05	5	Low suitable	local level road (> 1.25)	101.01	1
			Moderately suitable	district level road (1.24-0.81)	334.83	2
			High suitable	state level road (0.53-0.80)	1039.07	3
			Very high suitable	local, state, national, railway (<0.52)	1513.12	4

Densities of Settlement	0.04	4	Low suitable	< 242	34.01	1
			Moderately suitable	242-690	46.67	2
			High suitable	690-1138	1107.35	3
			Very high suitable	> 1138	1773.43	4
No. of Amenities	0.04	4	Low suitable	< 5	3.28	1
			Moderately suitable	5 to 10	2464.99	2
			Highly suitable	10 to 15	442.81	3
			Very highly suitable	> 15	50.38	4

3.4.5 Weighted Overlay Analysis

The GIS based weighted overlay analysis was used to find the levels of tourism potentials in the region (Pourebrahim *et al*., 2011; Aklıbasında and Bulut, 2014; Yuwono *et al*., 2021). The technique solves the composite spatial complications in common measurements of dissimilar and different ideas (Ambecha *et al*., 2020). The calculated weights based on AHP techniques were used in this weighted overlay analysis of selected criterions considering effective influences in hierarchy of certain inputs (Mansour *et al*., 2020). GIS is using unified entirely thematic strata with the weighted overlay techniques (Raha *et al*., 2021). The potentials of tourism in the region put in weighted overlay procedures. The rasterized maps prepared for selected criterions and reclassified with four categories according the suitability levels and used for weighted overlay. The cell values of respective input raster stratum are multiplied by their weights to give influence of criterions in defining the levels of tourism potentials (Cengiz and Akbulak, 2009; Bunruamkaew and Murayama, 2012; Wanyonyi *et al*., 2016; Ambecha *et al*., 2020; Chaudhary *et al*., 2021).

$T_p = \sum_{i=1}^{n} W_i X_i$ (4) (Cengiz and Akbulak, 2009)

where,

T_p = Tourism potential in the region,

W_i = AHP based calculated weight for selected criterion,

X_i = Score of sub-criteria of i^{th} layer,

n = Number of criterions

Thus, the estimated map showing tourism potential in the region was classified into four potentiality levels i.e. very high potential, high potential, moderate potential and less potential of tourism activities (Aklıbasında and Bulut, 2014) in the coastal region of Ratanagiri district.

3.4.6 Accuracy Assessment

The information of selected pixels from categorized map and reference data compared to get judgment of accuracy of produced map (Comber *et al*., 2012; Zolekar and Bhagat, 2015). The resultant irritated arrangement of categorized data counter to reference data universally recognized such as error matrix (Zolekar and Bhagat, 2015). The accuracy of produced map estimated for producers' and users' purposes using the error matrix. The inclusion of pixels considered as classified to the class and exclusion belongs to the actual class (Vijay *et al*., 2015). The overall accuracy estimated to understand the total applicability of produced map (Lillesand *et al*., 2016). Further, Kappa statistics also calculated to understand accuracy assessment (Comber *et al*., 2012).

$$K\hat{} = \frac{N\sum_{i=1}^{r} X_{ij} - \sum_{i=1}^{r}(X_i + .X+i)}{N^2 - \sum_{i=1}^{r}(X_i + .X+i)}$$ (5) (Lillesand *et al*., 2016)

where,

r = number of row in the error matrix,

x_{ij} = number of observations in row i and column j,

x_i + = total of observation in row i,

$x_{+1=}$ total of observation in column i,

N= total number of observation included in matrix.

The data form the study area collected through field assessments and sites selected using the Global Position System (GPS) as reference points from the classified map and compared in the error matrix. The overall accuracy of the categorized map is estimated 89.60 %. The producers' accuracy was estimated 94.55% for very highly suitable area and 86% for less suitable area whereas users' accuracy was estimated 96.30% for very highly suitable area and 86% for less suitable for tourism activities. The thematic maps viz. amenities and settlement were processed using inverse distance weighted (IWD) interpolation technique therefore, some areas from highly suitable category are merged in the category, 'moderate suitable'. About 87.80% producer's accuracy and 86.87% users' accuracy estimated for highly suitable area whereas 90.48% accuracy estimated for moderate suitable area as users' and producer's' perspectives (Table 16).

Table 16. Error matrix: accuracy assessment

Classified classes	Reference class					
	Very highly suitable	Highly suitable	Moderately suitable	Less suitable	Total sample	Users' accuracy (%)
Very highly suitable	52	3	0	0	55	96.30
Highly suitable	2	57	4	0	63	86.75
Moderately suitable	0	3	72	7	82	90.48
Less suitable	0	0	7	43	50	86.00
Total sample	54	63	83	50	250	
Producers' accuracy (%)	94.55	87.80	90.48	86.00		
Total accuracy (%)						89.60

4 RESULT AND DISCUSSIONS

The potential areas for tourism activities identified using multi-criteria based AHP techniques. The comparative significance of selected criterions with spatial variations estimated using the experts' opinions and AHP technique. Nine criterions (seacoast, elevation, slope, river, amenities, cultural and historical places, settlements, LULC, accessibility and connectivity) selected and analyzed for reclassification into four spatial categories of comparative influence in tourism activities. The estimated tourism potentiality map classified into four categories (Figure 12): 1) very high tourism potentials, 2) high tourism potentials, 3) moderate tourism potentials, and 4) less tourism potentials.

4.1 Very High Tourism Potentials

About 13% TGA (384.26km^2) shows very high potential for tourism activities in the coastal region of Ratnagiri district (Figure 12 and Table 17). The white sandy beaches including Kelshi, Anjarle, Murud, Guhagar, Ganpatipule, Ambolgad, Madban, etc., sunrise and sunset at seacoast, golden sand, sand dunes, lagoons, arial view of sea beaches, mangrove vegetation, scenic beauty, biodiversity, orchards of coconut and mangoes, clean and safety seacoasts are major tourists' attractions in the region. Rivers are major source of water for tourists and landscapes in river channel including waterfall, potholes, rapids, etc. show very high tourism potentials. Lowland areas with gentle (<5^o) slope are more suitable for tourism activities. The region have historical places like Suvarnadurg, Jaigad Fort, Yashwantgad, Gopalgad, Purngad, Tilak Museum and Ratnagiri Marine Museum and pilgrim centers e.g. Ganpatipule temple, Bhagvati Temple, Thibaw place, etc. These tourists are spending time in boating, bike riding, horse riding, balloon riding, lighthouse, lodgings, cafes, fairs, etc. in the stay time. The region has good amenities including bus and railway stations, medical facilities, courier facilities, entertainment gallery with good connectivity and accessibility. The settlement size is ideal for providing different facilities like lunch, dinner, parking and stay facilities for tourists. These facilities are key element for developing the coastal tourism in this region. The tourism activities are important source of employment to local people and local economy. Therefore, the government authorities are focusing on development of roads network, lodging and boarding facilities, entertainment, shop, beach security and safety, etc. However, the carrying capacity of the beaches in this region is limited compare to number of visitors' arrival. It has negative impact on natural water, land, sea marine, forests, etc. and socioeconomic environment (pollution, traffic jams, criminal activities, and increasing pressure on facilities like transportation, medical, amenities and services). Therefore, planning and monitoring of coastal tourism is need of time for development of local people with environmental sustainability.

4.2 High Tourism Potentials

About 26 % TGA (761.86 km^2) of the region was estimated in this category (Table 17) of high tourism potential. The cliffs, rocky platforms, headlands, river landscape, mangrove vegetation, coconut orchards, natural beauty of the seacoasts are major tourist attraction points in this region. The moderate elevation with moderate slope (5-25^o) are more suitable for different the tourism activities in this region. The fresh river water is available in all over coastal region. The researcher and academicians are visiting this area for the study of flora and fauna with botanical and medicinal approaches, river channel analysis, geomorphology, geology, soil analysis, marine studies, etc. The ganesh festival, turtle festival, mango festivals, fishing festivals, *holi* festival, food festivals, jayanti festivals as well as regional traditions, arts, etc. are attractions of urban people visiting this region. The network connectivity and accessibility, amenities and services available at settlements are supportive for tourism activities in the region.

Table 17. Potentiality characteristics for tourism

Potentiality classes	Area		Potentiality characteristics	Remark
	km^2	**%**		
Very high tourism potential	384.26	12.86	The white sandy beaches are the main attraction of tourists. The lowland area is suitable for the coastal tourism activities. The gentle slope (<5º) on shoreline is the significant morphological element for development of coastal tourism. The distance from the river channel (<1km) of the tourist places is attraction of tourists. The water source availability in the region supports to the development of tourism activities. The cultural and historical places are the attraction points of tourists. The accessibility and connectivity in the region is suitable for these activities. Ideal size of settlements for this activities observed in the region. Adequate amenities including service and facilities also observed in this region.	Sandy beaches are the main attraction points of a tourist in the region. The lowlands with gentle slope are more suitable for these activities. Efficient road network with different amenities is supportive for tourism in the region.
High tourism potential	761.86	25.49	The rocky beaches are the suitable morphological characteristic for the tourist activities in this region. The moderate elevation and slope is suitable for tourist movements in the coastal area. One to three km distance from river channel of the tourist places is potential quality for the development of tourism activities. The dense evergreen vegetation and the area under building are suitable lands for tourism. The cultural and historical places observed in the region. The accessibility and connectivity in this region is moderately suitable for tourist activities. The size of settlements is suitable for these activities. The amenities and facilities for tourism managed well in this region.	The physical features including cliffs, rocky platforms, headlands, hilltops with suitable slopes, river channels and evergreen forest are main tourists' attraction points in this coastal region. The cultural and historical places are favorable for the development of tourism activities in the area from this class. The local people and local self-government will be helpful for development of amenities and facilities for tourism development in the region.
Moderate tourism potential	1612.67	53.95	The rocky coastline with blackish characteristics is moderately suitable for the tourism activities. The highlands with steep slope (25-35º) are moderately suitable for these activities. The distance from river channel (3 to 6 km) to the tourist places is moderately attractive for the tourists visiting in the region.	The seacoast, mangrove vegetation and mango and coconuts orchards are main attraction points for tourist visiting in the region. The cultural and historical place also suitable tourism points. The moderate road network facilities are available in this region. Therefore, road

			The sparse vegetation and agriculture are moderately suitable for the tourism activities. The cultural and historical places are moderately attractive for tourists observed in this coastal area. The size of settlements observed moderately suitable. The amenities poorly managed in this coastal zone.	network facilities with good amenities will improve the tourism potentials in the region development.
Less tourism potential	230.21	7.70	The seacoast with headlands and cliffs is main attraction point of tourism. The very high elevation and slope are suitable for tourist activities like hill station camping, tracking, mediation camp, etc. The tourist places in the region are far away from river channel (> 6 km). The barren and open lands are useful for various tourism activities. Some cultural and historical places observed in this region. The accessibility and connectivity is poor but suitable for local tourism. Small size settlements observed in the region. Amenities and basic facilities poorly managed in the region.	The hilltops with steep slope are suitable for the tourism activities in the region. The improved road network with good services and facilities are major requirements for development of tourism activities in the region. The tourism adventure campaign, training programs for boating, fishing, communication, etc. will be helpful for tourism development of in this region.
Total	2989.00	100.00		

4.3 Moderate Tourism Potentials

The area with moderate tourism potentials estimated about 54.62% (1612.68km^2) (Table 17). The highland areas with steep slope (25-35^o) are suitable for the tourism activities (Figure 12) in this region. The river landscape features and vegetation cover are attraction points of tourists. This area show rich biodiversity, wildlife-watching, scuba diving. Therefore, the researchers and scholars are visiting the area for study of rare species, medicine plants, botanical species, orchards of coconuts, mango as well as other flora and fauna. The traditions like Jakhadi, Dhanagari Palkhi dance, ganesh festivals, *holi* festivals, fish-food festivals, mango festivals, etc., are attractions in the region for tourists. Availability of railway network is the advantage for this region for development of these activities. The size of settlements is unique for providing home based facilities for tourism like dinner, lunch, logging, parking facilities, etc. Therefore, local people can participate in this business with home base tourism management and planning development.

4.4 Less Tourism Potentials

The foothill and hilltop areas of Sahyadri is classified (7%, 193.92km^2) in this class (Table 17). The hilltops with steep slope (>35^o) are suitable for trekking, adventure camping, meditation camps, aerial views, etc. (Figure 12). The barren and open lands are also visiting areas of scholarly visitors for study of flora and fauna. The rainfall in monsoon season observed more in foothill and hilltop areas. The Vasishthi river is important source of water for agriculture, industrial and drinking purposes. The navigation observed in mouth section for fishing purposes. The tourists are visiting some cultural and historical places, however connectivity and accessibility observed poor. Therefore, development of road and railway network is helpful for improvements in the activities. The local people can participation in the tourism activities but they are facing the problems like steep slope, small size settlements, language barrier, transport facilities, etc. Therefore, tourism awareness in local people and development of infrastructural facilities will be helpful for development of tourism activities in the seacoast area with natural beauty, environmental suitability and natural resources.

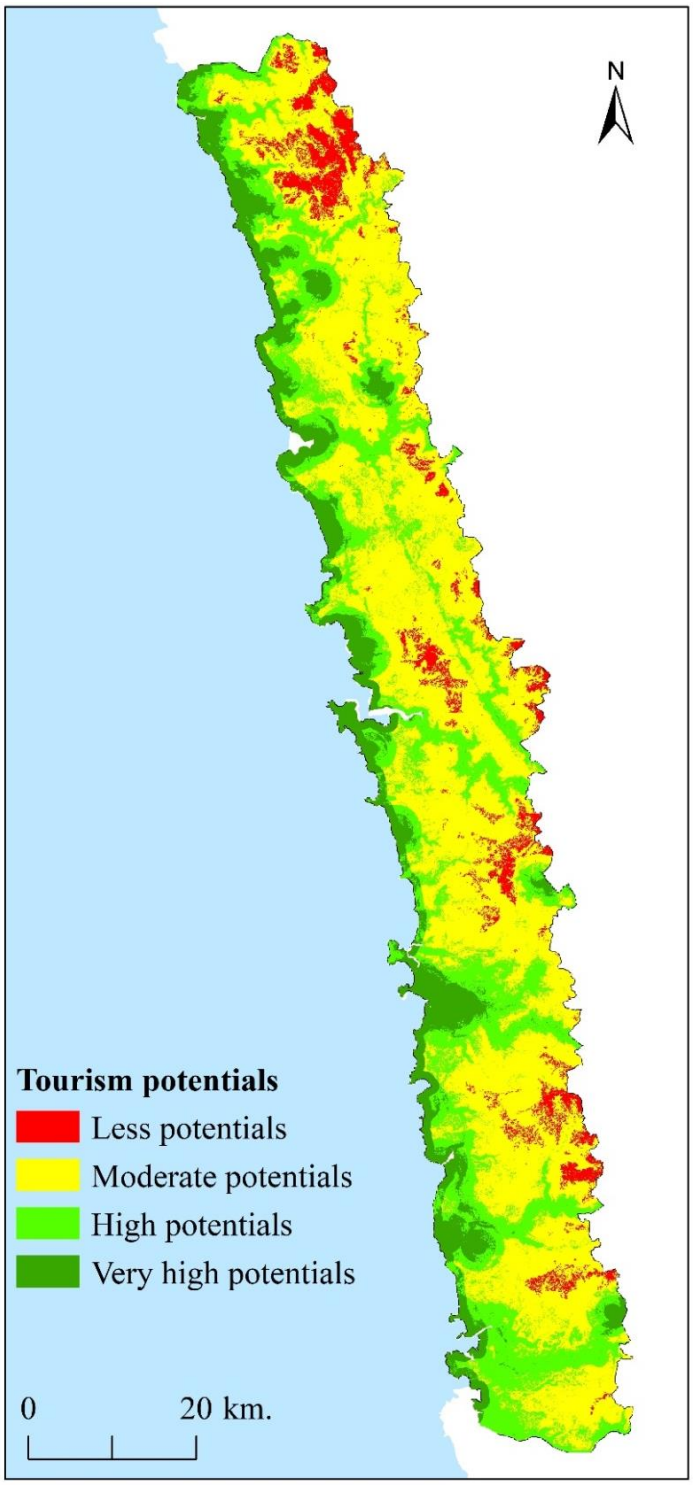

Figure 12. Tourism potentials

5 CONCLUSIONS

The AHP based MCDA techniques used for detection and delineation of the tourism potential zones in the coastal area of Ratnagiri district in Maharashtra (India). The conventional and satellite data viz. ASTER data was used the analysis in GIS software including Arc GIS (10.2), Global Mapper and ERDAS software. Seacoast, elevation, slope, river, LULC, available amenities, accessibility and connectivity, cultural and historical places and density of settlements used as criterion for the detection of tourism potential zones. The experts' opinions, literature survey and fieldwork used as the source of information for selection of criterions and determination of ranks. The weighted

overlay techniques used for the determination of score for selected criterions to find the comparative levels of tourism potentials: very high, high, moderate and less tourism potentials. About 13% of TGA show comparatively very high tourism potential, 25.80% show high, 54.62% moderate and 6.57% show less tourism potential for tourism. The overall accuracy of the categorized map is estimated 89.60%. The producers' accuracy was estimate 94.55% for very highly suitable and 86% for less suitable areas whereas users' accuracy was 96.30% for very highly suitable and 86% as less suitable area for tourism activities. The thematic maps viz. amenities and settlement were processed using inverse distance weighted (IWD) interpolation technique. Therefore, some areas from highly suitable category merged in the category, 'moderate suitable' and reduced producer's accuracy of the classified map about 87.80%. About 87.80% producer's accuracy and 86.87% users' accuracy estimated for highly suitable area whereas 90.48% accuracy estimated for moderate suitable area as users' and producers' perspectives. The sandy beaches, lowland area with gentle slope, river landscape features, road network, cultural and historical places, ideal size of settlement and number of amenities are attractions of the area classified into the class, very high potential of tourism. The class, 'high tourism potential' show the rocky beaches, moderate elevation with suitable slope, river landscape, healthy flora and fauna, traditional and historical places, good road network, ideal size of settlements and enough availability of amenities and services. The highlands with steep slope, river and healthy vegetation are main attractions of the class with moderate tourism potential. The high elevation with steep slope, poor road and railway network are disadvantages for the tourism activities in the class less suitable. The technique used in the study can be an effective apparatus for precise analysis of sites suitability for tourism activities.

ACKNOWLEDGMENTS

Anonymous reviewers thanked for useful comments and suggestions to improve the manuscript.

ABBREVIATIONS

AHP: Analytical Hierarchy Process; **DEM**: Digital Elevation Model; **GIS**: Geographical Information System; **LULC**: Land Use Land Cover; **MCA**: Multi-Criteria Analysis; **MCDM**: Multi-Criteria Decision-Making; **PCM**: Pairwise Comparison Matrix; **SOI**: Survey of India; **TGA**: Total geographical area.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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