Chapter – IV

Valuation of Landscape Units

4.1 Relevance

Landscape is usually established in the record of community goods connected with cultivation and conservation and improvement of natural resources i.e., forest resource, in-situ biota etc. But the particular description of a landscape and by addition its composition and value stay behind the indefinable.

This chapter appraises what is recognized about the perception of landscape and how landscapes are treasured. It does so beginning the standpoint of strategy decision making, which is apprehensive with the requirement for a worth for money confirmation support to direct the allotment of public support for the contributes of landscape as a public possessions.

Generally, the values produced by these learning are exceedingly appropriate, depending on both the landscape and revolutionize anticipated to that landscape. This is a significant peak to make a note of the reason which means that a landscape's "value" as deal with this reading. A more comprehensive appraisal of the entirety monetary value of landscapes therefore has to add these exercise values to the non use values. There can be no assumption on the equilibrium of the value categories wherever. The promoted worth technique employs typical economic practices for computing the economic profit of the ecological components of the study area. The study guesstimates of common value based on subsidiary alteration in ecosystem services to determine the mutual value of total ecosystems. The estimation of the landscape ecological units is intended based on the ecosystem services of the landscapes. Diverse categories of environmental services such as carbon impounding, oxygen creation methane and nitrogen emanation are anticipated in expressions of service excellence of the landscapes. The efficiency of dissimilar land use practices of landscape units such as agricultural land, fishery land, wetlands and other productive lands are considered for the valuation of landscapes.

Economists have developed a multiplicity of procedures for valuing landscape. In this thesis researchers separated the techniques into three types like market-based techniques, revealed preference techniques and stated preference techniques which vary from pure market to non-market based techniques.

4.1.1 Market Based Techniques

Where a profit produces by landscape ecology is a bought and sold straightforwardly in markets research can employ standard economic techniques to guesstimate values for both buyers and sellers. The market price technique employs standard economic techniques for computing the economic profit from marketed goods, based on the amount people procure at dissimilar costs and the amount supplied at different prices.

4.1.2 Revealed Preference Techniques

When market statistics are accessible for goods and services that are in a number of explicit ways interrelated to the landscape ecology value in question, such as the association between the expenses of travel and the number of people visiting a national park, these data can be exercised to suppose values. This approach is described as ‘revealed preference’.

4.1.3 Stated Preference Techniques

The techniques conversed so far are inadequate in their capability to reproduce all the values that landscape ecology has to recommend, in exacting non use or passive use, environmental profits. It is lucid that people are agreeable to recompense for such profits.

Land has two types of value i.e., economical value and ecological value. The present study comprises with both of these two value to consider the land valuation categorization of land so that the management strategies can be formulated as per the need. At the time of repeated field survey present study deals with economic valuation of land by using the pre determined questionnaire survey regarding the agricultural productivity and the production of fishery sectors.

Consequently vegetation biomass calculation has been carried out by Allometric Equation and oxygen production has also been considered through existing methods for calculation of the ecological value of a perticular land.

Coastal population pressure and settlement density has been considered for calculating the market value of a pice of land through Cencus data, 2011. Simultenously land use and land cover change detection has also been incorporated with the present study through Landsat 5 and Sentinel MSI temporal satellite imagery to understand the land use alteration practice and pressure on coastal resources. Accordingly all the value yields have been adding up to develop the ecological and economical valuation of landscape in coastal sectors.

4.2 Valuation of Vegetated Land

4.2.1 Sampling Strategy for Biomass Estimation

The random sampling technique was utilized for sampling the ground vegetation above the surface. Grid method is also exercised, which is one of the largely used for all varieties of vegetation sampling. The method is adaptable, cost effective and appropriate to baseline as well as project setting. As per the Kyoto Protocol norms "Grid Method" is also accepted by the Clean Development Mechanism (CDM) for afforestation and reforestation projects. Present study comprises sixteen (16) grids with 15 m ×15 m grid size which were positioned arbitrarily, determining the indicator parameters (e.g., tree DBH, or height), by means of diverse approaches such as allometric functions to compute the biomass and extrapolating the value per hectare and for the entire project quarter. The subsequent considerations were calculated for estimating the ground biomass pool above the surface plain.

4.2.2 Tree Diameter and Height Measurement

To estimate biomass of different trees, non disparaging method was exploited. The biomass of tree was estimated on the basis of Diameter at Breast Height **(**DBH) and tree height. DBH can be determined by evaluating tree Girth at Breast Height (GBH), in the order of 1.3 meter from the surface plain. The GBHs of trees having width greater than 10 cm were calculated directly by measuring tape. The tree height was considered through the following method which suggested by Pearson et al., 2005 (Annexure 13).

4.2.3 Above Ground Biomass

The Above Ground Biomass (AGB) of tree comprises the entire shoot, twigs, leaves, flowers, and fruits. It is considered through the subsequent formula (Zanne et al., 2009). The AGB of trees comprises the entire parts of plant on top of the soil. The random sampling method was employed for estimating the above ground biomass. The GBHs of trees having width larger than 10 cm were considered directly by measuring tape and elevation of the trees were calculated by using Abney Level Instrument. It is frequently used tree height measuring equipment based on trigonometrically principles. It provides exact angle of elevation and depression. Readings can be taken subsequent to detection the tree without disturbing the index limb. The gadget is miniature and light and can be used even in hills devoid of complexity (Blozan, 2006).

Allometric equations for biomass generally embrace information on stem width at breast height DBH (m), total tree height H (m), and wood density (kg/m^3). The unit of the AGB approximated from the allometric equation is the kilogram (kg). AGB is considered using the following formula:

$$\text{AGB (kg/tree)} = \text{Volume of tree } (m^3) \times \text{Wood density } (kg/m^3)$$
$$= \pi\, r^2 H\, (m^3) \times \text{Wood Density } (kg/m^3)$$
$$= (GBH)^2 / 4\pi \times H \times \text{Wood density } (kg/m^3)$$

Where,

r = Radius of the tree (m) = GBH/2π

H = Height of the tree (m)

Wherever, the wood thickness of tree variety was unavailable, the standard average value 0.6 gm/cm^3 were taken (Warran and Patwardhan, 2008; Zanne et al., 2009).

4.2.4 Below Ground Biomass

The Below Ground Biomass (BGB) contains all biomass of existing roots apart from fine roots having < 2 mm diameter. The belowground biomass has been intended by multiplying the above ground biomass by 0.26 factors as the root: shoot ratio (Ravindranath and Ostwald, 2007). For the estimation of carbon stock of major tree species, non destructive method was used. The biomass of trees was estimated on the basis of GBH and tree height.

The Below Ground Biomass (BGB) under the ground surface comprises all biomass of living roots not including fine roots having < 2 mm diameter. The BGB has been designed by multiplying AGB by 0.26 factors as the root: shoot ratio. BGB is considered by particular following formula BGB (kg/tree) or (ton/tree) = AGB (kg/tree) or (ton/tree) × 0.26 (MacDicken, 1997; Hangarge et al., 2012).

4.2.5 Total Biomass

Total biomass of trees was designed by sum of AGB and BGB of trees. The Total Biomass of trees was considered through the following method (MacDicken, 1997; Sheikh et al., 2011). Total biomass (kg/tree) or (ton/tree) = AGB + BGB (Table 4.1).

4.2.6 Carbon Estimation

Normally, for any floral species mainly tree species 50% of its biomass is measured as carbon (Pearson et al., 2005) i.e., Carbon storage = Biomass × 50% or Biomass/2. On average one tree fabricates almost 260 pounds of oxygen per year (260 pounds = 117.934 kg) (ThoughtCo, 2018). According to the NASA a person needs on an average 0.84 kg oxygen per day. So, computation throughout the year is (0.84 kg × 365 day) = 306.6 kg oxygen per year (Quora, 2016). A person's generated approximately 450 litres (roughly 900 grams) of carbon dioxide per day (0.9 gram × 365 days) = 328.5 kg per year through his respiration process (Quora, 2012). An emergent plant of tree would generates oxygen in ratio to the carbon retrained in the biomass, if the 1 particle of carbon is reserved then 1 molecule of oxygen is created, i.e., if 1 kg of carbon is engaged in the biomass 2.67 kg oxygen is formed (Quora, 2017).

Table 4.1: Calculation of vegetation biomass from field survey data (November, 2017).

Grid No.	No. of tree present in the grid	Average GBH (cm)	Average tree height (m)	Above ground biomass (ton/tree)	Below ground biomass (ton/tree)	Total biomass (ton/tree)	Total biomass (ton/grid)	Organic carbon (ton/grid)
1	60	45.72	14.99	0.1496	0.0388	0.1884	11.30	5.655
2	35	63.50	7.89	0.1519	0.0394	0.1913	6.69	3.345
3	110	27.94	10.25	0.0382	0.0099	0.0481	5.29	2.645
4	45	30.48	6.95	0.0308	0.0080	0.0388	1.75	0.875
5	55	55.88	11.02	0.1642	0.0427	0.2069	11.38	5.690
6	72	50.80	9.61	0.1184	0.0307	0.1491	10.74	5.37
7	16	58.42	5.19	0.0845	0.0219	0.1064	1.70	0.850
8	21	55.88	8.52	0.1270	0.0330	0.1600	3.36	1.680
9	70	17.78	5.38	0.0081	0.0021	0.0102	0.57	0.285
10	30	63.50	8.49	0.1634	0.0424	0.2058	6.18	3.090
11	75	25.40	6.45	0.0198	0.0051	0.0249	1.87	0.935
12	105	33.02	4.12	0.0214	0.0055	0.0269	2.83	1.415
13	35	40.64	8.16	0.0643	0.0167	0.0810	2.84	1.420
14	58	30.48	10.67	0.0473	0.0123	0.0596	3.46	1.730
15	70	45.72	8.43	0.0841	0.0218	0.1059	7.42	3.710
16	150	38.10	7.45	0.0516	0.0134	0.0650	9.75	4.875

Each grid is considered 15 m ×15 m (225 m^2)

Plate 4.1: Tree height and tree girth measurement for biomass estimation.

Subsequent to the standard classification of the maritime floral species (such as, vegetation of the low lying coastal stretches, vegetated beach ridge facade with inclined planes and older natural levees and ridge crest vegetations) which have been mentioned above chapter in Fig. 3.8. A number of probable sampling positions are preferred to accumulate the data for the vegetation biomass computation based on the field situation.

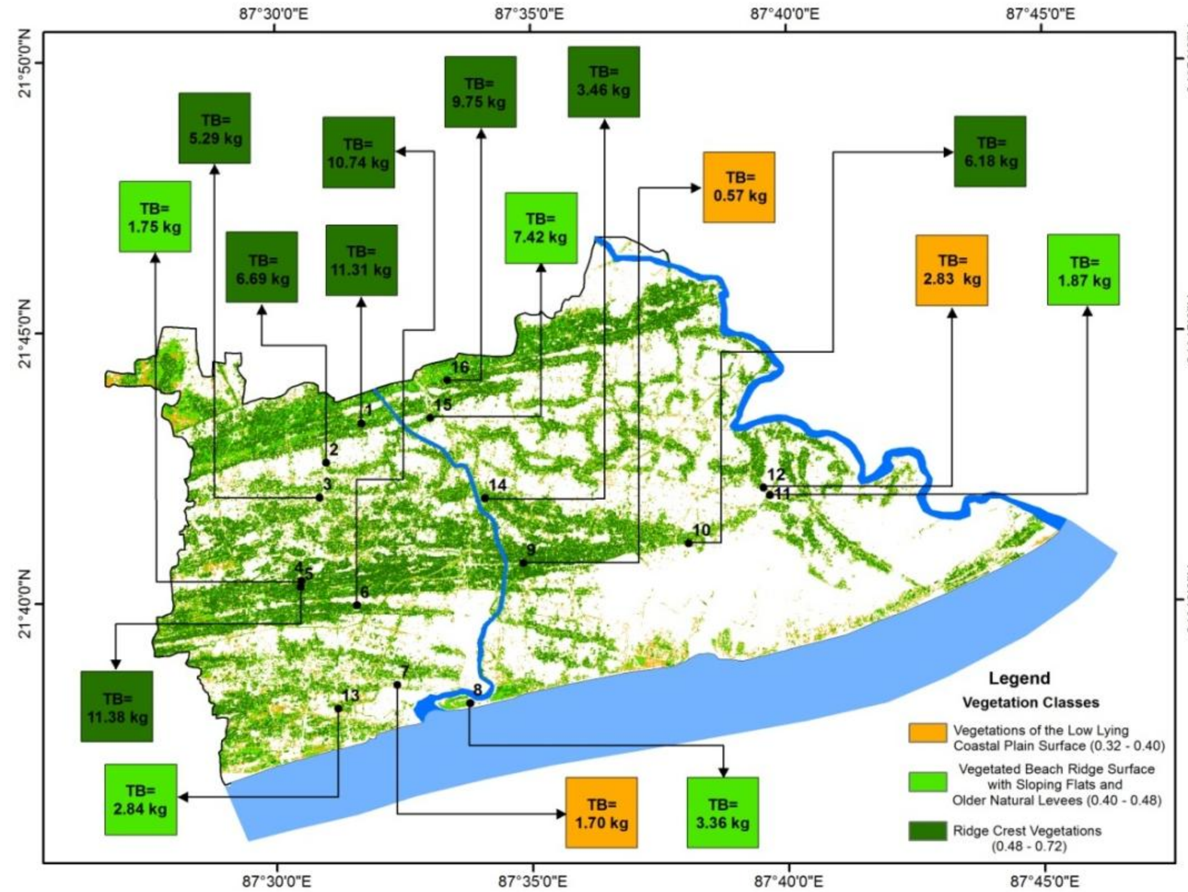

Fig. 4.1: Field survey location and amount of total biomass of different vegetated surface.

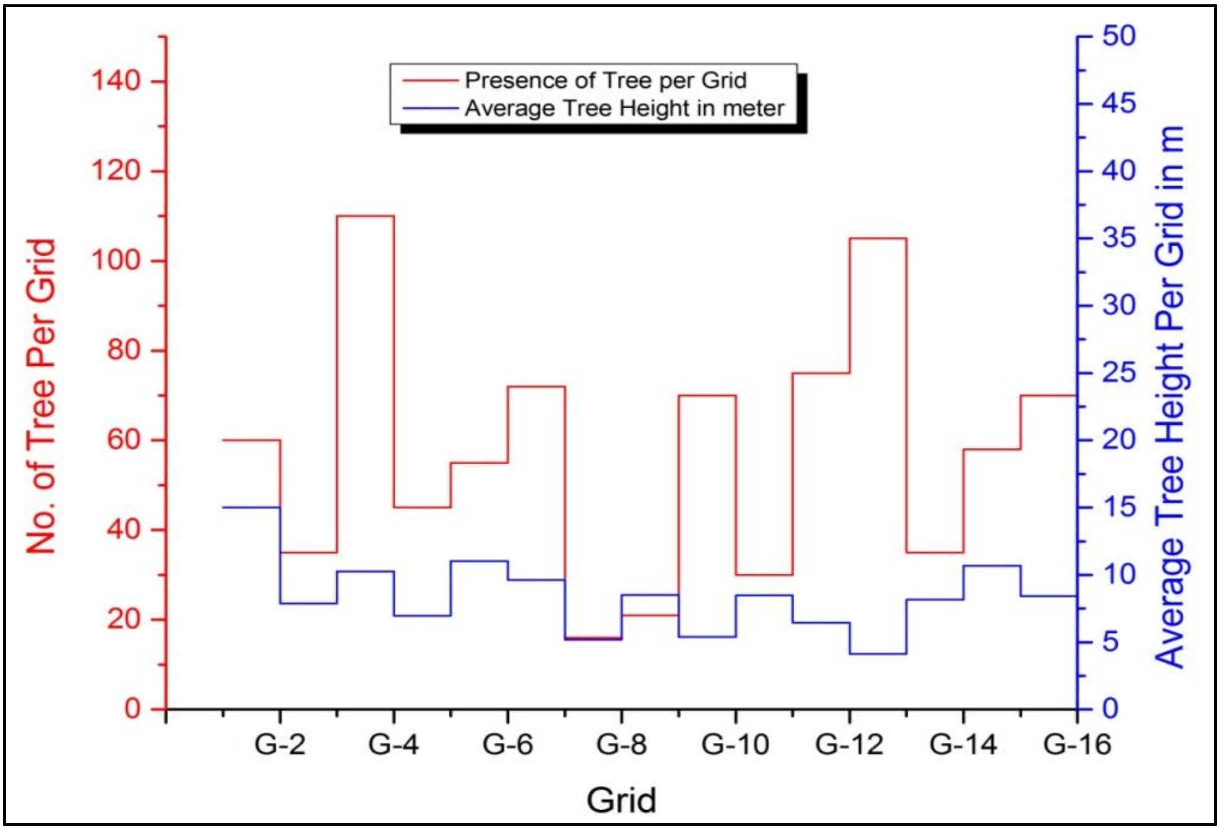

Fig. 4.2: Comparison between Presence of tree and Height of the tree per grid.

Accordingly, the sixteen (16) sampling sites have been considered for the AGB and BGB assessment of the province, which is almost, certainly covered the whole section of vegetated zone (Fig. 4.1).

Grid wise existence of tree species and height of the tree are conspires against each other to understand of equitability of the vegetations (Fig. 4.2). Where the quantity of trees are augmented the average height of the trees are steadily amplified in between Grid-1 to Grid-7. This indication implies that the areal exposure of the province is occupied dense type of vegetation and the occurrence of well succession of vegetation. Alternatively Grid-8 to Grid-16 shows the mixed or bush type of vegetation because there are no identical between occurrence of tree and height of the tree (Plate 4.1).

4.2.7 Fuel Wood Estimation

After the computation of total biomass and organic carbon of every grid, the concerned data are integrated to the three types of vegetation species for the assessment of the ecological services of the vegetated land. To consider the economical output of the vegetations, fuel wood value is estimated in each and every grid (Annexure 14). To calculate the amount of fuel wood of a particular tree, the volume of that tree has to be measured through the integration of radius and height of the tree (Blozan, 2006).

Plate 4.2: Land use alteration at inter dune flat areas (deforestation for vegetable gardening).

Tree volume mainly volume of the wood is broadly used determination process of wood quantity and is frequently anticipated for the appraisal of economic value or commercial exploitation potential. The wood volume of a tree incorporates trunk, branches, remnant and roots. Volume is generally anticipated for eminence trees from such dimensions as width, or diameter plus merchantable height, using a volume equation or a log rule.

Volume may be calculated directly on cut down trees or logs, but is frequently anticipated from dimensions such as smallest amount diameter or piece length (Plate 4.2). Direct measurement of volume is typically done by sectioning the tree into smaller pieces unspecified to be cylinders.

Eucalyptus is usually quite large trees and accomplishes a height of 40-60 feet and a width of 40-45 inch. The stem of the tree is normally straight and comprises with half of the total height. Wood is buying back with rate of kg 5-6 Rs. /kg 300-400 kg/tree in 4-5 years (Agropedia, 2017).

Table 4.2: Grid wise calculation of vegetation biomass and quantity of fuel wood.

Grid No.	Vegetation Types	Total Biomass in ton/225 m^2 grid/year	Organic Carbon Retained in ton/225 m^2 grid/year	Oxygen Production in ton/225 m^2 grid/year	Total Fuel Wood Production in ton/225 m^2 grid/year
1 2 3 5 6 10 14 16	Ridge crest vegetations (53000000 m^2 or 53.00 km^2)	8.1 ton	4.05 ton	10.81 ton	0.66 ton (663.79 kg)
4 8 11 13 15	Vegetated beach ridge surface with sloping flats and older natural levees (47594800 m^2 or 47.59 km^2)	3.51 ton	1.724 ton	4.60 ton	0.28 ton (282.52 kg)
7 9 12	Vegetation of the low lying coastal plain surface (29544600 m^2 or 29.54 km^2)	1.7 ton	0.85 ton	2.27 ton	0.14 ton (143.59 kg)

According to IMD, 2014 annual rainfall of Ramnagar-I and II Blocks are [Pre Monsoon 132.4 mm (March to May), Monsoon 1157.8 mm (June to September), Post Monson 89.0 mm (October to December) and Winter 47.8 mm (January to February)] estimated as 118.92 mm (119 mm). The ground water recharge competence of vegetated land is 0.27 million gallon/ha/year (10,33,355 litre/ha/year). It is anticipated that, 55 inches of average annual recharged is about to 830 million gallons per square mile per year (Hampton, 1963). Organic carbon reserved capability; oxygen production and fuel wood consumption ton/ha/year are very high in ridge crest vegetation areas than other types of vegetation (Table 4.2, 4.3).

Table 4.3: Ecological and economical services of coastal vegetated surface/ha/year.

Ecological factor	Ridge crest vegetations	Vegetated beach ridge surface with sloping flats and older natural levees	Vegetation of the low lying coastal plain surface
Organic carbon retained (ton/ha/year)	180 ton (1,80,000 kg)	76.6 ton (76,600 kg)	37.77 ton (37,770 kg)
Oxygen production (ton/ha/year)	480.6 ton (4,80,600 kg)	204.58 ton (2,04,580 kg)	100.86 ton (1,00,860 kg)
Ground water recharge (litre/ha/year)	0.27 Million gallon (10,33,355 Litre)		
Wood fuel (ton/ha/year)	29.50 ton (29,500 kg)	12.56 ton (12,560 kg)	6.38 ton (6,380 kg)
(1 ton = 1,000 kg); (1 Million gallon = 3785411.8 Litre); (1 Hectares = 10,000 Square meters)			

Finally, the ecological and economical values are calculated of three types of vegetation of the studied area. However, the economical and ecological services of the lands are converted into rupees/ha/year and prices of carbon Rs. 30/kg (Indiamart, 2018c), Oxygen Rs. 493/kg (Sigma-Aldrich, 2018), Drinking water Rs. 6/liter (Indiamart, 2018d) and Fuel wood Rs. 5/kg (Agropedia, 2017). Ridge crest vegetations occupy the more ecological services and more economical value than other category of vegetation (Table 4.4).

Table 4.4: Estimation of ecological and economical valuation in Rs./ha/year.

Ecological and economical parameters	Ridge crest vegetations (ha/year)	Vegetated beach ridge surface with sloping flats and older natural levees (ha/year)	Vegetation of the low lying coastal plain surface (ha/year)
Market value of organic carbon (Rs. 30/kg)	Rs. 54,00,000	Rs. 22,98,000	Rs. 11,21,100
Market value of oxygen production (Rs. 493/kg)	Rs. 23,69,35,800	Rs. 10,08,57,940	Rs. 4,97,23,980
Market value of ground water (Rs. 6/litre)	Rs. 62,00,130	Rs. 62,00,130	Rs. 62,00,130
Total ecological value (Rs./year)	**Rs. 24,85,35,930**	**Rs. 10,93,56,070**	**Rs. 5,70,45,210**
Market value of wood fuel (Rs. 5/kg)	Rs. 1,47,500	Rs. 62,800	Rs. 31,900

4.3 Valuation of Agricultural Lands

To calculate the agricultural productivity of the land of the study area, twenty (20) sample survey sites have been preferred to collect the production of single and double cropping cultivated field (Annexures 15, 16) and the spatial zonation of sample sites are being mapped in a scientific manner to cover the entire study area (Fig. 4.3). Repeated respondent survey has been conducted in the month of March in every year during four years (2014 to 2018) for this study.

The production of paddy is calculated in quintal of both cropping land of the region and this production of paddy converted into the market value in rupees. However, the productivity capacity of double cropping land is Rs. 14,659 /Bigha/year and the productivity capacity of single cropping land is Rs. 6,800 /Bigha/year (Annexure 17). So, the average productivity capacity of paddy field is Rs. 10,729 /Bigha/year. Accordingly the paddy production in Bigha is converted to per ha/year for the estimation of the economic value of agricultural land.

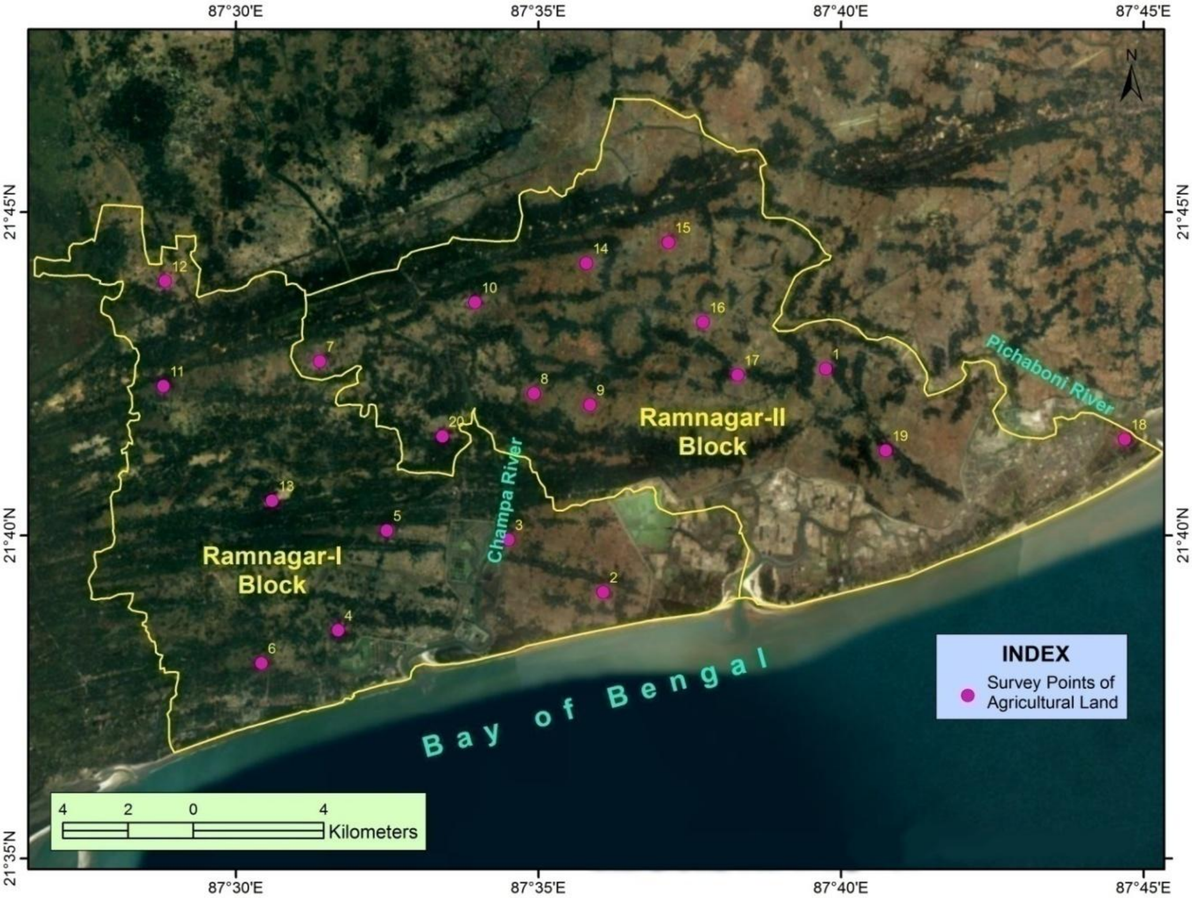

Fig. 4.3: Location of the agricultural sampling sites.

After the computation of economical value of the agricultural land per/ha/year, the ecological services of agricultural lands are estimated later on through different steps. Average carbon storage potential of agro forestry practices (rice field) is anticipated at an around 50 ton/ha/year in humid region (Montagnini, 2004). Ground water recharge from paddy fields absorbs about 42% (443 million m^3 per year) of the total recharge to the shallow aquifer and the total paddy field area of the region is 15,000 ha, out of which around two thirds are irrigated by groundwater and the mean annual rainfall of the area is about 1500 mm (Elhassan, 2003). Consequently the ground water recharge capacity of paddy field is calculated 2,48,179.2 liter/ha/year.

Assessment of Methane (CH_4) in wet phase is 41.8 g/m^2/year (418 kg/ha/year) and irrigation phase is 15 g/m^2/year (150 kg/ha/year) (Purkait et al., 2005). So, average methane emanation of paddy cultivation is 284 kg/ha/year and the amount of Nitrous Oxide (N_2O) emission from rice field is 250 kg/ha/year (Tang et al., 2018).

For the valuation of the landscapes the ecological services are transferred in the prices of market value. The market value of nitrogen and methane is Rs. 230/kg (Indiamart, 2018a) and Rs. 3,900/kg (Indiamart, 2018b) where the value of carbon and drinking water is already estimated above. The Agricultural lands have a capacity of high carbon storage and ground water recharge which reflects the high economic value of the land than other ecological services (Table 4.5). So, the agricultural land gives the much more ecological services than economic production.

Table 4.5: Ecological and economical valuation of agricultural land in Rs. /ha/year.

Ecological input	Single or double cropping paddy field	Market value per kg	Total economic value in rupees
Carbon storage kg/ha/year	50,000 kg (50 ton)	Rs. 30/kg	Rs. 15,00,000
Nitrogen emission kg/ha/year	250 kg (0.25 ton)	Rs. 230/kg	Rs. 57,500
Methane emission kg/ha/year	284 kg (0.284 ton)	Rs. 3,900/kg	Rs. 11,07,600
Ground water recharge litre /ha/year	2,48,179.2 Litre	Rs. 6/Litre	Rs. 14,89,075.2
Total ecological value			**Rs. 41,54,175.2**
Economical value			**Rs. 52, 982.72**

4.4 Land Valuation of Fishery Land

Different types of fishing activity have been taken place in the back shore areas of the Digha-Sankarpur coastal tract of the study area. According to the practices of fishing activities it can be classified into different way such as commercial fishing, subsistence fishing in the coastal wetlands, village pond fishing, open marine fishing and abandoned fishing in the wetlands. For the understanding of the annual fish production of such types of activities, respondent survey techniques are utilized of each and every plot through the pre designed questionnaire sheet (Annexures 18, 19, 20, 21) in the month of March, 2017. Total forty three (43) sample sites are selected for surveying the existing fishery plots and repeatedly respondent survey are continuing for validate the statement of the respondent (Annexure 22). The location of sample sites of different fishery plot such as, commercial fishing, subsistence fishing in the coastal wetlands, village pond fishing and open marine fishing are demarcated through mapped for the better understanding of the region (Fig. 4.4). Annual profit of the fishing activities has been estimated on the basis of simulation process of repeated respondent survey.

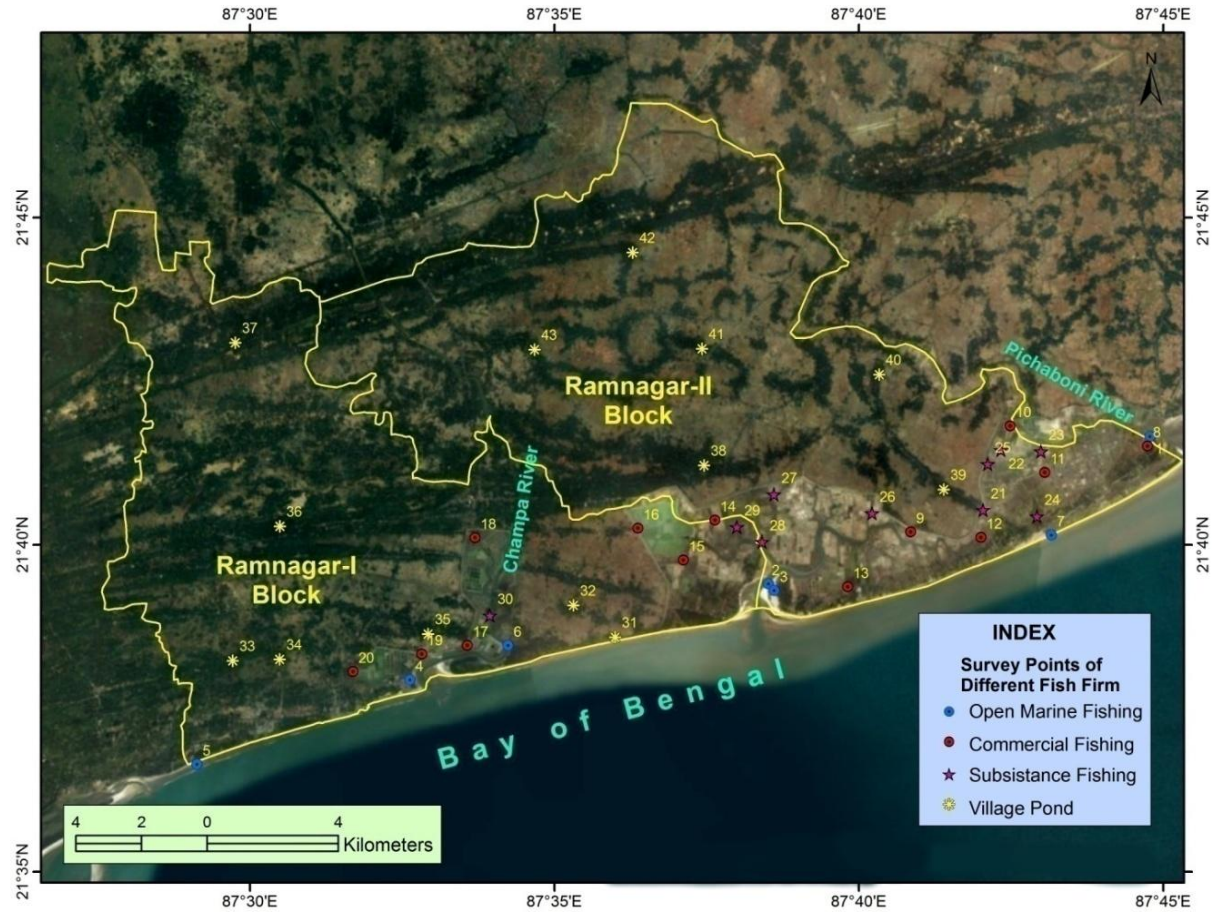

Fig. 4.4: Location of the sample sites of different fishery plots.

The economic values of the village pond fishing, commercial fishing and subsistence fishing in the coastal wetlands are calculated and result are as follows Rs. 11,04,841; Rs. 14,00,000 and 1,23,621 per/ha/year consecutively (Tables 4.6, 4.7, 4.8). Accordingly the economic valuation of the fishery land the fish production is also converted into the market value in rupees. The commercial fishery sector gives the much more economical value other than the village pond fishing and subsistence fishing in the coastal wetland areas.

Table 4.6: Estimation of yearly production in village pond fishing.

Total area of the village pond (ha)	Investment for fishing in one year (Rs.)	Production of fish in one year (quintal)	Market value of captured fish per kg (Rs.)	Total production in one year (Rs.)	Annual profit of fishery (Rs.)
1	1,85,159	86	150/kg	12,90,00	11,04,841

Table 4.7: Estimation of yearly production in commercial fishing (Plate 4.3).

Total area of the fishery (ha)	Investment for fishery in one year (Rs.)	Production of fish in one year (quintal)	Market value of captured fish per kg (Rs.)	Total production of fishery (Rs.)	Annual profit of fishery (Rs.)
1	56,00,000	175	400/kg.	70,00,000	14,00,000

Plate 4.3: Surveying of commercial fishing at Dadanpatrabar and Dakshin Purushottampur Village, 2017.

Table 4.8: Estimation of yearly production of subsistence fishing in the coastal wetlands (Plate 4.4).

Total area of the fishery (ha)	Investment for fishery in one year (Rs.)	Production of fish in one year (kg)	Market value of captured fish per kg (Rs.)	Total production of fishery (Rs.)	Annual profit of fishery (Rs.)
1	2,46,879	988	375/kg	3,70,500	1,23,621

Plate 4.4: Surveying of subsistence fishing in coastal wetlands at Dadanpatrabar and Sonamuhi Village, 2017.

The commercial fish firm and subsistence fishery lands are basically practices in the wetland areas of the coastal stretch. Moderate altitude embankments are usually installed for the protection of the wetland from other interruption of the different anthropogenic activities. To demarcate the sensitive location of the fishery plots a map has been prepared for the studied coast (Fig. 4.5). Areas of the abandoned fishing, commercial fishing and subsistence fishing in the coastal wetlands are 18.02 km^2, 10.84 km^2 and 4.09 km^2 out of 53.50 km^2 respectively (total area of the wetlands).

The open marine fishing activities are basically observed in six (6) major sites of the Ramnagar-I and II Administrative Blocks. The repetitive survey has been conducted (March, 2017) on these sites among the fisherman, who goes to the deep sea for capturing the marine fish. The response of the fisherman in every boat is recorded (amount of capturing fish) in one operation (Annexure 23).

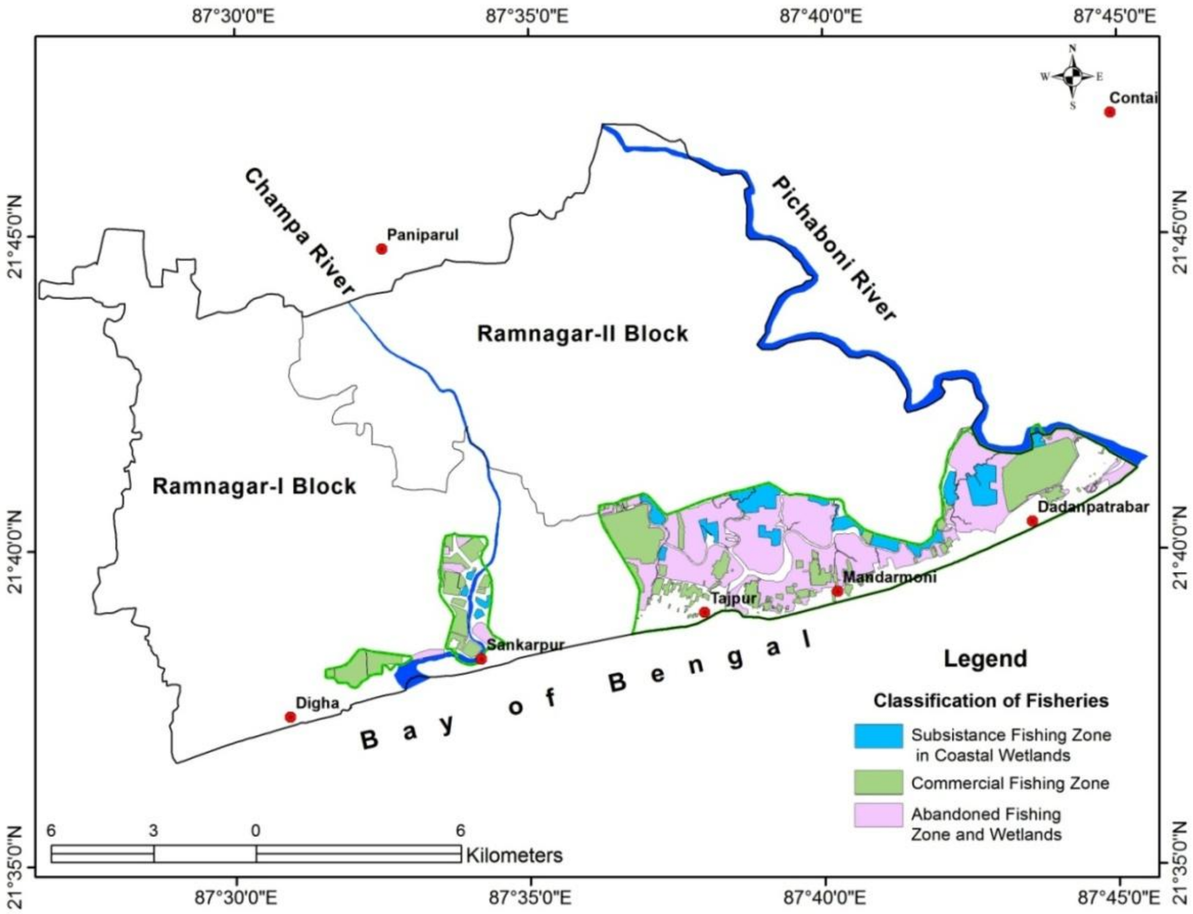

Fig. 4.5: Spatial distribution of different fisheries sector.

After the collection of field data in one operation of individual sites, the amount of captured fish are assimilated in one year. However, fishermen of this area are generally conducted 36 operations in one year; accordingly the annual captured fishes are estimated and converted in a market value in every site (Table 4.9). The annual profit of the open marine fishing in Sankarpur sector is much higher than other sites and the low profit shows the Jaldha Mohana sector.

Table 4.9: Estimation of yearly production in open marine fishing (Plate 4.5).

Fishing sector	Profit for one operation in Rs.	Profit for one year in Rs. (36 operation/year)
Udaipur Sector	8,000	2,88,000
Digha Mohana	85,000	30,60,000
Sankarpur Sector	4,20,000	1,51,20,000
Jaldha Mohana	3,500	1,26,000
Dadanpatrabar Sector	60,000	21,60,000
Soula River Mouth	90,000	32,40,000

Plate 4.5: Surveying of open marine fishing at Sankarpur and Jaldha Mohana sector, 2017.

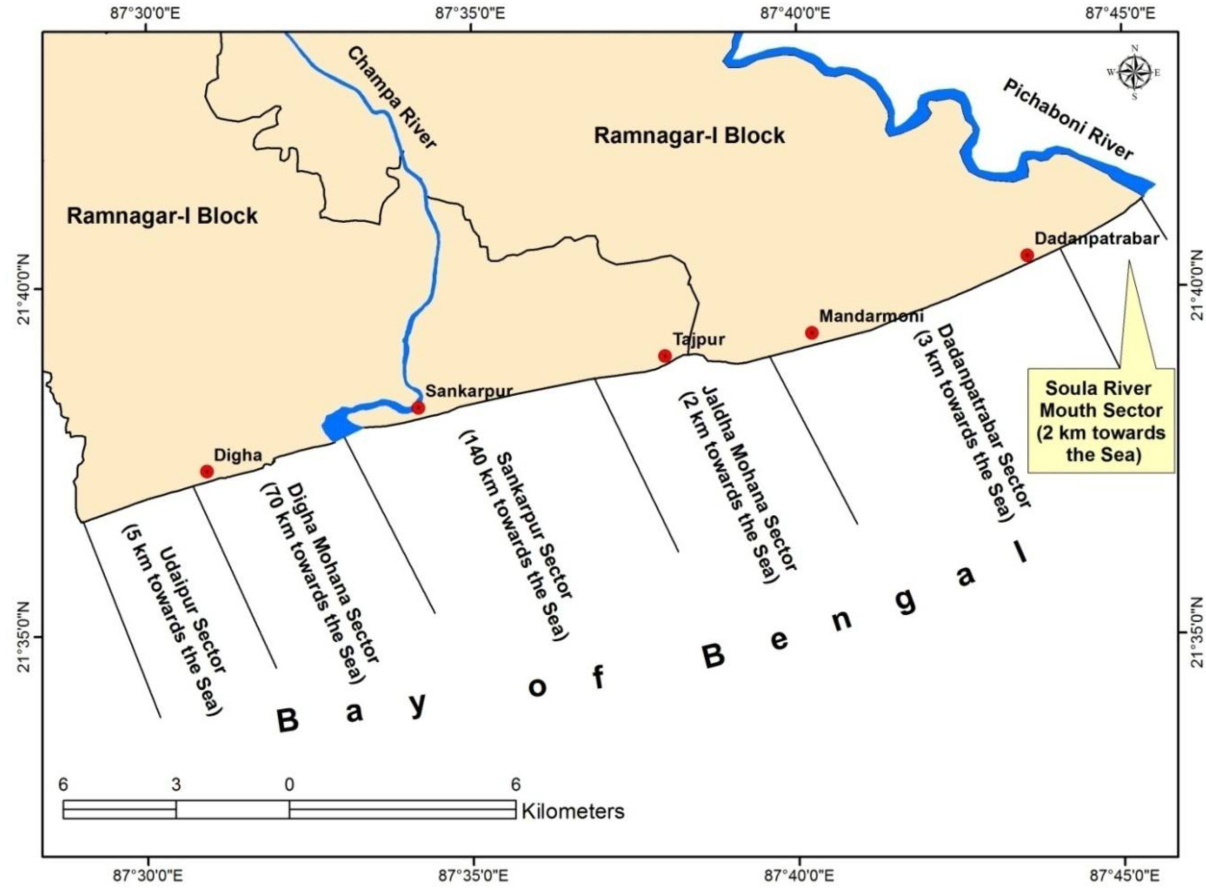

Fig. 4.6: Seaward extension of the open marine fishing.

The zonation of the open marine fishing sectors (e.g., Udaipur Sector; Digha Mohana; Sankarpur Sector; Jaldha Mohana; Dadanpatrabar Sector and Soula River Mouth) and the movement distance for marine fish capturing from the harbor to seaward side is stated in km (Fig. 4.6) and directed in the map.

Coastal wetlands provide a good ecological service and play a significant role for environmental adjustment of the coastal environment. Different types of major ecological services are identified in this particular region. The depressional wetland or swamp are sequestered an average 317 gm carbon/m^2/year (Climate Citizen, 2012). In case of brackish water methane fluxes 13.8 gm/m^2/year (Holm et al., 2016) and coastal wetlands receive nitrogen 1,500 kg/ha/year (Waquoit Bay, 2018). All the ecological services are converted to the market value for assessing the ecological valuation of the coastal wetlands of this region (Table 4.10).

Table 4.10: Ecological valuation of different fish firm plots in Rs. /ha/year.

Ecological parameters	Depressional wetland, brakish water and swamps area	Market value in Rs. Per kg	Total economic value in Rs.
Carbon sequestration kg/ha/year	3,170 kg.	30/kg	95,100
Nitrogen receive kg/ha/year	1500 kg.	230/kg	3, 45,000
Methane emission kg/ha/year	138 kg.	3,900/kg	5,38,200
Total ecological value			**9,78,300**
(1 Hectares = 10,000 Square meters/0.01 Square kilometres); (1 Square kilometres= 100 Hectares)			

4.5 Final Ecological and Economical Valuation of Coastal Landscape Units

Identification of different landscape units like vegetated land, coastal wetland and agricultural land for economical as well as ecological valuation estimation and comparative ecological service of different landscape/ha/year shows that vegetated land's carbon sequestration is very high than other land unit on the other hand coastal wetland has a greater power of nitrogen receive capacity than other two. Total biomass of ridge crest vegetation is very high throughout the present study area and economically commercial fishing is much more significant than other economic activities of present study area (Table 4.11).

Table 4.11: Ecological and economical valuation of coastal landscapes units /ha/year.

Valuation of landscape units (per/ha/year)	Ecological services in Rs.	Economic services in Rs.	Total value in Rs.
Ridge crest vegetations	24,85,35,930	1,47,500	24,86,83,430
Vegetated beach ridge surface with sloping flats and older natural levees	10,93,56,070	62,800	10,94,18,870
Vegetation of the low lying coastal plain surface	5,70,45,210	31,900	5,70,77,110
Agricultural land (paddy field)	41,54,175.2	52, 983	42,07,157.92
Village pond	9,78,300	11,04,841	20,83,141
Subsistence fishing in the coastal wetlands	9,78,300	1,23,621	11,01,921
Commercial fishing	9,78,300	14,00,000	23,78,300

The valuation of ecological services indicates high estimated values of diversified vegetated areas of the coastal belt, and economical services on the other side indicates the estimated higher values in favour of commercial fish farming plots and open marine fishing sectors of the sea shores. However, the study also shows the lowest values of agricultural rice paddy fields of the region.

4.6 Land Use / Land Cover Change Detection Analysis between 1990 and 2017

Land use /land cover (LU / LC) alteration is the most significant anthropogenic driver of environmental adjustment on all spatial and temporal scales. These transformations include the furthermost environmental apprehensions of human populations today, together with climate change, biodiversity loss and the pollution of water, soils, and air. LU / LC can generally point out the modification of the eco-environment of the area. LU / LC of the Earth is altering considerably for the reason of human behavior and natural catastrophes. Information regarding alteration is helpful for bringing up to date LU / LC maps for scheduling and management of natural resources. Coastal zones are most susceptible for land use alterations in this rapid industrialization and urbanization period. It is indispensable to appraise LU / LC alteration to develop competent management approaches.

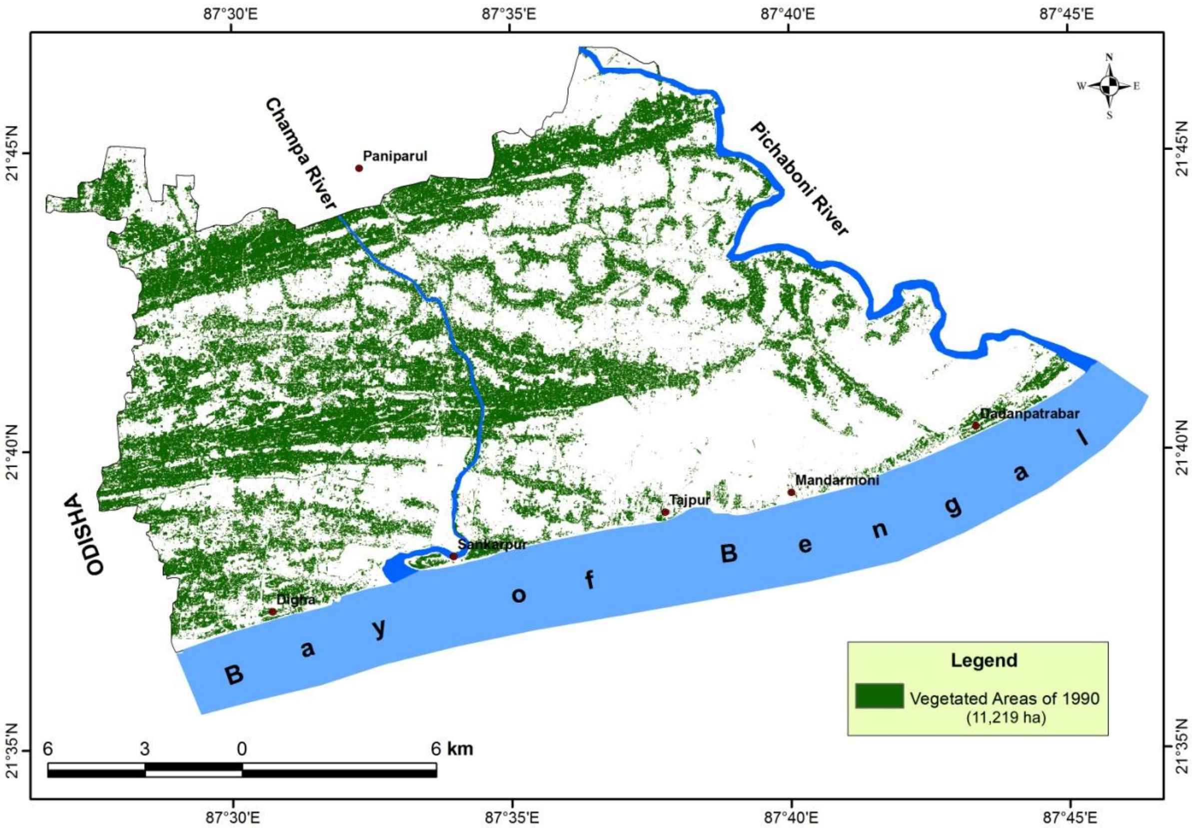

Fig. 4.7: Vegetation coverage in the year of 1990.

The LU / LC change detection matrix has been evaluated from 1990 to 2017 using multi temporal Landsat 5 and Sentinel-2 MSI satellite data and digital change detection techniques. Firstly the change of the vegetation coverage in between the year of 1990 and 2017 are examined from the utilization of the digital classification techniques. The vegetation coverage has been increased in 2017 (1,794 ha) contrast with 1990 due to street plantation and different Govt. policies like aforestation programme by Gram Panchyat, Panchyat Samiti and Zilla Parisad also (Figs. 4.7, 4.8).

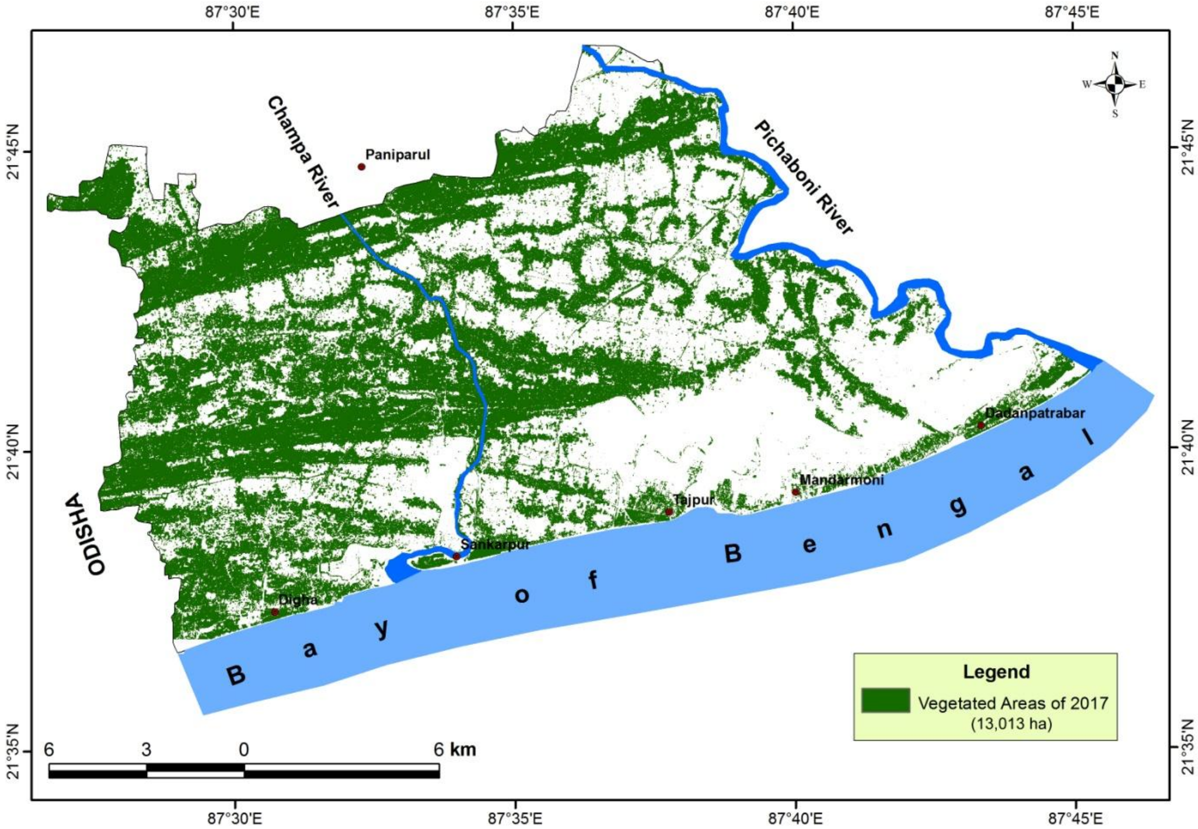

Fig. 4.8: Vegetation coverage in the year of 2017.

4.6.1 Spectral Angle Mapper (SAM)

Spectral Angle Mapper (SAM) is a physically based spectral categorization that uses an *n*-D angle to equivalent pixels to indication spectra. The algorithm establishes the spectral resemblance between two spectra by calculating the angle connecting the spectra and treating them as vectors in a space with dimensionality equivalent to the number of bands. This procedure, when employed on calibrated reflectance data, is comparatively insensible to enlightenment and albedo property. End-member spectra utilized by SAM can come from American Standard Code for Information Interchange (ASCII) files or spectral libraries, or research can pull out them directly from a remotely sensed data (as Region of Interest (ROI) average spectra). SAM evaluates the angle between the end-member spectrum vector and each pixel vector in *n*-D space lesser.

Angles symbolize nearer matches to the reference spectrum. Pixels further away than the particular utmost angle threshold in radians are not classified. SAM classification suppose to reflectance data. However, if research uses radiance data, the error is usually not important because the beginning is still near to zero.

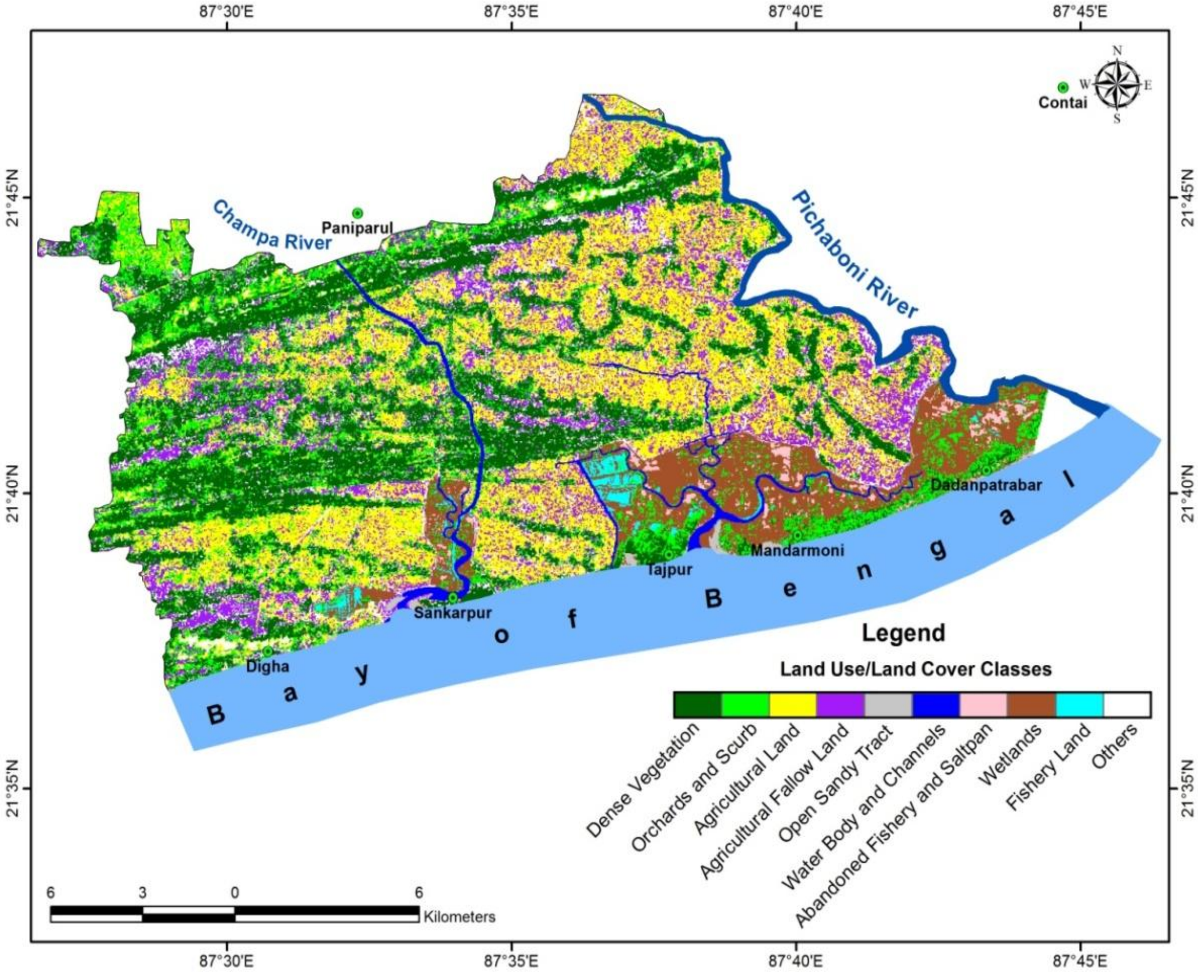

Fig. 4.9: Digital classification of land use / land covers in 1990.

This technique is not exaggerated by solar lighting features, because the angle between the two vectors is self-regulating of the vectors length (Crosta et al., 1998). The SAM is considered with following formula (Kruse et al., 1993):

$$\alpha = \cos^{-1}\left(\frac{\sum_{i=1}^{nb} t_i r_i}{\left(\sum_{i=1}^{nb} t_i^2\right)^{1/2}\left(\sum_{i=1}^{nb} r_i^2\right)^{1/2}}\right)$$

where,

nb= The number of bands

t_i=Test spectrum

r_i=Reference spectrum

The major recompense of the SAM algorithm is that, it's a simple and hurried technique for mapping the spectral resemblance of image spectra to reference spectra. It is also an extremely dominating categorization process because it suppresses the persuade of shading effects to emphasize the target reflectance distinctiveness (De Carvalho and Meneses, 2000).

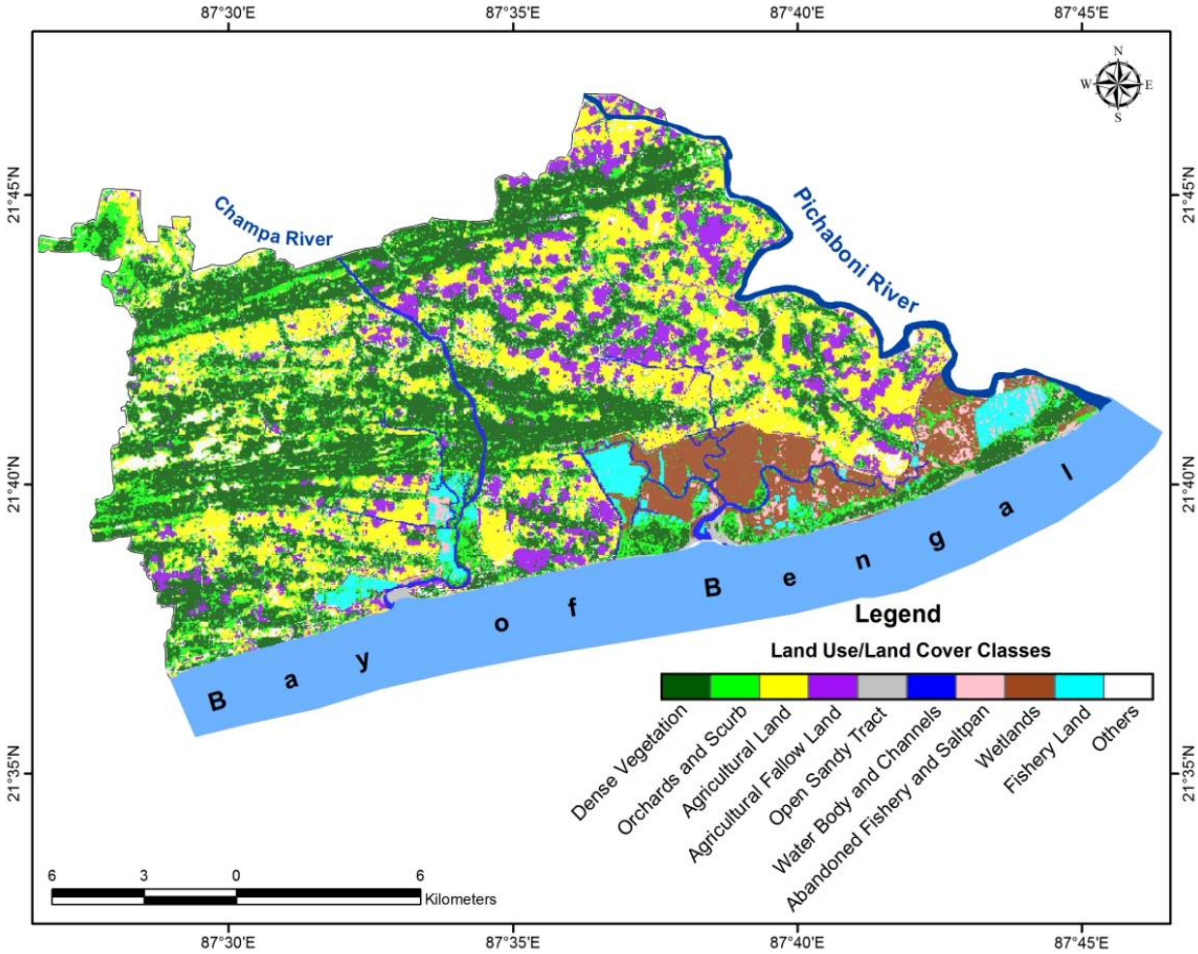

Fig. 4.10: Digital classification of land use / land covers in 2017.

Table 4.12: Spatial change of land use / land covers between 1990 and 2017.

Sl. No.	LU/LC classes	Area 1990 (ha)	Area 2017 (ha)	Aerial change in ha	% of Aerial change
1	Dense vegetation	7107	9505	2398 (Increased)	34.38
2	Orchards and scrub	4112	4522	410 (Increased)	5.88
3	Agricultural land	7128	6260	868 (Reduced)	12.45
4	Agricultural fallow land	4630	3223	1407 (Reduced)	20.17
5	Open sandy tract	370	288	82 (Reduced)	1.18

6	Water body and channels	501	489	12 (Reduced)	0.17
7	Abandoned fishery and saltpan	275	402	127 (Increased)	1.82
8	Wetlands	2459	1759	700 (Reduced)	10.04
9	Fishery land	241	793	552 (Increased)	7.92
10	Others	2616	2198	418 (Reduced)	5.99
	Total Area	29439 ha (294.39 km^2)	29439 ha (294.39 km^2)		100

The SAM was able to provide reasonable classification results so the entire study area is classified in ten (10) types of LU / LC categorization in both temporal phase such as 1990 and 2017 (Figs. 4.9, 4.10). In the period of 27 years each and every classes are modified and changed in different LU / LC classes. Dense vegetation class is highly increased in the year of 2017 than 1990 and agricultural fallow land is much reduced in 2017 (Table 4.12). Finally, dense vegetation, orchards and scrub and fishery land are increased in 2017 and other LU / LC classes are reduced in the same year (Fig. 4.11).

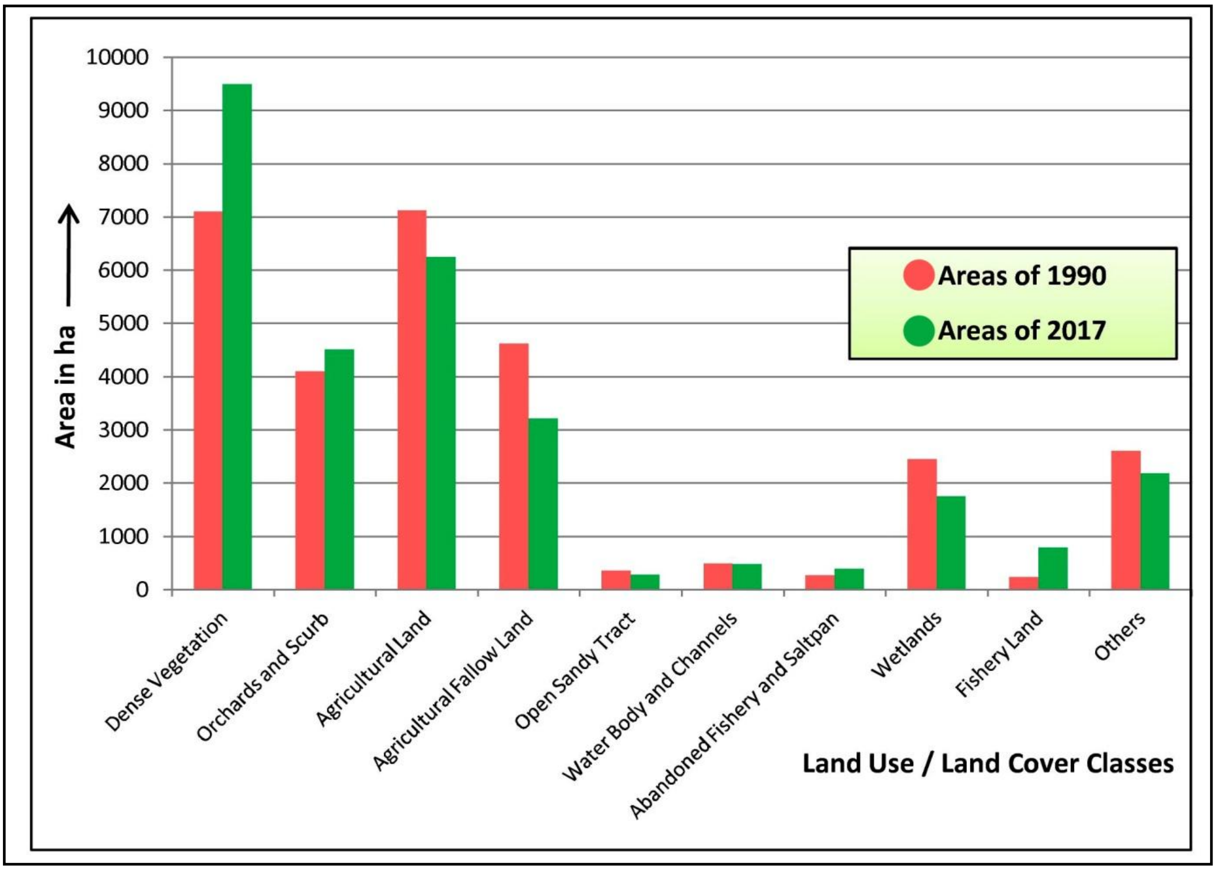

Fig. 4.11: Changing scenario land use / land cover between 1990 and 2017.

4.6.2 Change Detection Matrix

Remote sensing and GIS are the brilliant apparatus for the incorporated investigation of geo-spatial data. The produced LU / LC images are investigated and change detection was conceded. The yield LU / LC images are employed to perceive the LU / LC alteration in the province through Land Change Modeler (LCM) of IDRISI Selva software. LU / LC change detection matrix was also equipped to comprehend the alterations take place in each category over the period of 27 years (Table 4.13). From the table, it is found that there is a considerable change in the LU / LC area during the period of 27 years (1990 to 2017).

Table 4.13: Change detection matrix between 1990 and 2017.

Land use / land cover categorizations	Occupied classes	Area in ha	Percentage of area
Dense vegetation (2398 ha increased)	Dense vegetation	5277.52	55.52
	Orchards and scrub	1994.74	20.99
	Agriculture land	748.33	7.87
	Agricultural fallow land	872.28	9.18
	Open sandy tract	28.99	0.30
	Water body and channels	25.12	0.26
	Others	477.17	5.02
	Abandoned fishery and saltpan	72.74	0.77
	Fishery land	8.12	0.09
Total areas of dense vegetations		9505.00	100.00
Orchards and scrub (410 ha increased)	Dense vegetation	1171.03	25.90
	Orchards and scrub	1188.53	26.28
	Open sandy tract	25.26	0.56
	Water body and channels	26.48	0.59
	Abandoned fishery and saltpan	15.27	0.34
	Wetlands	274.54	6.07
	Fishery land	20.39	0.45
	Agriculture land	866.10	19.15
	Agricultural fallow land	631.20	13.96
	Others	303.21	6.71
Total areas of orchards and scrub		4522.01	100.00
Agricultural land (868 ha reduced)	Dense vegetation	218.82	3.50
	Orchards and scrub	487.35	7.79
	Agriculture land	3138.94	50.14
	Agricultural fallow land	1646.27	26.30
	Open sandy tract	6.25	0.10
	Water body and channels	6.50	0.10
	Others	755.63	12.07
Total areas of agricultural land		6259.76	100.00
Agricultural fallow land (1407 ha reduced)	Dense vegetation	129.15	4.01
	Orchards and scrub	337.60	10.47
	Agriculture land	1322.88	41.04
	Agricultural fallow land	962.84	29.87
	Open sandy tract	4.55	0.14
	Water body and channels	13.81	0.43
	Others	452.18	14.03
Total areas of agricultural fallow land		3223.00	100.00

Open sandy tract (82 ha reduced)	Dense vegetation	28.50	9.90
	Orchards and scrub	24.04	8.35
	Open sandy tract	160.09	55.59
	Water body and channels	17.78	6.17
	Abandoned fishery and saltpan	0.24	0.08
	Wetlands	27.86	9.67
	Fishery land	0.24	0.08
	Agriculture land	7.55	2.62
	Agricultural fallow land	13.65	4.74
	Others	8.04	2.79
Total areas of open sandy tract		288.00	100.00
Water body and channels (12 ha reduced)	Dense vegetation	5.19	1.06
	Orchards and scrub	9.17	1.88
	Open sandy tract	3.71	0.76
	Water body and channels	370.22	75.71
	Abandoned fishery and saltpan	1.46	0.30
	Wetlands	39.07	7.99
	Fishery land	7.39	1.51
	Agriculture land	19.98	4.09
	Agricultural fallow land	15.76	3.22
	Others	17.06	3.49
Total areas of water body and channel		489.01	100.00
Abandoned fishery and saltpan (127 ha increased)	Dense vegetation	8.29	2.06
	Orchards and scrub	19.06	4.74
	Open sandy tract	7.80	1.94
	Water body and channels	2.22	0.55
	Abandoned fishery and saltpan	118.69	29.52
	Wetlands	245.95	61.18
Total areas of abandoned fishery and saltpan		402.01	100.00
Wetlands (700 ha reduced)	Dense vegetation	13.09	0.74
	Orchards and scrub	25.17	1.43
	Open sandy tract	39.12	2.22
	Water body and channels	41.09	2.34
	Abandoned fishery and saltpan	148.15	8.42
	Wetlands	1308.94	74.41
	Fishery land	183.42	10.43
Total areas of wetland		1758.98	100.00
Fishery land (552 ha increased)	Dense vegetation	6.90	0.87
	Orchards and scrub	30.25	3.81
	Open sandy tract	5.65	0.71
	Water body and channels	6.42	0.81
	Abandoned fishery and saltpan	64.25	8.10
	Wetlands	439.51	55.42
	Fishery land	240.03	30.27
Total areas of fishery land		793.01	100.00
Others (418 ha reduced)	Dense vegetation	228.41	10.39
	Orchards and scrub	351.78	16.00
	Agriculture land	830.34	37.77
	Agricultural fallow land	478.33	21.76
	Open sandy tract	3.98	0.18
	Water body and channels	5.44	0.25
	Others	299.88	13.64
Total areas of others land		2198.16	100.00

Plate 4.6: Back dune areas converted into fishery land.

Table 4.14: Validation between digital classification and vector classification of LU / LC in 2017.

Land Use / Land Cover Classes	Areas of Digital Classification (ha)	Areas of Vector Classification (ha)
Dense vegetation, scrub and orchards	14027	14058.19
Agricultural lands	6260	6345.27
Agricultural fallow lands	3223.21	3151.52
Active channels	370.51	361.84
Active fisheries, abandoned fisheries and wetlands	3281.58	3295.78
Others	2276.17	2225.16
Total	29438.47	29437.76

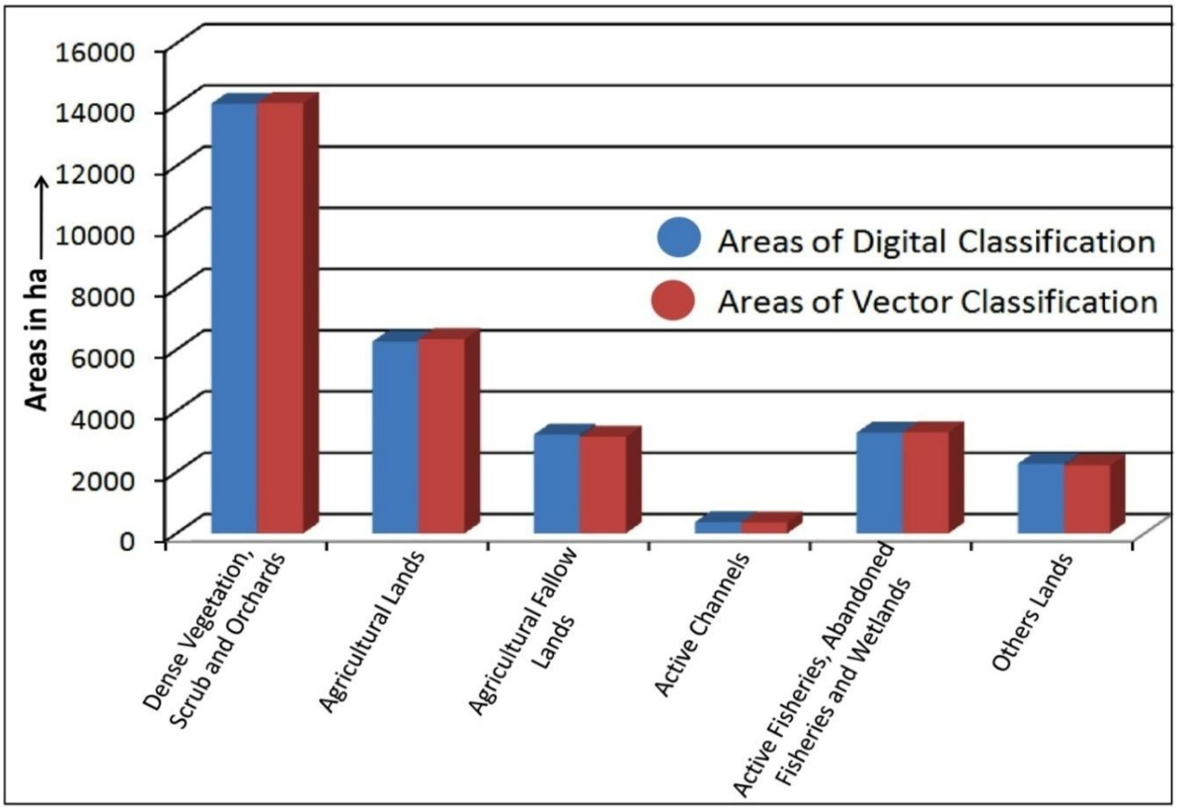

Fig. 4.12: Validation of the LU / LC categorization area between digital and vector classification in 2017.

For the verification of the digital classification of LU / LC the vector classification has been completed by using the Google Earth image data. The spatial alterations for both classifications are not a great deal of variation of the particular province. Accordingly, the digital classification symbolizes a very vigorous classification of LU / LC (Table 4.14; Fig. 4.12).

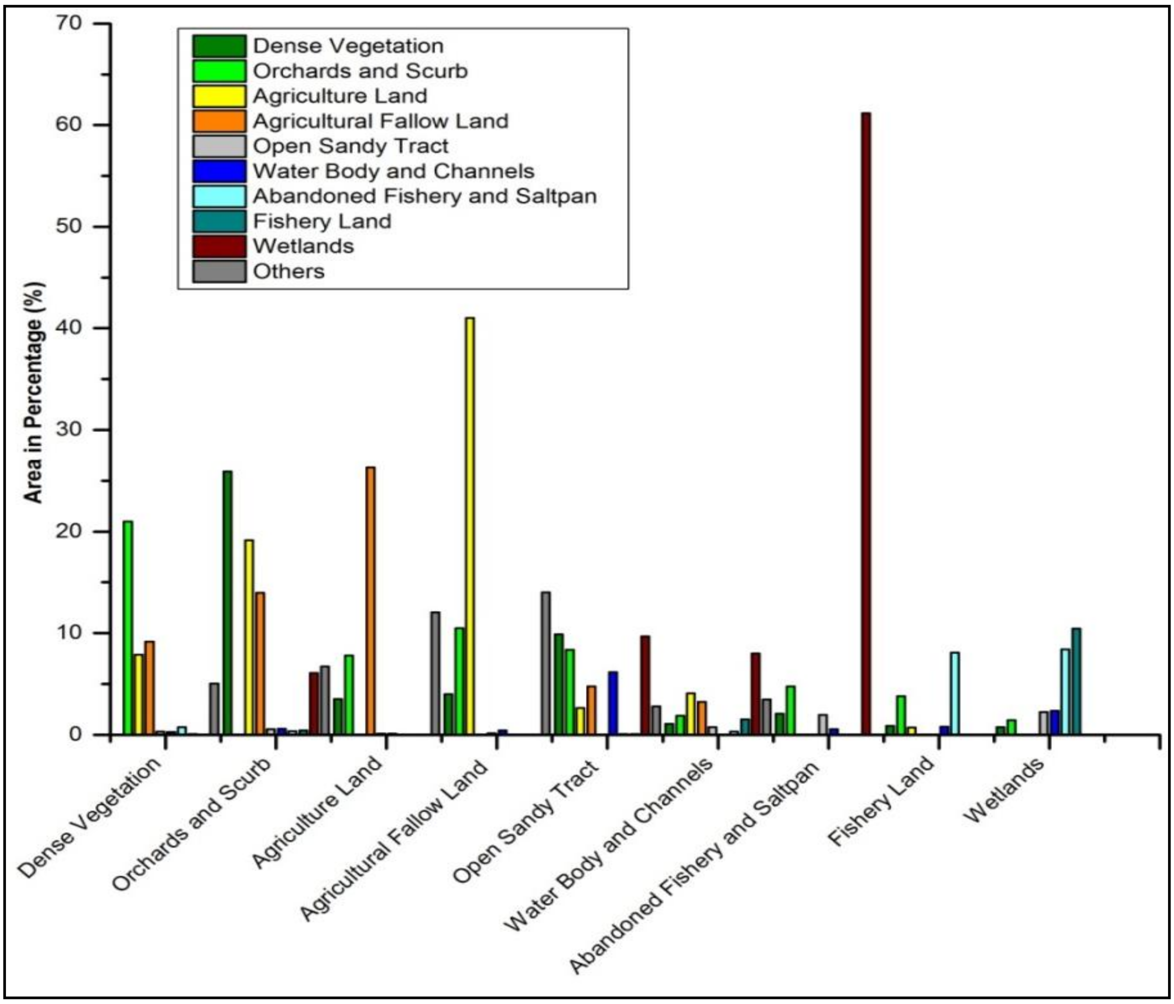

Fig. 4.13: Percentage of area converted in between 1990 and 2017.

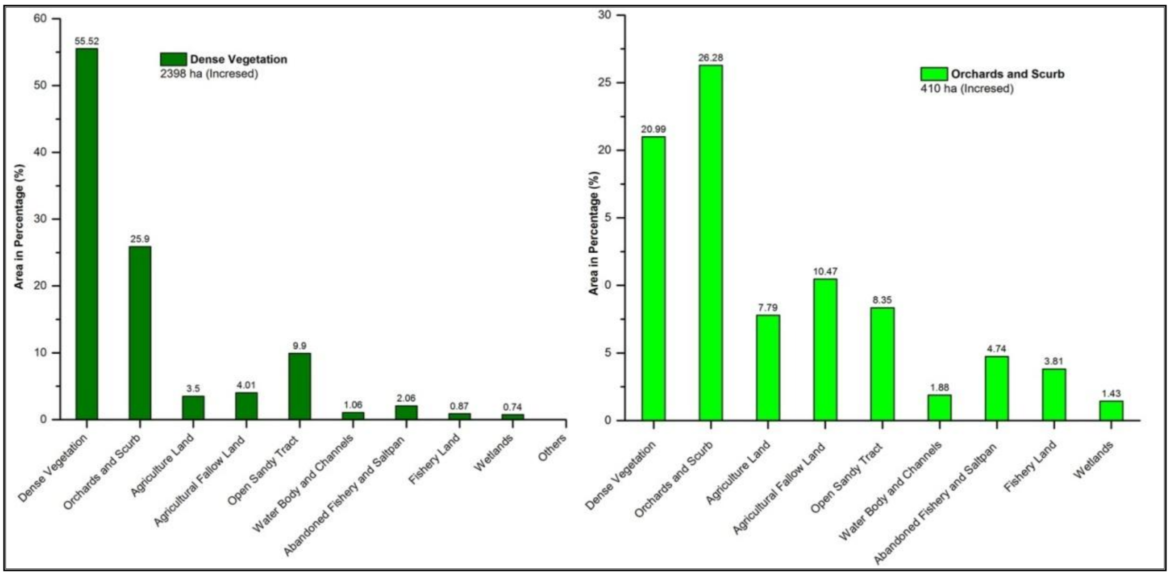

Fig. 4.14: Conversion of orchards and scrub is extreme into dense vegetation between 1990 and 2017.

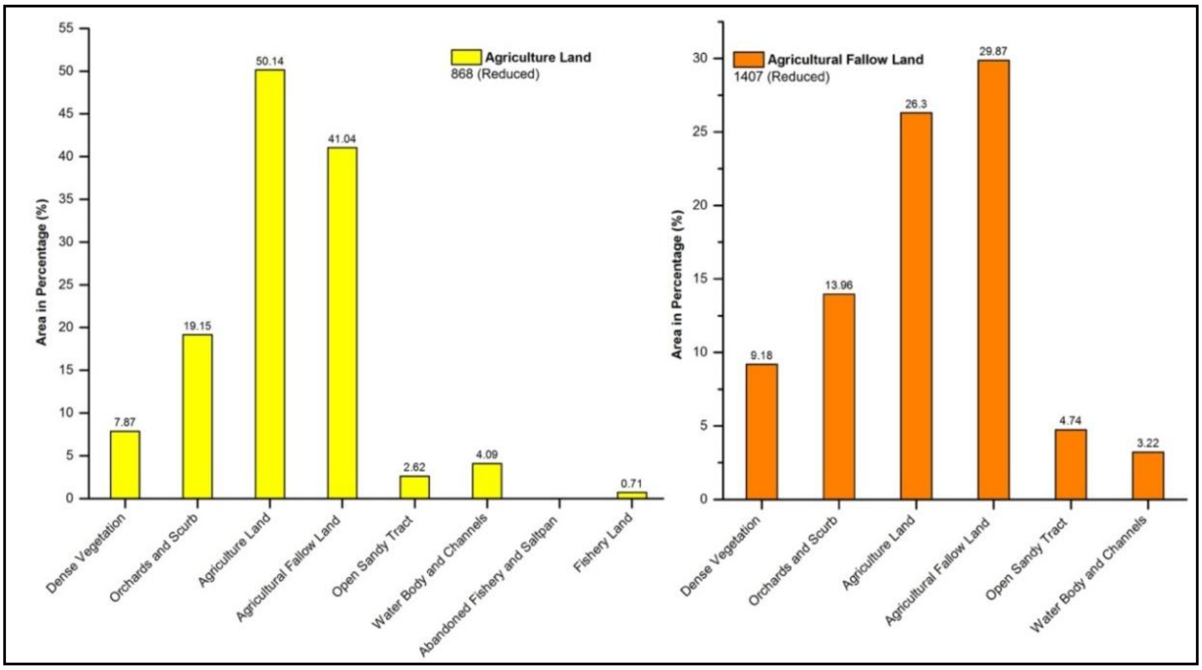

Fig. 4.15: Conversion of agricultural fallow land is extreme into agricultural land between 1990 and 2017.

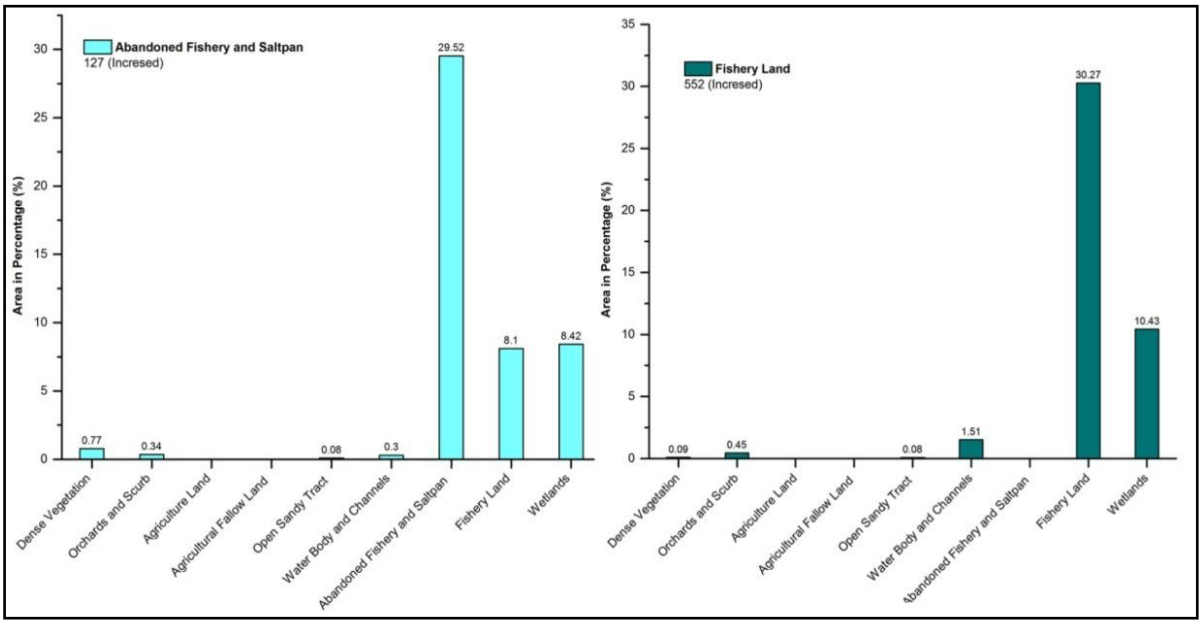

Fig. 4.16: Conversion of fishery land is extreme into abandoned fishery and salt pan between 1990 and 2017.

4.6.3 Land Use / Land Cover Alteration

The present supervised digital classification map denotes ten (10) distinctive classes like dense vegetation, orchards and scrub, agricultural land, agricultural fallow land, open sandy tract, water body and channels, abandoned fishery and saltpan, wetlands fishery land and others which has been prepared by using remotely sensed data, GIS techniques and also with the help of continuous field survey. It is also very clear that the dense vegetated of this area has a greater percentage of land area whereas the abandoned fishery and saltpan area has very smaller areas of occupancy. On the other hand change detection matrix also shows that the changeability rate is also very high in dense vegetated class and the smallest changeability is present in water body and channels class (Figs. 4.13, 4.14, 4.15, 4.16, 4.17, 4.18). The change detection matrix vividly represents the percentage of changeability of different classes into other classes (Plates 4.6, 4.7).

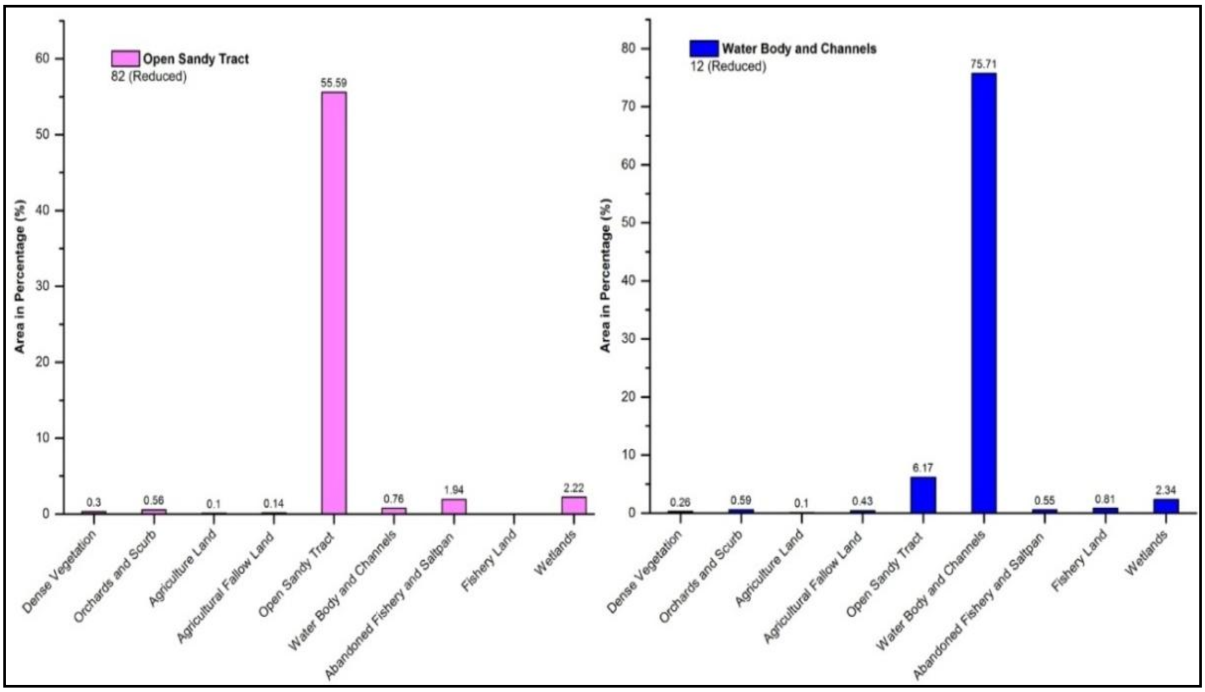

Fig. 4.17: Conversion of water body and channels are extreme into open sandy tract between 1990 and 2017.

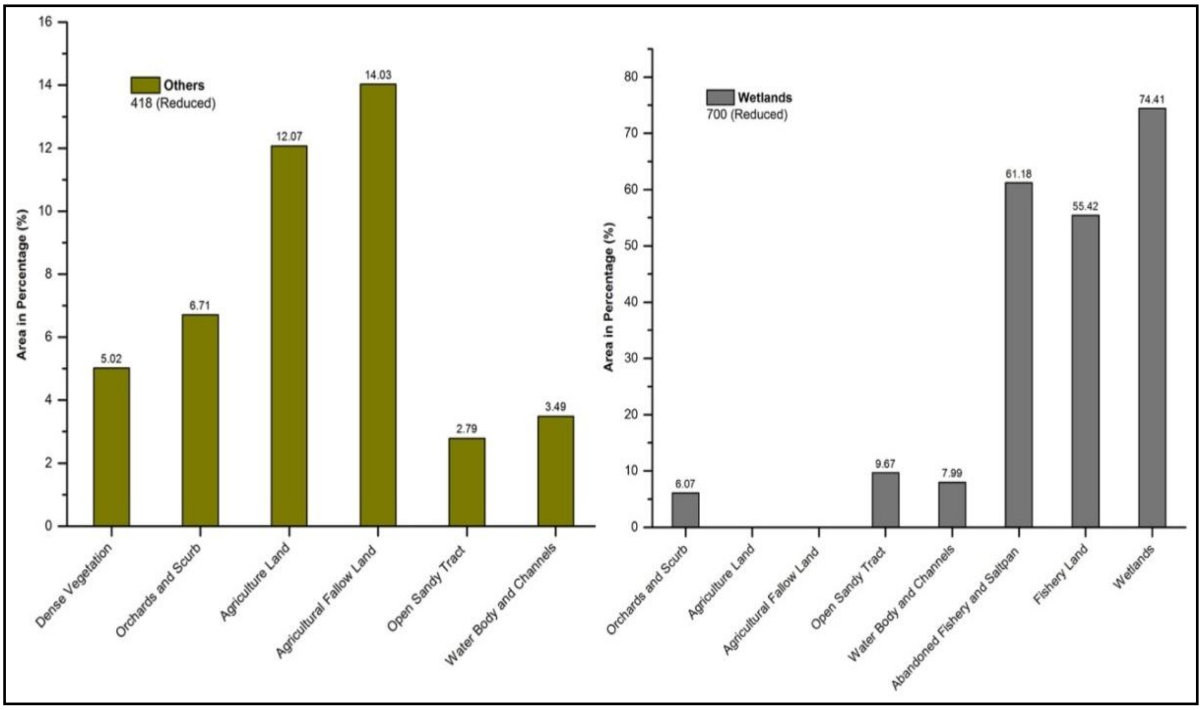

Fig. 4.18: Conversion of wetlands is extreme into abandoned fishery and saltpan between 1990 and 2017.

Plate 4.7: Land use conversion at wetlands areas into traditional salt processing ground.

4.7 Population Pressure Estimation

Population density has been computed through the help of Census Report of 2011. Total number of Village of Ramnagar-I and II Administrative Blocks are 151 and 137 respectively (Annexure 24). Some new Villages are delineated but their data is still not available in the Census, 2011.

Table 4.15: Estimation of population density through Census data, 2011

No. Of bands	Distance	Total area In km^2	Total population	Population density in km^2	Percentage of total population	No. Of villages	Nature of topography
Band-1	0-3 km	77.61	45573	587.2052	14.1496	57	Beach, dune, wetland and low land
Band-2	3-6 km	73.08	88082	1205.2819	27.3480	72	Ridge, swale topography and paleo tidal basin
Band-3	6-9 km	68.09	98958	1453.3412	30.7248	76	Ridge, swale, estuarine flood plain and natural levee
Band-4	9-12 km	60.10	68848	1145.5574	21.3761	62	Sand ridge topography and dune slope
Band-5	12-15 km	24.27	20617	849.4849	6.4012	20	Paleo tidal basin (part of Dubda Basin)
Total		**303.15**	**322078**		**100**	**287**	

For the spatial zonation of population pressure 3 km interval bands are delineated from the shore front to the landward side of the region and band three occupies the higher population pressure of the region due to the protection of the coastal hazards (Fig. 4.19). Landscape characteristic of this higher pressure zone are comprises with ridge, swale, estuarine flood plain and natural levee that can also includes 76 Villages of the region (Table

4.15). The very low population pressure shows that the (Band 1) shorefront areas of the study area because this zone is the highly vulnerable for such kind of coastal hazards.

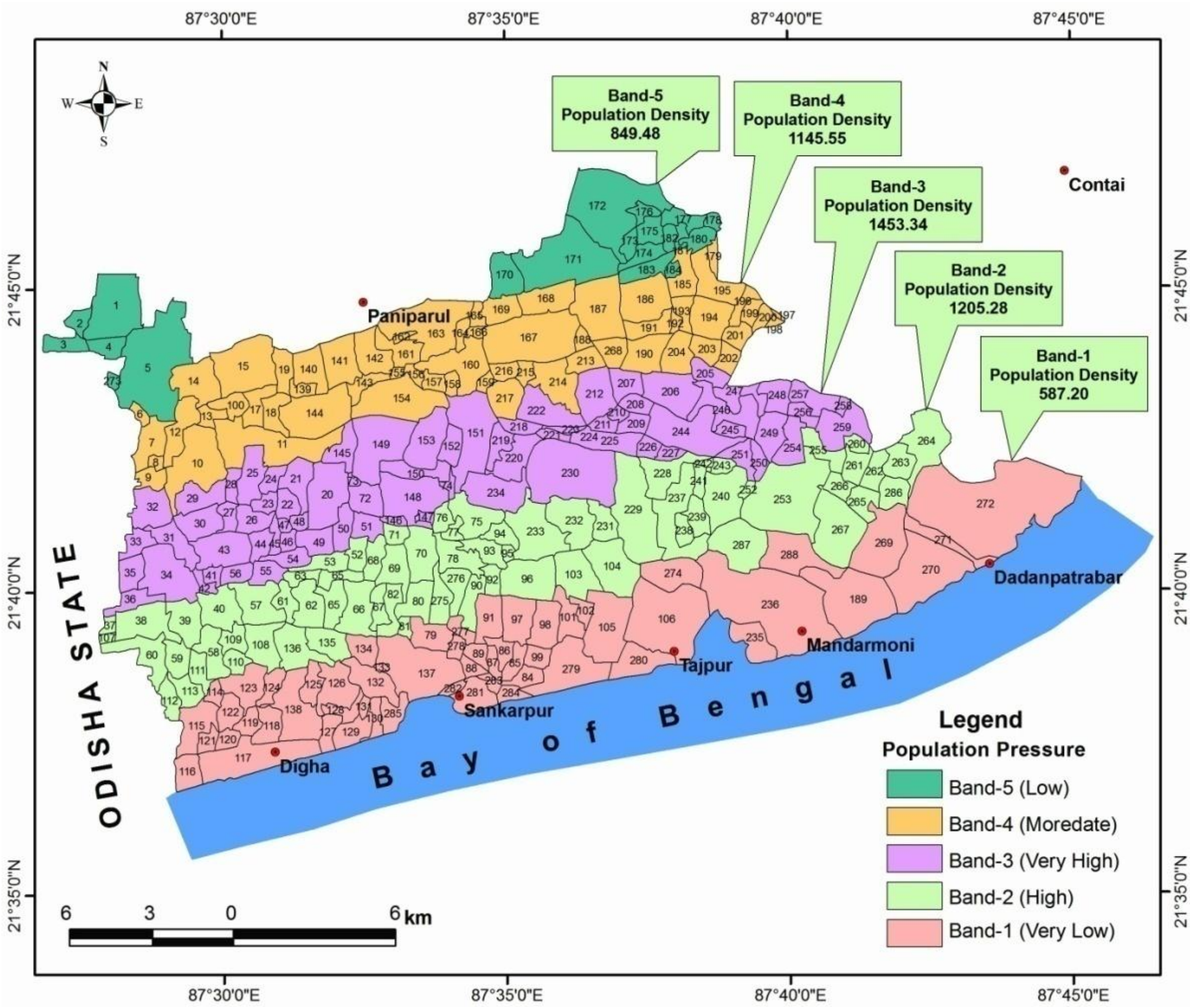

Fig.4.19: Estimation the population pressure through population density at Ramnagar Blocks.

4.8 Density-Based Spatial Clustering of Applications with Noise or Density Based Clustering Algorithm

Density based clustering algorithm has contributed a very important responsibility in finding non linear shapes structure based on the density. Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is most extensively used density based algorithm. It exploits the perception of concentration reach ability and density connectivity.

The DBSCAN algorithm was first commenced by Ester et al. 1996, and relies on a density-based concept of clusters. Clusters are recognized by appearing at the density of points. Regions with a high density of points portray the subsistence of clusters whereas regions with a low density of points point out clusters of noise or clusters of outliers. This algorithm is predominantly appropriated to contract with great datasets, with noise, and is able to recognize clusters with diverse sizes and shapes.

Table 4.16: Estimation of settlement density through DBSCAN model.

Settlement Category	Total settlement	Total area in km^2	Settlement Density in km^2	Percentage of total settlement	Percentage of total area
High density settlement	7059	12.34	572.04	28.53	4.191718
Moderate density settlement	13706	78.81	173.91	55.39	26.77061
Low density settlement	3716	52.18	71.22	15.02	17.72479
Areas with sparse settlement	264	20.84	13.08	1.07	7.079045
Areas without settlement	0	130.22	0	0	44.23384
Total	24745	294.39		100	100

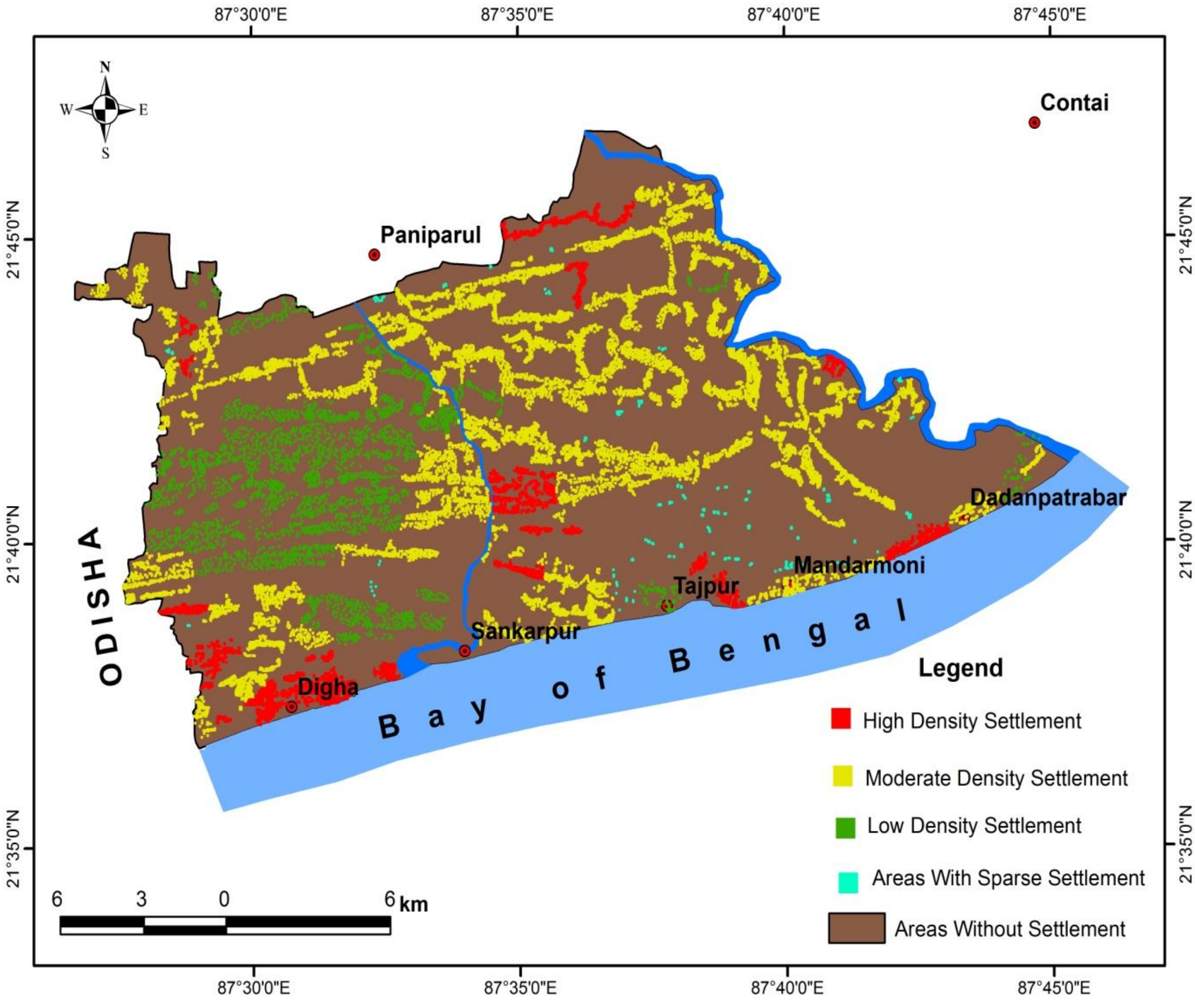

Fig. 20: Settlement density map of the studied coast.

The key design of the DBSCAN algorithm is that, for every spot of a cluster, the neighborhood of a given radius has to include at least a least amount of number of points, that is, the concentration in the neighborhood has to go beyond some predefined threshold. This algorithm desires three input considerations: k, the neighbor list size; Eps, the radius that delimitate the neighborhood area of a point (Eps-neighbourhood); MinPts, the least amount of points that have got to exist in the Eps-neighbourhood.

The clustering procedure is based on the categorization of the points in the dataset as center points, border points and noise points, and on the use of compactness relationships between points (directly density-reachable, density-reachable, density-connected to form the clusters). The DBSCAN algorithm was developed using Visual Basic 6.0.

The result shows that the high density settlement is found in the coastal urban areas and flat beach ridge portion and moderate density settlement occupies the more areas of the study area. Low density settlement concentrates the inter dune flat areas and areas with sparse settlement found in the wetland areas (Table 4.16; Fig. 4.20)

4.9 Environmental Zoning Approach

The subsequent attempt is an investigation of the ecological understanding of the substantial, biotic, socioeconomic and cultural surroundings for the expansion of the actions anticipated in the studied coast. This zoning train breakdown the physical, biotic, socioeconomic and cultural features of the zone of revise, which are understand in sequence opening with the primary stride to allocate principles to the attributes, to then resolve the vulnerability of the ecological elements according to the ecological contacts. This is to convene the necessities distinct in the expressions of orientation for organizing Environmental Impact Assessments (EIA), to prepare the suitable supervision approaches for low lying coastal tract. The environmental zoning was acquired opening with a amalgamation of the identification of the baseline for the lessons, based on the environmental explanation and description of the area, and a general look at the circumstances of the ecological units and resources found in the region. It consists of superimposing thematic maps acquired from the ecological categorization, investigating each one constituent unconnectedly to consequently classify and prioritize those features that resolve the sensitivity of a place.

Environmental zoning scheme is a pioneering coastal zone management approach in the contemporary circumstances. Environmental zoning approach is extremely appropriate for the susceptible vicinities concerning the land use pattern. In this circumstance this approach may exceedingly suitable for the present study arena as the zone is positioned in a maritime susceptible area experienced with tropical landfall and allied coastal extreme events. The main argument of this advance is how to reduce the harshness of vulnerability of a predisposed part commencing the pioneering land use pattern.

Table 4.17: Calculation of area in different environmental zones.

Sl. no.	Environmental zones	Area in km^2	Percentage of area
1	Tidal channels and creeks	5.34	1.81
2	Regulatory zone (50 m buffer)	24.21	8.22
3	Recreation zone	15.28	5.19
4	No use zone	13.02	4.42
5	Protective zone	28.53	9.69
6	Orchards with settlement	53.09	18.03
7	Agricultural use	107.32	36.46
8	Zone of conservation	47.6	16.17
	Total	294.39	100.00

According to researcher's ground authentication through selected ground point during the field survey the environmental zoning approach map has been equipped to demonstrate that which piece of land of the coastal stretch should be employed for what rationale by the customary coastal dwellers to make certain the diminish of coastal hazard brutality. If the indigenous coastal community of the Kanthi Coastal Plain complies with this approach then they would be benefitted from the viciousness of imminent coastal hazards. To set up this map one should reserve in mind that some places of the frontage face of the ocean should be untenanted which are treated as the place of natural processes and their modification actions.

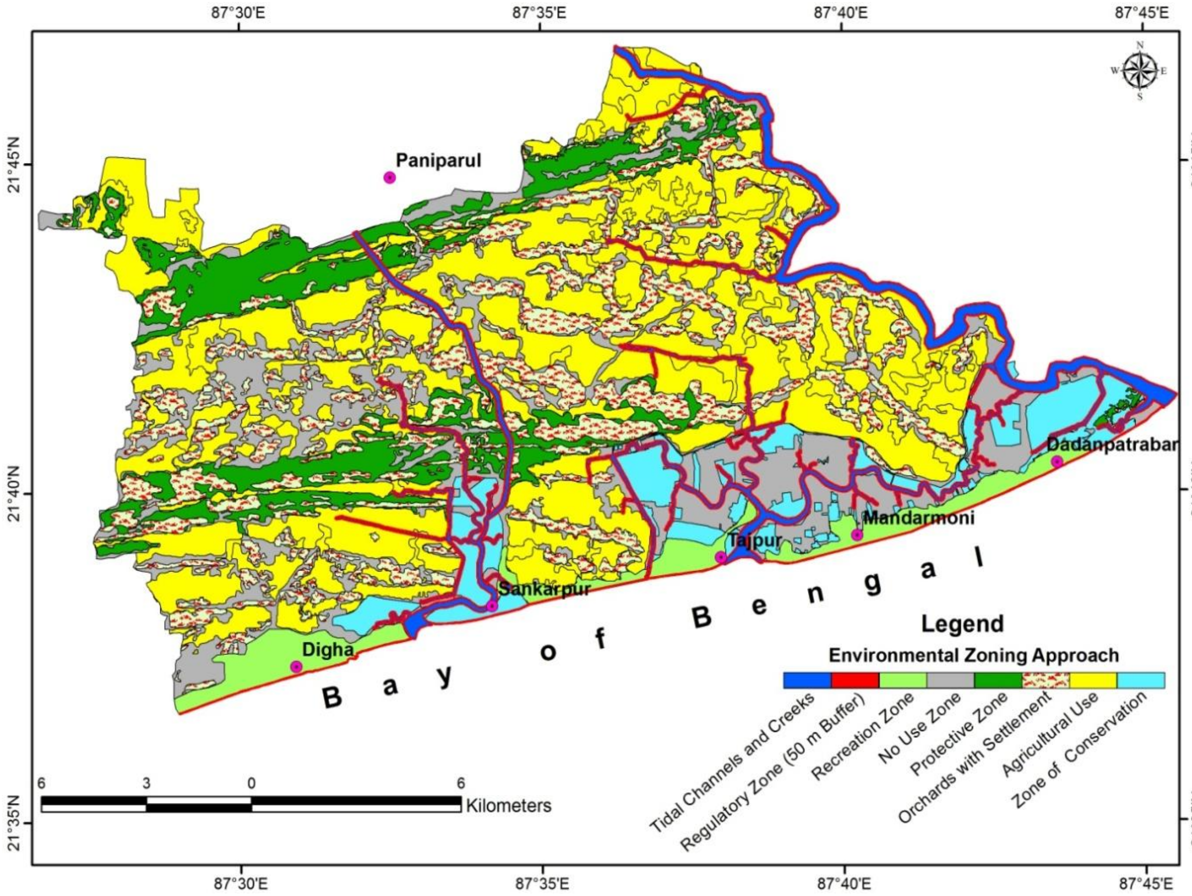

Fig. 4.21: Environmental zoning map of the Ramnagar-I and II Administrative Blocks.

The Fig. 4.21 denotes eight successive areas like Tidal channels and creeks, Regulatory zone (50 m buffer), Recreation zone, Protective zone, Orchards with settlement, Agricultural use and Zone of conservation where the natural processes are always plays their role to adjust the natural setting. As per the vigorous field survey researcher intimated this environmental zoning approach exclusively for this studied coast with a great percentage of agricultural land and a very small percentage of tidal creck which is very much significant for this chenier coast. The result of the environmental zoning, together with the project's environmental assessment, is the basis for instituting the Environmental Management Zoning for the actions to be commenced in the area of influence of Ramnagar coast. This is used to set up the special categories for environmental sensitivity for the studied coast.

4.10 Major Findings

The present chapter gives the following research findings which are much more significant to formulate the appropriate management strategies according to the topographic categorization.

- Identification of different landscape units like vegetated land, coastal wetland and agricultural land are utilized to estimate their services in the form of economical as well as ecological valuation of these landscape units.
- The total biomass concentration of vegetation is very high in ridge crest part and at the same time it is available in low concentration in low lying coastal plain surface, while ground water recharge capacity (infiltration rate) is very high in vegetated land which is estimated as 10,33,355 liter/ha/year.
- Comparative ecological service of different landscape/ha/year shows that vegetated land's carbon sequestration is very high than other landscape units. On the other hand, the coastal wetland has a greater power of nitrogen receive capacity than other two landscape units.
- Fishery with open marine fishing is highly significant than agricultural land in connection with productivity, and economically, commercial fishing is much more significant than other economic activities of present study area.
- In connection with the ecological service and productivity, the vegetated lands occupy the more ecological services and respectively commercial fisheries have a greater power of productivity capacity than other landscape units.

- The change detection matrix of land use and land cover shows that the area of dense vegetation is highly converted to newer land use practices, and the minimum alteration has been occurred in open sandy tract area.
- The population pressure is very high in back barrier dune area which comprises with band three and having the population density of 1453.34 behind 6 km from the shoreline.
- The environmental zoning map illustrates the eight sensitive environmental zones such as: Tidal channels and creeks, Regulatory zone (50 m buffer), Recreation zone, Protective zone, Orchards with settlement, Agricultural use and Zone of conservation which is improved for the maintenance of sensitive coastal environment of the study region.