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ANTHROPOGENIC DRIVERS OF COASTAL MORPHOLOGY ALONG WESTERN SECTION OF THE PURBA MEDINIPUR COASTAL TRACT, WEST BENGAL, INDIA

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Abstract

The Purba Medinipur (East Midnapore) coastal tract, West Bengal, India, has experienced rapid geomorphic transformation due to increasing anthropogenic stress on an insubstantial coastal system. This study analyzes the drivers of coastal morphological change along the western section of the Purba Medinipur coast through geospatial approaches, mainly relational analysis and impact analysis. The relational perspective highlights the dynamic interaction between hydrology and geomorphology, while the impact analysis assesses how hydrological processes affect coastal landforms. Tidal water intrusion, groundwater salinity with high pH, and cyclic hydro-geomorphic interactions significantly contribute to landscape degradation and vegetation loss. Human activities such as land reclamation for housing, agriculture, and commercial purposes, along with the conversion of agricultural land into pisciculture ponds, shrimp farms, and saltpans, have increased soil salinity and geomorphic instability. Additional pressures include mangrove depletion, dune hydrology alteration, population growth, and embankment breaching. Natural processes such as river course shifting, storm surges from the Bay of Bengal, and variations in sediment discharge further accelerate coastal erosion and landscape change. LULC change detection discloses that uncontrolled development is increasing the susceptibility of the coastal geo-environment and destabilizing the coastal landscape over time.

Keywords: Coastal geomorphology, Anthropogenic drivers, LULC change, Coastal erosion, Mangrove degradation, Dune hydrology, Purba Medinipur coast

I. INTRODUCTION

Coastal geomorphology of Purba Medinipur must be studied by considering the two major types of geospatial analysis, like relational analysis and impact analysis (Ahamad, 1972; Das, 2023). The first is associated with the close relationship between hydrology and geomorphology, and the second with the impact of hydrology on geomorphology (Bird, 2008; Maity et al., 2020). When surface tidal water plays an important role in the modification of coastal geomorphic landscape by a change in its physical and chemical properties, groundwater with high pH influences the process of landscape degradation and depletion of natural vegetation (Maity et al., 2020). Complexity in geomorphic processes like the nature, direction, and magnitude of erosion has been changing temporally due to land use change and urbanization (Hooke, 2000). A complex hydro-geomorphic cycle has been affecting the landscape and geo-environment. At the time of high tide, saline water passes horizontally and vertically through the surface landscape and finally reaches into the groundwater in a cyclic fashion (Patra, 2023). The phenomenon leads to the destruction of the geo-environment of the study area. This cycle is also eligible to change the entire geomorphic landscape within a span of time. Land reclamation is being practiced mainly for housing, agriculture, and commercial uses. Removal of forest land for reclamation in the coastal regime leads to tidal breaches, salinity hazards, and destabilization of sand dune fields (Das, 2022). Coastal erosion of Purba Medinipur forms a classic example of how human intervention into natural processes disturbs their rhythm and proves extremely costly in the long run (Karak et al., 2025). There is no single reason for rapid and complex changes in the geomorphic landscape of the Purba Medinipur coast. The effect of uncontrolled development is destabilizing the coastal geo-environment by making it vulnerable to coastal hazards (Das, 2023). Conversion of fertile agricultural lands into pisciculture ponds, saltpans, and shrimp farming ponds has been increasing the soil salinity level over time. It is degrading the landscape through the destruction of the structure, compaction, and composition of alluvial soils. In the coastal lowland, agriculture is energizing the land degradation processes by creating waterlogging conditions and surface breaching. Moreover, due to shifting of the river courses, changes in the underwater topography, frequency, magnitude of sea-wave, frequent storm surges over the Bay of Bengal, and intermittent sediment discharge in the coastal plain, the coastal landscape changes over time (Bird, 2008; Karak et al., 2025). This study is very important to understand the following objectives.

1) To analyze how anthropogenic activities influence coastal morphology.

II. METHODS AND TECHNIQUES

The study is based on geospatial and field-based analysis to examine anthropogenic drivers affecting coastal morphology along the western section of the Purba Medinipur coastal tract. Secondary data, such as satellite imagery, census data, and LULC datasets, were used to identify spatial and temporal changes in the coastal landscape. GIS and RS techniques were applied for relational analysis between hydrology and geomorphology and for impact analysis to assess human interventions such as land reclamation, shrimp farming, agricultural

expansion, and embankment breaching. Decadal population growth and human encroachment were analyzed using census statistics and spatial mapping. Field observations were conducted to validate changes in dune hydrology, mangrove disappearance, coastal resource units, and geomorphic sensitivity. Change detection analysis of LULC helped to evaluate the conversion of coastal features and the increasing vulnerability of the geo-environments due to anthropogenic activities.

III. LOCATION OF THE STUDY AREA

The western section of the Purba Medinipur coastal tract is situated in the Purba Medinipur district of West Bengal, extending between 21°36' 35" N and 22°02' 23" N latitudes and 87°22' 48" E and 88°01' 12" E longitudes. The length of the coast of the district is 55.22 kilometers, stretching from the border of Odisha to the Rasulpur Estuary. This coastal tract includes four Community Development Blocks, such as Ramnagar I, Ramnagar II, Contai I, and Deshapran (FIGURE 1).

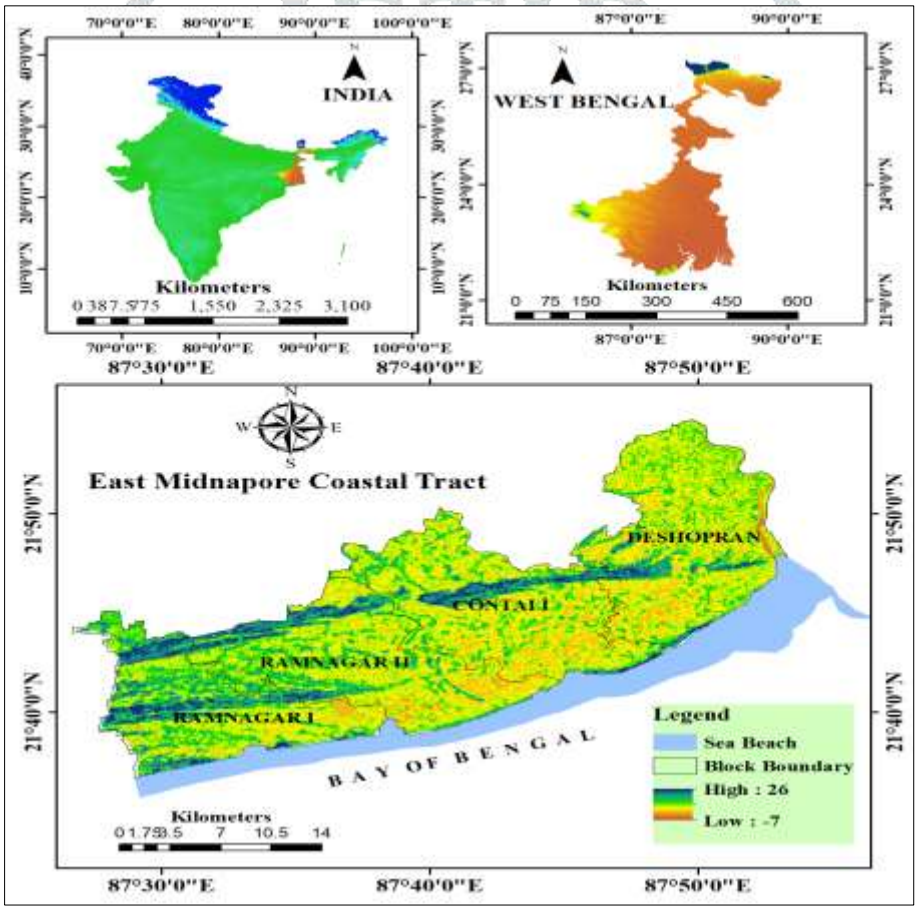

FIGURE 1: Location of the study area

IV. GEOMORPHOLOGICAL ENVIRONMENTS OF THE STUDY AREA

This coastal tract is characterized by low-lying terrain with extensive fluvial and marine plains, several creeks, coastal estuaries, beach ridges, mudflats, sandy beach plains, and dune ridges, all of which are subject to continuous geomorphological changes. This coastal belt has been rich in a variety of habitats, and it provides a

distinctive shelter for an enormous diversity of flora and fauna species (Paul, 1987). This variety of flora and fauna plays an important role in regulating climate change and influencing geomorphic processes (FIGURE 2).

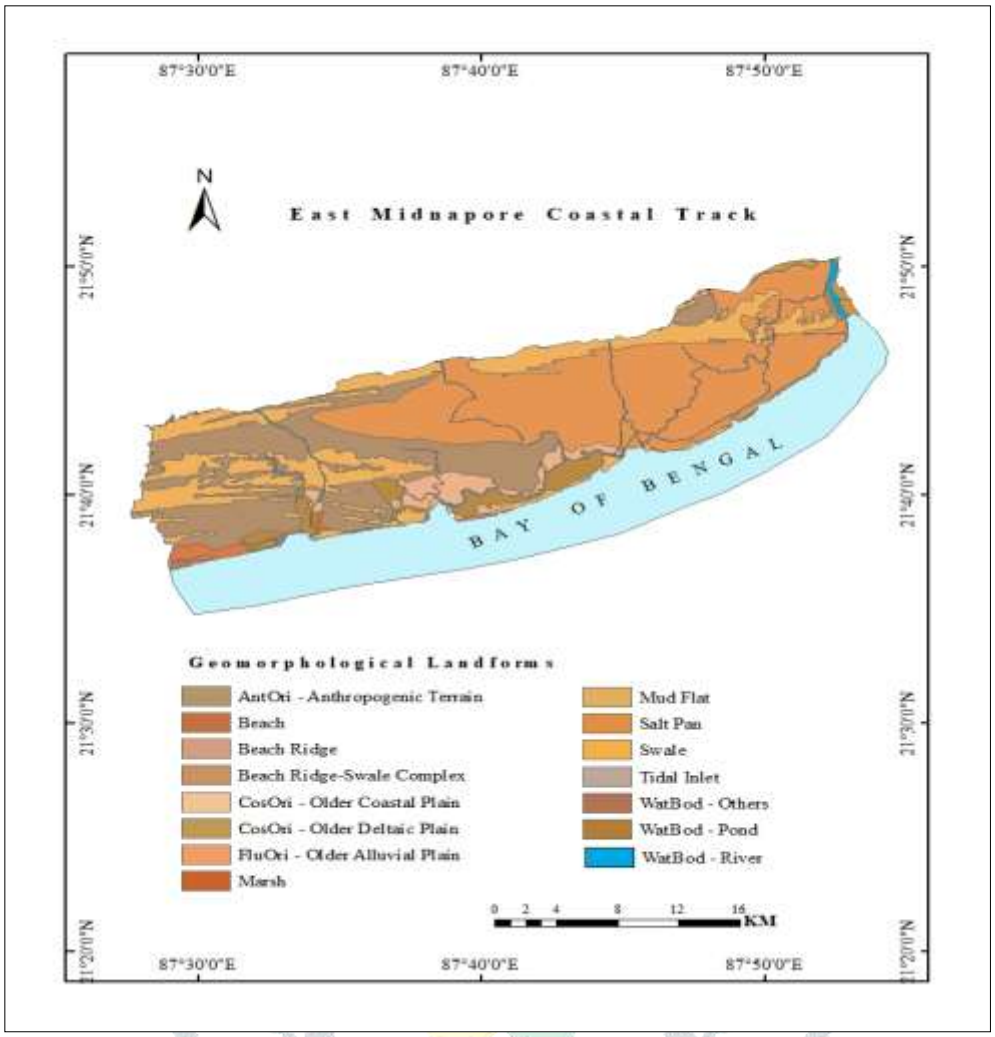

FIGURE 2: Geomorphology map of the study area (Source: GSI)

V. ANALYSIS OF ANTHROPOGENIC ACTIVITIES

A. COASTAL RESOURCE UNITS

The coastal belt has various resources such as marine fisheries, mangrove, sand, salt manufacturing, sea beaches, etc. As per the observation of researchers, several coastal resource zones are found in the study area. Here, coastal dwellers live and collect these types of resources. The coastal resource zonation maps in 1994, 2004, 2014, and 2021 have been prepared to mention the various resource zones (FIGURE 5). According to the present study, wetland, mangrove forest, beach, marine fishing region, inland fishing region, beach ridge, and sand dune are considered as the resource zones of the study areas. The local people depend on these resources for their livelihood. After several observations, the results show that coastal wetland, mangrove forest, and beach ridge have been decreasing gradually.

B. HUMAN ENCROACHMENT ON COASTAL LANDSCAPE

The Bengal coast has been experiencing rapid but uneven urban growth and development for the past 30-35 years. Depending upon the varied growth and development of urban areas and their vulnerability to geo-environmental disasters, the entire coastal sector can be classified into two halves. The western sector is the centre of attraction and business hub, where the eastern sector is in the hinterland area of the higher-order business centre. Western urban unit is constituted with the coastal part of Ramnagar-I, Ramnagar-II, and the eastern sector is constituted with the coastal part of Contai-I and Contai-II or Deshopran, where urban growth and development are uneven in terms of amenities, functions, land-man ratio, etc. The Western sector is linked with all the interrelated and interdependent geomorphic, hydrologic, and anthropogenic functions. The scope in the tourism sector and hotel business has been attracting people from all over the country into the higher-order urban centres to pursue economic satisfaction. Behind the rapid growth of urbanization in Digha, Shankarpur, Tajpur, and Mandarmoni, the pull factor of migration is most dominant, whereas in Junput and Rasulpur, the push factor of migration has been playing a dominant role over time. Behind these factors of migration, several exposed hydrogeomorphic disasters have been playing a significant role. Wetlands have been converted for urban space in the west, whereas fertile agricultural lands have been converted for Pisciculture, aquaculture, and salt pan factories in the east.

TABLE 1: Stages of the land degradation process that take part in geomorphic processes

Stages	Occurrences
Stage-I	Excessive use of groundwater for economic satisfaction at Digha, Shankarpur, Tajpur, Mandarmoni, Dadanpatrabar, and Junput coastal areas.
Stage-II	Subsidence of the coast, beach lowering, due to the 'Cone of Depression'. It's already started in Digha, Shankarpur area.
Stage-III	Tidal ingression through coastal lowlands at Digha, Shankarpur, Tajpur, Mandarmoni, Dadanpatrabar, and Junput coastal area.
Stage-IV	Salt incursion into fertile soil, soil quality degradation, and loss of soil structure
Stage-V	Loss of vegetative land, agricultural land, forest, and marshy land.
Stage-VI	Urbanization, forest clearance, land degradation for Pisciculture, salt factory, and landscape alteration. Salinity in both soil and water contaminates groundwater through unrestricted shallow tube wells and fractured ground around the coast.

The surface landscape and groundwater aquifer of the Kanthi coastal plain have been under serious stress due to excessive land reclamation, scarcity of fresh water, and huge sediment discharge through Peechaboni, Jaldah channel, and river Rasulpur, greater coastal development in New Digha, Old Digha, Shankarpur, Tajpur, Mandarmoni, Dadanpatrabar, and Junput areas, land use changes, and others. There is no single reason for rapid and complex changes in the geomorphic landscape and behavioural changes in the aquifer system in the study

area. The effect of uncontrolled development has been destabilizing the coastal hydrologic and geomorphic environment by making it vulnerable to coastal hazards (TABLE 1).

C. CHANGES OF DUNE HYDROLOGY

Hydrology is a major component of the sand dune environment because hydrology controls the vegetation growth, sand dune development, and weathering process. Dune hydrology is a critical hydrological system. Coastal sand dunes act both as recharging zones and support an elevated water table (Carter, 1988). The less dense fresh water overrides the denser salt water into the porous sediment of the coastal dune. The fresh water travels into the sand dunes through a curved path and extends seaward with a varying distance from the shoreline to produce a subaqueous discharge zone. The fresh water salt water interface fluctuates due to its position by usual natural seasonal factors and human factors like over extraction of fluids from the coastal dune around the fishing harbour of Jalda estuary and Digha, Sankarpur estuary. Water is pumped excessively by a large number of tube wells over the dunes, where the fresh groundwater has shifted landward. It is experienced by the local people living close to the coast of Mondarmoni, Silampur, Sonamuhi, Dadanpatrabar, Dakshin Purusattyampur, and particularly dune ridges that every tube well becomes obsolete after 6 months and 8 months of pumping as the brackish water zone of the salt-fresh water interface in tensed the wells and contaminates the fresh water by incursion of Salt water. In the Mondarmoni shoreline, from Mondarmoni to the Jalda estuary, the fresh water table of dune ridge topography intercepts the beach berm and fore shore areas in the form of the resurgence zone, causing a clearly visible seepage line of the low tides.

D. CHANGES IN DECADAL POPULATION GROWTH

From census data of 1991, 2001, and 2011 of Ramnagar I & II, Contai I, and Deshopran administrative blocks have been considered for the present study to make out the types of occupation practices by local people (FIGURE 2). According to the census data, there has been a huge change in the socioeconomic condition of local people, especially in the coastal areas. Due to the location of the Salt Factory in Mania mouza, with a big scope for livelihood, which is considered as dwelling in Purushottampur (Dakshin) villages. So, in the following three decades, the maximum population resides in this area. Generally, the increased population in Ramnagar I & II, Contai I, and Deshopran CD blocks is due to the availability of coastal resources practices. Some mouzas are gradually decreasing their own importance due to the encroachment by tourism sectors.

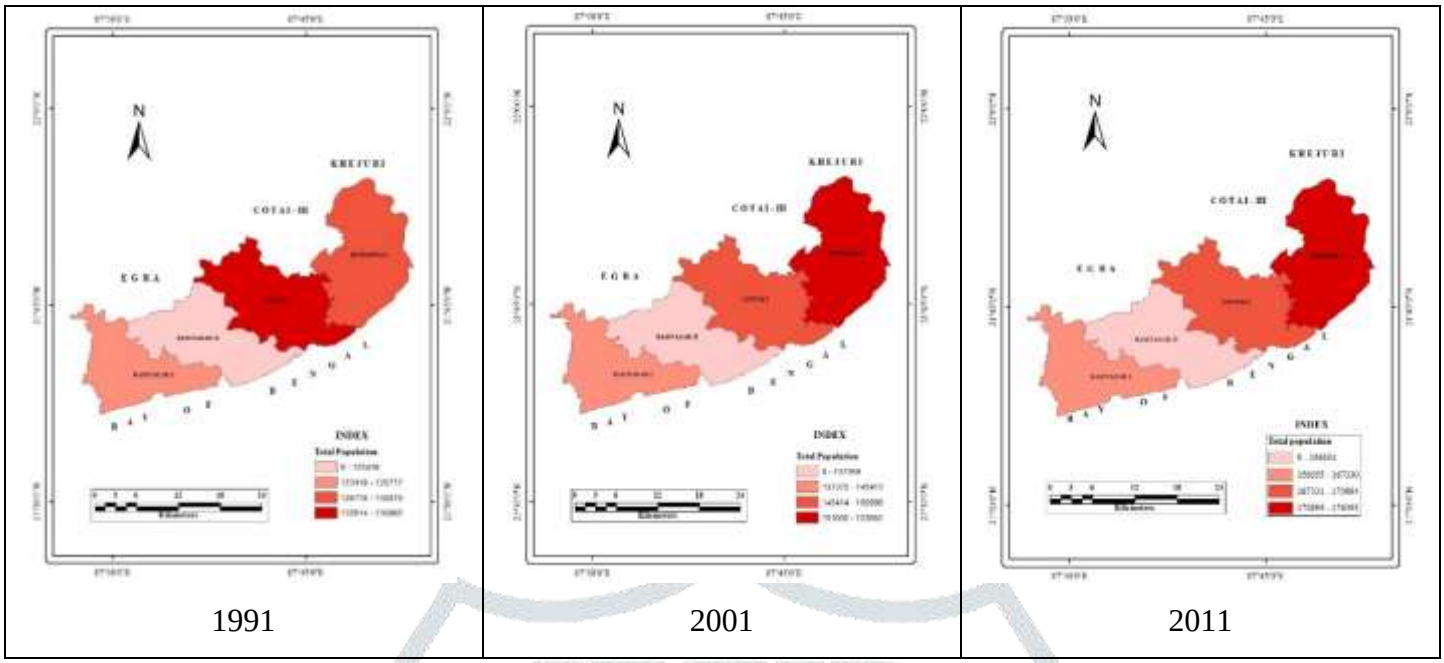

FIGURE 3: Showing the block-wise population distribution map (1991-2011) of the study area

E. DISAPPEARANCE OF MANGROVE FOREST AND GEOMORPHIC SENSITIVITY

The vegetation community in the tidal-dominated sandy coast is under threat due to the non-scientific use of chemical substances in dry fish processing and also harmful chemical properties generated from industries, fishing harbour, drainage system, etc. Mangrove species, namely Avicennia Alba, Avicennia marina, Avicennia officinalis, Bruguiera gymnorrhiza, Excoecaria agallocha, Ceriops decandra, Sonneratia apetala, are serious stake because of manmade activities along the coastal tract. Absence of these species has been accelerating erosional processes on the landscape over time. Quality of plant diversity and richness of natural vegetation in tidal areas are urgently required to save the landscape from the rapid loss of its geomorphic and ecological environment. Mangrove species at Digha, Shankarpur, Tajpur, Mandarmani, Haripur, and Junput beaches are gradually disappearing due to some anthropogenic activities.

(a) Sands from the Digha beaches are being used randomly for the construction work and other purposes. This anthropogenic activity is causing a major threat to these species. Tourism and urban development are also responsible for the extinction of such species.

(b) These species are being severely disturbed by hotel constructions, the boat manufacturing industry, huge vehicles carrying tourists, land reclamation, and artificial embankment construction. All these manmade activities are changing the operational systems between species and their environment in the coastal regime.

(c) Waste disposal related to dry fish industries has tremendously hampering the richness of vegetation on the coast.

F. CHANGE DETECTION ANALYSIS BY LULC

The Land Use/Land Cover maps are prepared from satellite imagery by Landsat-5 & 7 for 1994 and 2004, and Landsat-8 for both 2014 and 2021. The maps showed an area coverage of 632.69 sq km of the total study area. Water bodies, built-up area, farmland, saltpan, wetland, dense vegetation, dunes, and agricultural land are mentioned in LULC by the supervised classification. Where dense vegetation was 17.97% in 1994, it decreases in 11.69% by 2021. Where the built-up area and wetland were 18.41% and 7.75% respectively in 1994, it change in 44.22% and 0.43% by 2021. Where saltpan was 15.66% in 1994, it decreases in 3.71% by 2021. Where dunes were 16.77% in 1994, it decreases in 0.52% by 2021. There have been tremendous changes in LULC after three decades in this study area (FIGURE 5). A primary survey is done in almost 363 hotels, and almost 95% hotels are situated in Digha. A list is collected from DSDA, where 376 hotels are listed. According to the primary survey, almost 363 hotels could be constructed, but among these 363 hotels, many do not have proper features according to the DSDA list. Hotel owners are avoiding the legal process to build up the hotels. Only a few hotels are built up legally, having sarai license (FIGURE 4).

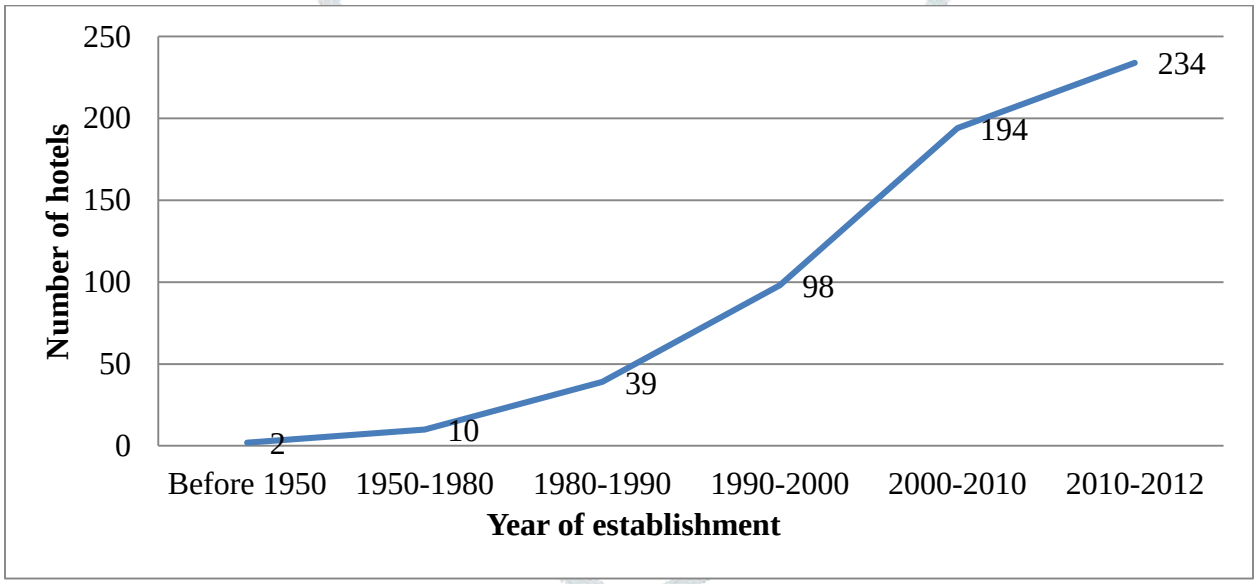

FIGURE 4: Growth of hotels in Digha-Sankarpur coastal area (Source: DSDA)

Agricultural and forest land conversion is mainly found in the coastal belt between Mandarmoni and Dadanpatrabar coast, whereas wet land conversion is found in the Digha, Shankarpur and Tajpur coast. The landscape of the Junput coast under Contai-I block, which was covered with dense forests and rich in vegetation before 10 to 15 years back, presently converted in to tidal playground**.** Land conversion is mainly takes place due to saline incursion from tidal waters that increases the pH level in the soil. Loss of forest land in this area has also been recorded. The problems of landscape degradation due to waterlogging and soil salinity are directly related to the geological and hydrological formations. The problem of waterlogging has been defined as the retention of the area under water for a considerable period. The agricultural land has been said to be waterlogged as its productivity or fertility has been adversely affected by tidal saline water ingress. Conversion of fertile agricultural

land into sat pans, aquaculture ponds, and shrimp farming ponds has been contributing to the land degradation process by a change in physiochemical properties of soil and groundwater.

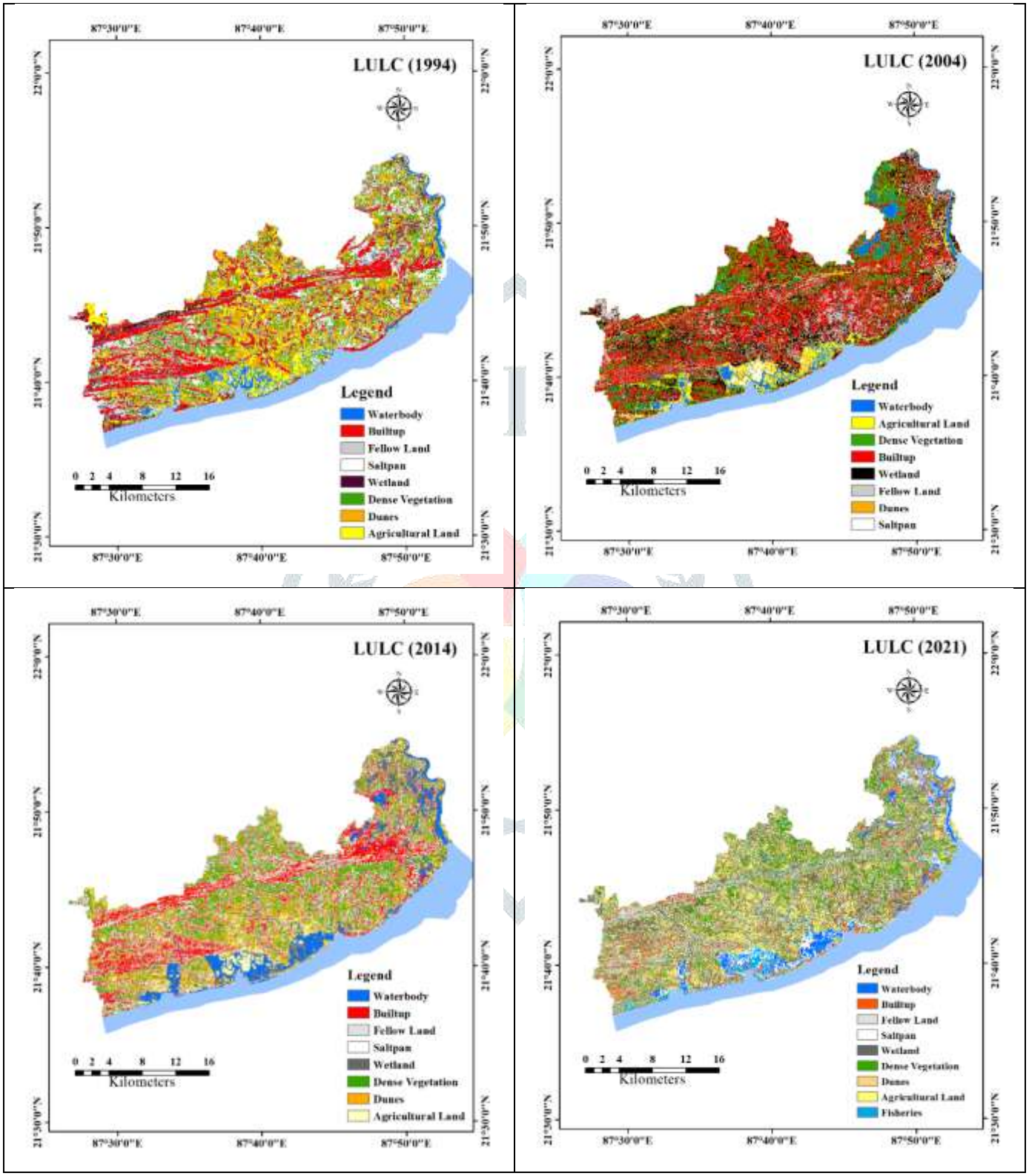

FIGURE 5: Showing the block-wise LULC change map (1994-2001) of the study area (Source: LANDSAT 5, 7 & 8)

G. EMBANKMENT BREACHING

The embankment breaching is very common in flood years and at the time of high tide, full moon tides, and cyclonic disturbances over the Bay of Bengal. It takes place through overtopping, poor maintenance of the embankment, and other anthropogenic activities. It has an adverse impact on the geomorphic landscape over time. In the southern and eastern portion of the study area, which extends from the Rasulpur channel to Udaipur beach, there exist extremely complicated systems of embankments. The embankments of the estuary face of the Rasulpur River, Peechaboni channel, and Jaldah channel have less value in keeping out salt water inundation caused by high tides and storm wave actions. Human interventions are also responsible for the damage to these embankments. Embankments parallel to the coast have increased seasonal silt deposition within the Rasulpur river bed, channel bed of Peechaboni, and Jaldah, etc. Coastal sand dunes and beach ridges are not sufficient to resist coastal erosion and are not adequate to prevent the entrance of marine water directly into coastal lowlands. Damages to the embankment in the southern part of the Shankarpur Mouza may connect the creek at any moment through a newly developed channel, resulting in which the Shankarpur creek will be filled with sand, and the whole hydrological and geomorphological process will be disrupted and affect the geo-environment of this area (FIGURE 6).

FIGURE 6: Anthropogenic activities of the study area

VI. CONCLUSION

The study highlights that the coastal morphology of the western section of the Purba Medinipur coastal tract in West Bengal has been significantly influenced by various anthropogenic activities along with natural hydro-geomorphic processes. Human interventions such as land reclamation, expansion of agriculture in coastal lowlands, rapid population growth, and the conversion of agricultural land into pisciculture, saltpans, and shrimp farming areas have accelerated landscape degradation and increased soil salinity. These activities have altered the natural hydrological regime, leading to waterlogging, embankment breaching, and destabilization of sand dune systems. The study also reveals that human encroachment on coastal landscapes and the loss of mangrove forests have increased geomorphic sensitivity and reduced the natural protective barriers against coastal hazards. In addition, natural processes such as shifting river courses, storm surges from the Bay of Bengal, and variations in wave energy further intensify the morphological changes. Overall, the interaction between anthropogenic pressures and natural coastal dynamics has made the Purba Medinipur coast highly vulnerable to erosion, salinity intrusion, and environmental degradation. Therefore, sustainable coastal management, protection of mangrove ecosystems, and regulated land use planning are essential to maintain the stability of coastal geomorphic landscapes and to reduce future environmental risks in the region.

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Author contribution: KCR: Conceptualization, Writing, original draft, software, data curation, analysis of the results, methodology, and editing the article.

REFERENCES

1) Ahamad, E. (1972). Coastal Geomorphology of India Orient Longman Ltd. New Delhi. 222p.
2) Bandyopadhyay, S. (1997). Natural environmental hazards and their management: a case study of Sagar Island, India. Singapore Journal of Tropical Geography, 18(1), 20-45.
3) Bird, E. C. (2008). Coastal geomorphology: an introduction. John Wiley & Sons.
4) Carter R.W.G. (1988) Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines. Academic Press, London.
5) Das, G. K. (2022). Beach Environments along the Coastal Stretches of West Bengal, India. Research Journal of Marine Sciences ISSN, 2321, 1296.
6) Das, G. K. (2022). Coastal Environments of India. Springer International Publishing.
7) Das, R., & Dandapath, P. (2014). Existence and experience of Purba Medinipur coastal belt on its morpho-dynamic journey with the distinctive geology and geomorphology. International Journal of Science and Research, 3(6), 1242-1251.
8) Goswami, A. (1997). Medinipore coastal belt, West Bengal, a Morpho Stratiographic, Hydrologic and hydro chemical and appraisal. In 8th national symposium on hydrology, Jadavpur University, Calcutta, Proceeding (Vol. 33, p. 39).
9) Hooke, R. (2000). On the history of humans as geomorphic agents. GEOLOGY-BOULDER-, 28(9), 843-846.
10) Karak, R., Mamgain, S., et al., (2025). Earth Observation-Based Analysis and Modelling of Coastline Erosion and Accretion along the Parts of the East Coast of India. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 48, 65-73.
11) Maity, P. K., Das, S., & Das, R. (2020). Geochemical Study and Remedial Measures of Seawater Ingression in the Southern Part of Purba Midnapur District in West Bengal. INDIAN SCIENCE CRUISER Kolkata, 34(2), 36.
12) Mondal, M., Dandapath, P., & Shukla, J. (2013). Emerging Dimension of Coastal Ecotourism Resources along the Coast of West Bengal. International Journal of Advanced Research in Management and Social Sciences, 2(1), 58-73.
13) Mukherjee, A., Chatterjee, S., 1997. Coastal Erosion and Accretion at and around Digha in Medinipur District of West Bengal. Indian Journal of Geography and Environment, 2:1-12.
14) Niyogi, D. (1970). Morphology and evolution of the Balasore shoreline, Orissa. Studies in Earth Sciences, West Commemoration Vol, Today and Tomorrow's Printers and Publishers, New Delhi, India, 289-304.
15) Paul, A.K., 1987. Morpho-ecological variations in the Sundarban Mudflats. Geographical review of India, 49(1), pp.1-14.
16) Paul, A.K., 1996. Degradation of coastal vegetation in West Bengal. Indian Journal of Landscape Systems and Ecological Studies, 19(1), pp.39-50.

17) Paul, A.K., 2002. Coastal Geomorphology and Environment ACB publication Kolkata p. 757.

18) Rishi, K.C., Panda, D., Analysis of Shoreline Changes along Western Section of East Midnapore Coastal Tract of West Bengal, India: An Application of Digital Shoreline Analysis System (DSAS). Ind. J. of Landscape Systems and Ecological Studies 46(1&2) Jun. & Dec. 2023, 5-28; ISSN 0971-4170;