Geologic and Tectonic Framework and its Landforms Evolution of the East Midnapore Coastal Stretch, West Bengal, India

Dr. Kartik Chandra Rishi

Department of Geography, Hijli College, Kharagpur, West Bengal, India
Corresponding Author Email: *rishikartik.88[at]gmail.com*

Abstract: ***The East Midnapore coastal stretch of West Bengal represents a dynamic geomorphic and tectonic environment shaped during the late Quaternary, particularly over the last ~6000 years following Holocene sea-level fluctuations. The region displays different coastal landforms, including sandy beaches, dune complexes, and tidal flats formed through marine transgression–regression cycles and fluvial sediment supply, primarily from the Subarnarekha and associated river systems. Geo-dynamically, the area lies within the Bengal Basin, a tectonically active zone influenced by the convergence of the Indian, Eurasian, and Burmese plates. Geological analysis discloses multiple depositional phases from the Cretaceous to Holocene, with significant contributions from fluvial, lagoonal, and marine environments. Subsurface stratigraphy indicates alternating sedimentary sequences reflecting environmental shifts. Tectonic lineaments, predominantly oriented NE–SW, further highlight structural control over basin evolution. This study provides an integrated understanding of geomorphic development, sedimentation processes, and tectonic influences shaping the East Midnapore coastal zone.***

Keywords: Holocene, Tectonics, Bengal basin, Transgression, Lineaments, East Midnapore coastal stretch

1. Introduction

The present geomorphic distribution, such as the beach, active dunes, mud flats, etc., has developed over the last 6000 years with the last sea level fall after the Holocene climatic optimum through sand deposition by the role of the Subarnarekha River (Bandopadhyay, 2000) in the present-day study. It is evident that the numerous scientific observations show that sea level changes along the Bay of Bengal coast have undergone a dynamic in general, according to geological studies. The entire process of coastal landforms along the East Midnapore coastal stretch of Bengal Basin occurred after sea level rise, which is about 6000 yrs BP. The expansion of consecutive rows of dunes with interfering tidal flats developed during the Holocene period. But the erosion system is established in the western section of the Midnapore coastal plain lands. The Basis of tidal amplitude, the coast has two distinct environments. These are: (a) Macro-tidal zone (range > 4 m), which is characterized by several creeks adjacent to islands with mangrove vegetation that extends from the Sagar Island in South 24 Parganas to the margin of Bangladesh. (b) Meso tidal (tidal range is 2 – 4 m) Medinipur coastal (Digha, Sankarpur, Junput, Mandarmoni) plain to the west of the Hugli estuary, which is characterized by rows of sandy dunes separated by clayey tidal flats. It extends from Sagar Island to the Orissa border to the west.

The geodynamic development of Bengal basin is directly related to the collision between the Indian Plate and the Eurasian Plate to the north and the Burmese Plate to the east which is building the Himalaya mountain process and the Indo-Burma mountain process in the north and east respectively (Hossain, 1985; Hossain, 2019; Khan, 1991; Khan & Chouhan, 1996; Steckler, 2016). The Bengal basin is surrounded by a cratonic passive boundary within the Indian Plate to the west, Indo Eurasia collision boundary to the north, and Indo Burma subduction boundary to the east (Figure 4.1). However, the north-eastern boundary of the Indian Plate system is in collision with the Burma Plate. To the south, it carries on as the Bengal basin fan to the Bay of Bengal on the east coast of India. Current geodetic measurements illustrate that the movement of the Indian Plate is ~6 cm/yr in the northeast direction, which results ~in a 4.5 cm/yr rate of collision with the Eurasian Plate, and ~a 4.6 cm/yr rate of collision with the Burmese Plate (Akhter et al., 2018).

The Bengal basin is located at the junction of three important plates, which is essential to have an approach to plate tectonics and paleo-geographic rebuilding from the super-continent Gondwana land to comprehend the geodynamic development of the Bengal basin. A standard traditional models recommend that the India–Eurasia which is part of Tibet collision event was started 50–55 Ma ago (DeCelles et al., 2002; Najman, 2006; Zhu, 2005), whereas Ali and Aitchison (2008), Aitchison, (2007), Aitchison, (2019), Baxter et al. (2016), and Yang, (2020) proposed that the new models with much younger age. This latest model is relying on strong databases from multiple geological and geophysical databases. So, for the convenience of consideration, it's required to consider major geodynamic actions with their temporal as well as spatial relationships and the development of this basin. With the references, the first geological map of Bangladesh, which is part of the Bengal Basin, prepared by Bakr and Jackson (1964), was further improved in connection with hydrocarbon prospecting of the basin (Bakhtine, 1966; Guha, 1978; Guha & Kitovani, 1965; Matin, 1983). However, it is further than an argument that the availability of geodynamic maps is not extensive, to some extent inaccurate, and complicated to access for study. This study is very important to understand the following objective: (a) to analyze the relationship between the structural framework of the geologic and tectonic setting and the evolution of landforms in the study area.

2. Methods and Techniques

The study is based on an integrated analysis of geological, geomorphological, and geophysical data. Secondary data sources include geological maps from the Geological Survey of India (Bhukosh), previous research studies, and borehole data. Lithological and stratigraphic interpretations were derived using isochronal mapping and subsurface profiling from drilling records. Remote sensing techniques, including satellite imagery interpretation, are used to identify geomorphic features and tectonic lineaments. Comparative analysis of sediment characteristics helped classify depositional environments. The study also incorporates plate tectonic models and geodetic data to understand regional geodynamic evolution and its influence on coastal landform development.

3. 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 (Fig. 1). The length of the coast of the district 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.

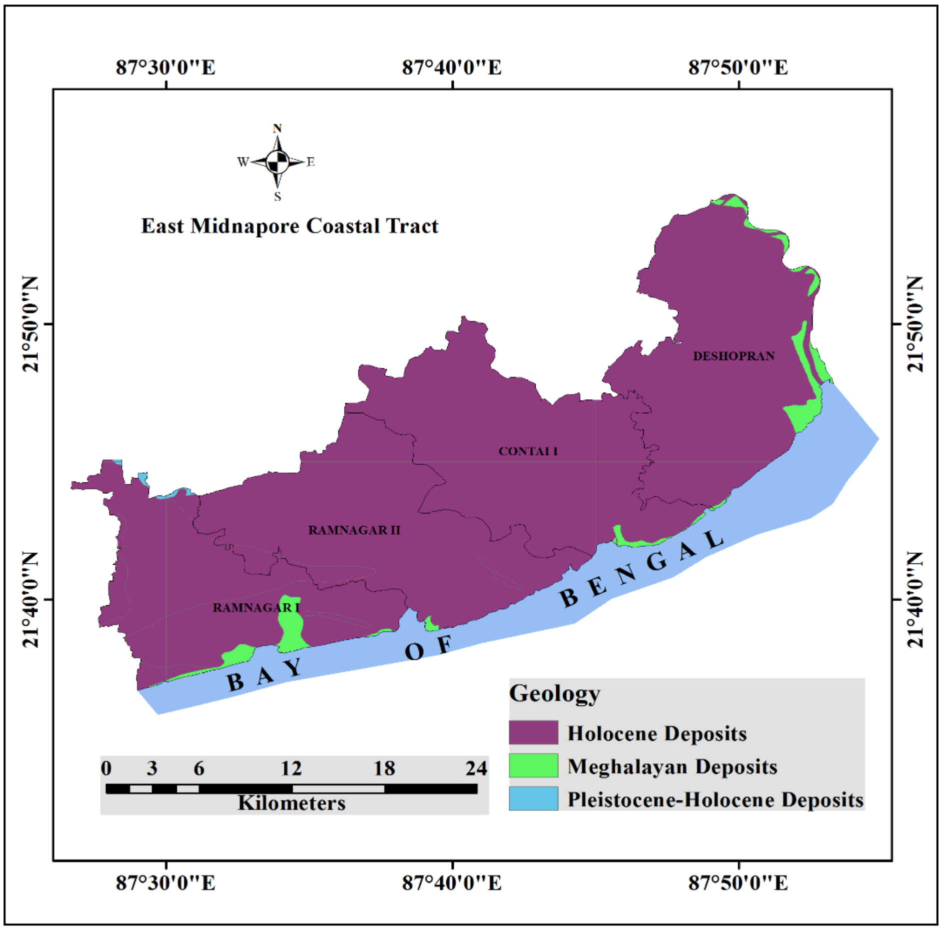

Figure 1: Location of the study area (Source: GSI)

4. Geological Analysis of the Study Area

The study area is the south-eastern section of Bengal Geosyncline, which is characterized by a stable shelf and a deep basin in the west and east, respectively. It is surrounded by the Indian shield in the west, which is bounded by a series of encephalon faults system. Through Geophysical surveys along with deep drilled data sources in this plain of Bengal, showing that widespread basaltic lava is overlying coal containing Gondwana-type sediments. Afterward, geological history is a recurrence of ocean transgression as well as regression, which was main occurrence which is influencing the deposition through the evolution of this basin. The drainage system of this study was created from the Chhotanagpur plateau region, which is the geological mediator for sedimentation processes. The first evidence of transgression in the Bengal basin is through period, of Cretaceous but the upper Cretaceous period has a regression stage. While the regressive phase was general in the Quaternary period, an oscillatory environment was also there at that time period (Tiwary & Banerjee, 1985). According to Raman et al. (1986), through isochronal mapping of lithologic layers, it was found that the Ranaghat and Krishnanagar area has a depositional lowland, and Contai has another depositional lowland in Paleocene and Cretaceous. According to Niyogi (1970), the presence of the Belda-Contai upland, which was not occupied by any large river system in the recent past, is noteworthy. Also, he explained that this highland was developed mostly by the Subarnarekha and Kasai rivers. The major source of sediment loads during the Eocene period was the Palaeo Damodar River. For the period of Cretaceous time, the Ghatal area was under the control of a restricted lagoon environment system, which was substituted by open marine shelf environment during the Paleocene and Eocene period (Raman, 1986) (Fig. 3).

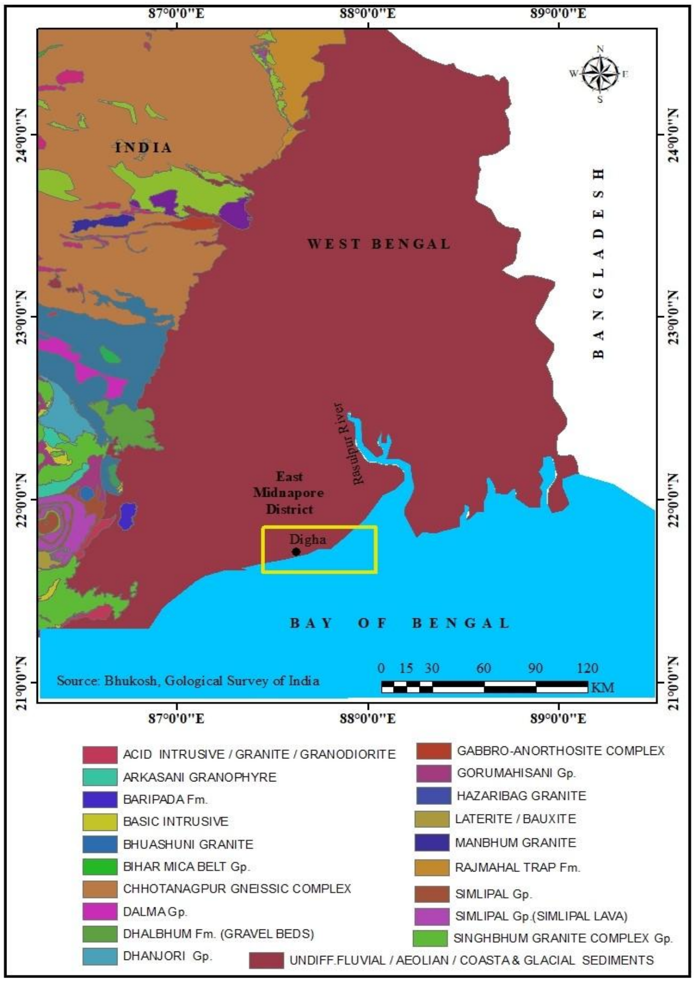

Figure 2: Geological map of East Midnapore district with study area (Source: GSI)

Chakraborti (1991) disagree with this view of Niyogi and suggested an inter-fingering relationship of the rows of dunes, beach ridges, and clayey intertidal flat of the adjacent coastal plain in the east. In the eastern side of the Subarnarekha delta, according to Niyogi (1970), six regular cycles of beach ridges alternating with a variable number of bars are noticeable, which are evidence of shifting of the shoreline in the coastal region. As Chakraborty (1991) stated, only one ridge is present in connection with dune rows situated in the mesotidal coastal plain. These beach ridges are named as "older beach ridge" from their morphodynamics, as stated by Chakraborty. Also, he explained the consecutive dune rows (namely ancient dune rows, older dune rows, and the beach front dune rows) with the clayey tidal flat plains and the local beach ridges are determined in regression of the period of the Holocene. Also, he recommended that the "Ancient dune complex" situated along the Medinipur coast (approximately 10 to 15 km north of the present-day shoreline position) determines the location of the ancient strandline in the area (Table 1).

From the geological map, the whole district is created with six different geological formations since the late Pleistocene era to the Late Holocene era (Table 2). The larger part of this area was created by the Panskura formation in the Middle Holocene period, which is composition by finer sand, silt, and muddy. The urban centre of Haldia municipality is located in the Panskura formations. The parallel sand dune ridges have created in period of Late Holocene which is consist of medium grained semi-compact grey sands, the Digha and Contai are situated in this area. Some portion of Contai is expanded to the Panskura formation. Also, some portion of Digha is situated in the Basudebpur formation, which is consist of dark grey and black clay along with deposited mudflats, formed in Middle Holocene to Late Holocene time period. The sea beach is characterized by very finer, white and grey sands with muddy particles which is formed in the Late Holocene period. The Sijua formation formed during the Late Pleistocene to Early Holocene, consists of sandy loam, silty clay, and caliche. The Kasai river formation, which was formed during the Late Holocene period, consists of unoxidised sand and silt shown in the palaeo and recent river courses (such as Kasai, Rupnarayan, Rasulpur river) and their surrounding areas (Jana & Paul, 2018). The coastal plain region is covered with younger alluviums, which are formed in the Holocene period. The early Holocene to Late Holocene sand dune ridges are divided by palaeo tidal flats, which are surrounded by the Contai and Digha coast. The Haldia region is formed by estuarine floodplain alluviums during the period of Late Holocene to Late Pleistocene (Niyogi, 1975; Paul, 2002; Chakrabarti, 2005). Recently, deposits such as tidal flats, beaches, and sand dunes have been found in emerged and submerged regions. Tidal flats of the Channel fringe and backwater wetlands are deposited by muddy, finer sand and silt (Fig. 2).

Table 1: Thickness of on-lapping and off-lapping sequences in the coastal tract of Midnapore, West Bengal

Area	Well Location	Older eroded land			Onlapping series		Overlapping series		Remarks
		Depths (m.BGL)	Thickness	Sediment type	Thickness	Sediment type	Thickness	Sediment type	
Midnapore Coastal Plain	Negua (bordering an ancient dune complex)	67.44	2.84	Gravel by a tiny amount of caliche & Fe nodules	7.06	Sticky Grey Clay	57.54	Alternating series of sand (finer to coarse with clay by basal layer of kankar, gravel, and Fe nodules (3 m)	Increased thickness of sediments (Quaternary period) of Hooghly estuaries compared to the Medinipur coastal plain, possibly due to structural lowering or geosynclinal down warping.
	Digha (bordering the older dune/beach front dune complex	97.53	12.19	Most coarse sand, subrounded to subangular	12.20	Sticky Grey muddy mostly by sand (finer to medium)	73.14	Alternating series of sands (finer to medium), silty clay by basal (6.09 m) of coarse sand	

Source: Chakraborty. P., 199

Table 2: Geological succession of Purba Medinipur District with study area

Ages	Geological Units	Lithological characteristics
Holocene period	Recently, flood plain deposition	Alternating layers of sand and silt
	Present-day beach deposits	Fine medium greyish brown sands
	Recent dune sand	good sorted, white colour to grayish, yellow sand deposits
	Basudebpur Formation	Sand, silt, and muddy (non-oxidized or sometimes oxidized)
	Panskura Formation	Laterite soils
Late Pleistocene to Holocene period	Sijua forming	Clay and gravel
Pleistocene period	Lalgarh Formation	Consists of quartz, granite, and phyllite, with sometimes laterite
Carboniferous to Triassic	Laterite formation	Laterite with sometimes ring-like silica
	Tertiary Gravel bed	Different size Gravels
	Bhairab Banki	Clay, gravel, and conglomerate
Meso-proterozoic	Younger Volcanics	Tourmaline with quartz rocks
		Kuilapal granite rocks
Paleo-Proterozoic	Dalma Volcanics	Quartzite rocks
		Epidote or hornblende schists
	Singhbhum Group	Quartzite rocks
		Mica and schist, sometimes garnetiferous
		Calc gneisses and granulites
		Garnet staurolite schists, along with kayanites
		Garnetiferous-phyllites

(Source: GSI, 2007)

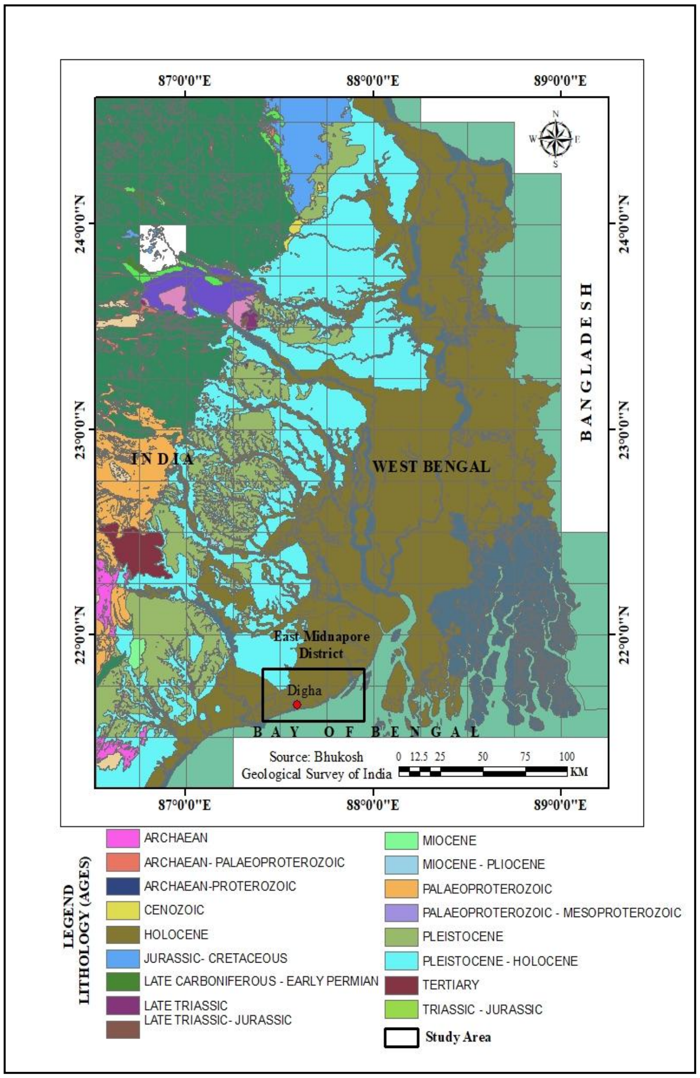

Figure 3: Lithology map of East Midnapore District with study area (Source: GSI)

5. Sub-surface Geology of the Study Area

According to Chakraborty (1991), the East Midnapore coastal belt is underlain by unconsolidated sediments of sand, silt, and clay texture. The types of these sediments are classified into seven diverse zones which rely on physical, biological, and mineralogical characteristics. Along with the borehole study in the Digha coast belt (Goswami, 1968), the subsurface geology of the area may be demonstrated. There are three groups of sediment types observed in the study of boreholes. The study stated that the thickness of each group of sediments differs from 45 m to 60 m. Explained the three groups following: (i) Group C: Marine: range from 0 MSL to -55 m, (ii) Group B: Fluvial: ranges from -55 m to -70 m and, (iii) Group A: Lagoonal: from -70 m to -140 m. The Group A sediments comprise exchange sand and clay layers, which are characterized by a greyish-white colour with a high content of mica substances. The laterite hard solid mass formed by the local accumulation of matter, which varies in size and coarse sediments in the Group B, might have been derived from the nearby laterite horizon layer. Goswami (1968) recommended that a marine transgression possibly took place after the deposition of Group B sediments, which resulted in the formation of Group C sediments under marine processes. The presence of a thick plastic clay bed at the base of this group is significant. Marine organisms are also present in the sandy component of the group of sediments (Table 3).

Table 3: Terrain analysis and classification of the Midnapore coastal belt

Specifics	Physical feature unit	Geomorphological unit	Geological Unit
Coastal and Fluvio-tidal Facies	a) The beach face units b) Beachfront sand dune complex c) Presently, mud or sand d) Older beach ridges complex e) Older sand dune complex f) Older tidal ponds g) The ancient intertidal flat plains h) Ancient sand dune complex and tidal ponds i) Ancient fluvio-tidal flat plains	a) The active marine coastal plains b) The abandoned marine coastal plains c) The inactive marine coastal plains d) The Inactive fluvio tidal flats	a) The current Midnapore Coastal Deposits b) The older Midnapore Coastal Plains c) The ancient Midnapore Coastal Plain

Source: Chakraborty. P. 1991

6. Lineaments Tectonic of the study area

Numerous tectonic lineaments across the Bengal coastal sediments are identified with the help of analysis of aerial photographs and satellite imagery data by some geologists, like Babu (1972), Rakshit (1980), and Das et al. (1985), which can be connected with the tectonic history of Bengal Basin. In the study, most of these lineaments are positioned in the NE - SW direction of the Bengal Basin. According to Nandy (1983), a significant overall plate tectonic framework within the present-day setup of field in the eastern part of the Bengal Basin where the structural experience of the Tripura-Mizoram Fold Belt is probably to cover the area below the alluvium of the Ganga delta plain (Fig. 4).

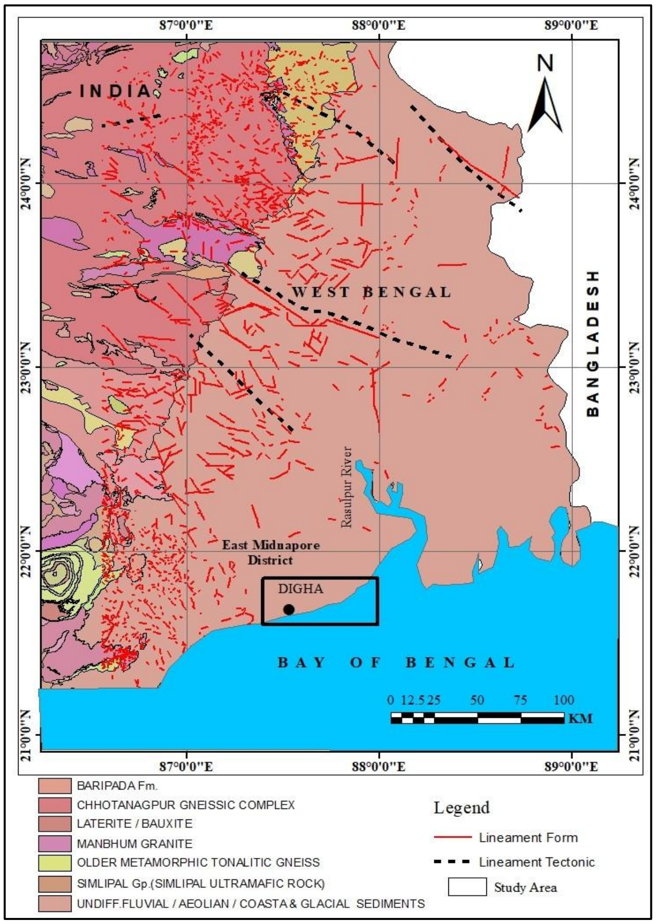

Figure 4: Lineaments Tectonic and forms map with the study area (Source: GSI)

7. Conclusion

The East Midnapore coastal stretch represents a complex interplay of geomorphic evolution, sedimentary processes, and tectonic controls within the Bengal Basin. The present coastal landscape, including beaches, dune systems, and tidal flats, was largely developed during the Holocene epoch following significant sea-level fluctuations. Fluvial inputs, particularly from the Subarnarekha and other rivers draining the Chhotanagpur Plateau, played a crucial role in shaping coastal sedimentation patterns. Geological evidence indicates repeated marine transgression and regression cycles since the Cretaceous, contributing to diverse depositional environments such as lagoonal, fluvial, and marine settings. Subsurface analysis reveals layered sedimentary sequences reflecting environmental transitions, while surface geomorphology highlights the significance of ancient shoreline shifts marked by dune complexes and beach ridges. The presence of NE-SW oriented tectonic lineaments suggests structural influences on sediment deposition and landscape evolution. Furthermore, the region's geodynamic setting at the convergence of major tectonic plates continues to influence its geological stability and evolution. Overall, the study underscores that both past climatic events and ongoing tectonic processes have collectively governed the development of this coastal system, making it highly dynamic and sensitive to future environmental changes.

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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] Aitchison, J. C., Ali, J. R., & Davis, A. M. (2007). When and where did India and Asia collide? Journal of Geophysical Research: Solid Earth, 112. https://doi.org/10.1029/ 2006JB004706

[2] Aitchison, J. C., Ao, A., Bhowmik, S., Clarke, G. L., Ireland, T. R., Kachovich, S., Lokho, K., Stojanovic, D., Roeder, T., Truscott, N., Zhen, Y., & Zhou, R. (2019). Tectonic evolution of the western margin of the Burma microplate based on new fossil and radiometric age constraints. Tectonics, 38, 1718–1741. https://doi.org/10.1029/2018TC005049

[3] Akhter, S. H., Bhuiyan, A. H., & Steckler, M. S. (2018). Geodynamic modeling and hydrocarbon potentiality in Bengal Basin, Bangladesh. AGU Fall Meeting Suppl. Abstract T33-320227.

[4] Ali, J. R., & Aitchison, J. C. (2008). Gondwana to Asia: Plate tectonics, paleogeography and the biological connectivity of the Indian sub-continent from the Middle Jurassic through latest Eocene (166–35 Ma). Earth-Science Reviews, 88(3-4), 145–166. https://doi.org/10.1016 /j.earscirev.2008.01.007

[5] Babu, P.V.L.P., 1972. A review of the geomorphological studies around the Hooghly delta-Bengal Basin. In Proceedings Seminar, Geomorphology, Geohydrology

and Geotechniques of the Lower Ganga Basin. Indian Institute of Technology.

[6] Bakhtin, M. I. (1966). Major tectonic features of Pakistan: Part II. The Eastern Province. Science and Industry, 4, 89–100.

[7] Bakr, M. A., & Jackson, R. O. (1964). Geological map of Pakistan. Geological Survey of Pakistan.

[8] Bandyopadhyay, S., 2000. Coastal changes in the perspective of long-term evolution of an estuary: Hugli, West Bengal, India. Quaternary Sea Level Variation, Shoreline Displacement and Coastal Environments, New Academic Publishers, New Delhi, pp.103-115.

[9] Baxter, A. T., Aitchison, J. C., Ali, J. R., Chan, J. S.-L., & Chan, G. H. N. (2016). Detrital chrome spinel evidence for a Neotethyan intra-oceanic island arc collision with India in the Paleocene. Journal of Asian Earth Sciences, 128, 90–104. https://doi.org/10.1016/j.jseaes.2016.06.023

[10] Chakrabarti, A. (2005), Sedimentary structures of tidal flats: A journey from coast to inner estuarine region of eastern India. Journal of Earth System Science, 114(3), pp 353- 368.

[11] Chakrabarty, P. (1995). Evolutionary history of the coastal Quaternaries of the Bengal plain. India Sci Acad, 61(A), 343-354.

[12] Chakraborti, P, 1991. Process Response System Analysis in the Macrotidal Estuaries and Mesotidal Coastal Plain of Eastern India. In: Vaidyanadhan R(ed) Quaternary Deltas Memories.

[13] Das, D.K., Majumdar, J.P. and Ganguly, A. (1985) Evolution of the landscape in the Calcutta-Sundarban coastal areas of South Bengal, India. Proc. Indian Acad. Sci. (Earth Planet Sci.), Bangalore, Vol. 94, No. 3, pp. 143-152.

[14] 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.

[15] DeCelles, P. G., Robinson, D. M., & Zandt, G. (2002). Implications of shortening in the Himalayan fold-thrust belt for uplift of the Tibetan Plateau. Tectonics, 21(6), 1062. https://doi.org/10.1029/2001TC001322

[16] Goswami, A., 1968. A Study of Saltwater Encroachment in the Coastal Aquifer at Digha, Midnapore District, West Bengal, India. Bulletin International Association of Science Hydrology, Paris, 13(03):77-87.

[17] Guha, D. K. (1978). Tectonic framework and Oil & Gas prospects of Bangladesh. In Proc. of the 4th annual Conf. Bangladesh Geol. Soc. (pp. 65–75).

[18] Guha, D. K., & Kitovani, S. K. (1965). Geology and Oil & Gas prospects of the NW part of Chittagong & Chittagong Hill Tracts with 1st tectonic framework of East Pakistan. Unpublished Report Oil and Gas Development Corporation of Pakistan (OGDC).

[19] Hossain, M. S., Khan, M. S. H., Chowdhury, K. R., & Abdullah, R. (2019). Synthesis of the tectonic and structural elements of the Bengal Basin and its surroundings. In S. Mukherjee (Ed.), Tectonics & structural geology: Indian context. Springer International Publishing AG. 135–218 pp. https://doi.org/10.1007/978-3-319-99341-6_6

[20] Jana, S., & Paul, A.K. (2018), Genetical classification of deltaic and non-deltaic sequences of landforms of Subarnarekha middle course and lower course sections in Odisha and parts of West Bengal with application of geospatial technology. Journal of Coastal Sciences, 5(1), pp16-26.

[21] Khan, A. A. (1991). Tectonics of the Bengal Basin. Journal of Himalayan Geology, 2(1), 91–101.

[22] Khan, A. A., & Chouhan, R. K. S. (1996). The crustal dynamics and the tectonic trends in the Bengal Basin. Journal of Geodynamics, 22(3/4), 267–286. https://doi.org/10.1016/0264-3707(96)00022-1

[23] Khan, M. S. H., Hossain, M. S., & Chowdhury, K. R. (2017). Geomorphic implication and active tectonics of the Sitapahar Anticline – CTFB Bangladesh. Bangladesh Geoscience Journal, 23, 1–24.

[24] Matin, M. A., Khan, M. A. M., Fariduddin, M., Boul, M. A., Hossain, M. M. T., & Kononov, A. I. (1983). The tectonic map of Bangladesh – past & present. Bangladesh Journal of Geology, 2, 29–36.

[25] Najman, Y. (2006). The detrital record of orogenesis: A review of approaches and techniques used in the Himalayan sedimentary basins. Earth-Science Reviews, 74, 1–72. https://doi.org/10.1016/j.earscirev.2005.04.004

[26] Niyogi, D. (1970). Geology background of beach erosion at Digha. Geology Mineral Metal Society India, 19, 191-195.

[27] Niyogi, D., 1970. Morphology and Evolution of the Balasore Shoreline, Orissa. Today and Tomorrow's Publications, Faridabad, India, West Commemoration Volume, pp-289- 304.

[28] Niyogi, Depankar, 1975.Quternary Geology of the Coastal Plain in West Bengal and Orissa. Indian Journal of Earth Sciences, 2(01):68-72.

[29] Paul, Ashis, 2002. Coastal Geomorphology and Environment. ACB Publication, Kolkata, pp. 575

[30] Steckler, M. S., Mondal, D., Akhter, S. H., Seeber, L., Feng, L., & Gale, J. (2016). Locked and loading megathrust linked to active subduction beneath the Indo-Burman ranges. Nature Geoscience, 9(8), 615–618. https://doi.org/10. 1038/ngeo2760

[31] Tiwari, S. & Banerjee, S.K., 1985. Seismic stratigraphy of onshore West Bengal basin, Bull. Oil and Natural Gas Commission, 22,97-121.

[32] Yang, L., Xiao, W., Rahman, M. J. J., Windley, B. F., Schulmann, K., Ao, S., Zhang, J., Chen, Z., Hossain, M. S., & Dong, Y. (2020). Indo-Burma passive amalgamation along the Kaladan Fault: Insights from zircon provenance in the Chittagong-Tripura Fold Belt (Bangladesh). Geological Society of America Bulletin. https://doi.org/10. 1130/B35429.1

[33] Zhu, B. D., Kidd, W. S. F., Rowley, D. B., Currie, B. S., & Shaffique, N. (2005). Age of Initiation of the India-Asia collision in the east-central Himalaya. The Journal of Geology, 113(3), 265–285. doi:10.1086/428805