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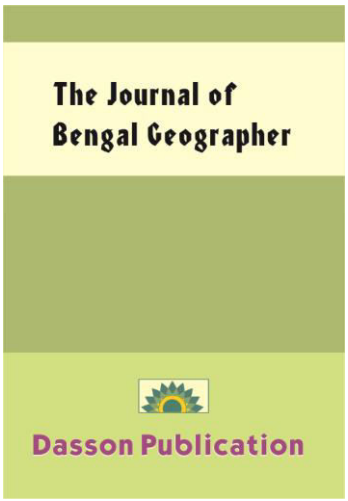

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Accelerated Geomorphic Hazard and Its Impact on Recent Coastal Environment: A Case Study at Jaldah To Mandarmoni Of Purba Medinipur (West Bengal)

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Abstract

The Coast is a most important dynamic zone of the West Bengal. This paper assesses the impact of Accelerated geomorphic hazard on recent coastal environment. The coastal erosion is most important for the changing coastal environment along the jaldah to Mandarmoni coastal tract, which is part of West Bengal coast. Through the erosional mark and shifting of shoreline and also related data have been detected that the coastal accelerated geomorphic hazard, coastal erosion has remarkable along this area over the last decade. As a result of that the shore line has been shifted landward and the entire environment has changed. It has been observed that the coastal erosion and shifting of shoreline of this area also shifted landward at a rate of 4m to 12m/year. At many places the coastal dunes, coastal vegetation and also ecosystem are totally destroyed by accelerate wave erosion. The agricultural land and fish farms are also affected by these accelerated hazards.

Introduction

Coastal zone is the area of interaction between land and sea. It includes both terrestrial as well as marine resources, which may be renewable as well as non-renewable. In addition, interactions between various natural processes and human activities are important factors in the coastal area. At present, many coastal areas worldwide are experiencing shoreline erosion, with a concomitant landward displacement of the shoreline (CARTER ,**1988).**Coastal communities are more vulnerable to climate change because in addition to metrological parameters they are also affected by changes in oceanic parameters, especially increases in sea level and wave heights that will, in some cases, represent physical, social and economic impacts on community.The coastline of West Bengal along the Bay of Bengal is about around 350km and is dominated by the Ganga delta, which covers around 60 percent of this coastline. The elevation of the coast in the southernmost region is <3m above the sea level (Umitsu, 1987, 1993).This coastal tract can be divided into two distinct zones based on the continuous erosion and accretion. When the resultant sediment transport entering a particular area is greater than the sediment going out from the area, accretion or beach development takes place. On the other hand, when there is a deficit of the incoming sediment supply into a particular area with reference to the sediment going out of the same area, beach erosion takes place. Coastal erosion is the most important geomorphic hazard in recent time of this area. According to the researchers, the major cause of coastal erosion and shoreline change is sea level rise. Sea level rise is one of the oft-cited effects of global warming which has a direct role in coastal erosion. It is a particularly ominous threat to the human community because a number of large cities and 10% of the world's population lives in coastal areas within an elevation of 10 m from mean sea level (McGranahan et al., 2007). According to Miller and Douglas (2004), the global sea level has risen, on average, by 1.5-2.0 mm/year in the last century and since 1993, the rate has increased to 3 mm/year (Church and White, 2006). The latest IPCC Report (Solomon et al., 2007) predicts that the global sea level will rise by about 60 cm by 2100 AD. By field investigation and throughout variation of highest sea gauge 1977 to 2012, evidence indicate that a general sea level rise along this coastal tract. (In record and evidence of highest sea gauge during the last 30 years generally increasing which relatively 2m to 3m). Through the highest sea gauge data and field investigation it's have been detected that the local

sea level has rise remarkable along this area over the last 30 years, the rise of sea gauge and also sea level increasing about 15cm/last 3 decades .

The study area

The study area is located Kanthi (Contai) costal area in purba Medinipur district, West-Bengal. The study area lies 87°37'15"E To 87°39'30"E and 21°32'N to 21°33'30"N with total length of coastal tract 5km.Consist of 6 villages-Berakona, Tajpur, Julboni, Jaldah, Silampur and Mandarmoni. The geographical area is cover by SOI toposheet no 73 –o/6, 73-o/10, 73-o/16 and Indian 108-57(IRS-LISS-3). Digha and Mandarmoni are most important urban centre as well as a popular tourist centre near this coastal tract (Figure-1).

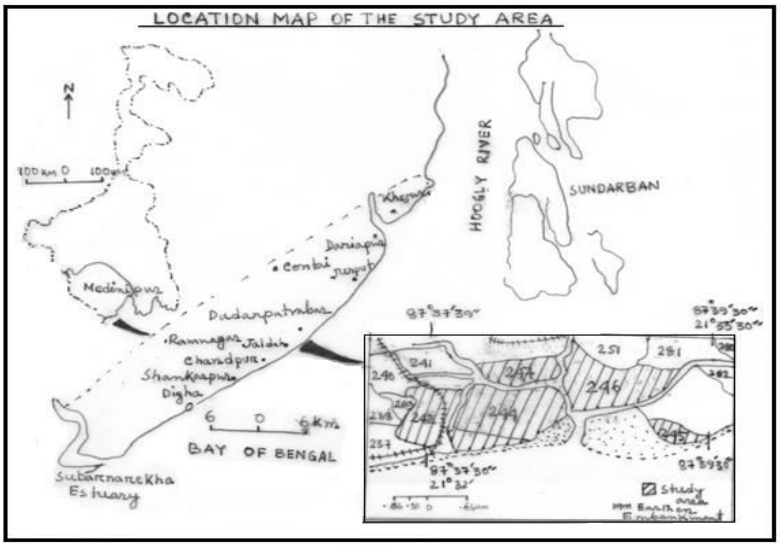

Fig no 1

Objectives

Geo environmental study of any a coastal area in India appears to be a real challenge because of it's over changing conditions as well as the lack of availability of sufficient data. For the study of geo-environmental viz: coastal erosion, shifting of shoreline, change of geomorphology and land use is influenced by the micro level local change of sea level. Based on the forgoing scenario this investigation has been carried out the following objectives:

1. To assess the short term local change of sea level.
2. To find out the changing nature of geomorphic hazards of this area.
3. To find out the geomorphic hazards, how can related to coastal environmental problems

4. To recommend a viable plan on the basis of geo-environmental study of the coastal area

Materials and methods

Data use

Data used for this study are -

1. Satellite imageries (LANDSET – MSS, LANDSET – TM LANDSET-ETM+, IRS – LISS III).
2. Toposheet of corresponding to the study area (73-O/6 and 73-O/10).
3. Bathymetric map of West Bengal coast.
4. Last 30 years sea gauge data of River research instituted.
5. Few years field observation data.

Methodology

Prior to visiting field area, the present authors surveyed the existing literature such as report of geological survey of India, Digha to Shankarpur development authority, Dept. Of environment of West Bengal Govt. etc and recent research paper published in different journal and presented different seminars, congresses etc to prepare a complete field work programme.

Field work

The field work was conducted from the December 2003 to November 2012. The aims of fieldwork were—

1. To assess the recent sea level change;
2. To find out the recent geo-environmental problems;
3. Seasonal variation of sea gauge, rainfall, shifting of shoreline, variation of dunes; morphology and land use were measured and observed for the assessment;
4. Various field works;

Laboratory testing and mapping

Sea gauge data collect through field River Research Instituted (Table-1 and Table-2) during last 35 years in various seasons have use for preparing graph and figure and collect the cyclonic data from IMD during 1891-2009(Table-3). Physical environmental data and socio economic data collect through field survey for the analysis and preparation of final mapping and figure.

Results and discussion

Change of sea gauge and sea level rise

Through the field investigation and observed the sea gauge that there is a tendency of local sea level rise at a remarkable rate during the last 30 years along Digha-Mandarmoni coastal tract. By the

Table 1. Statement of monsoonal highest sea gauge at Digha sea coast, Purba Medinipur

Sea gauge					
Year	Jun	July	August	September	October
1977	2.97	2.71	2.29	3.09	2.08
1980	2.030	3.645	3.505	3.375	3.385
1983	2.985	2.915	3.310	3.215	1.96
1986	2.28	2.88	3.13	2.24	3.05
1989	2.521	2.561	2.371	2.561	2.97
1992	2.201	2.301	2.301	0.790	0.680
1995	4.01	4.21	4.11	2.74	2.74
1998	4.69	4.69	6.055	5.355	4.69
2001	4.505	5.355	5.385	4.010	4.505
2005	4.750	5.240	5.240	5.240	4.690
2006	4.880	4.990	5.355	4.880	4.520
2007	4.750	4.680	4.750	4.680	4.380
2008	4.55	4.750	4.990	5.890	4.710
2010	4.780	4.680	4.780	5.010	5.250
2011	5.285	5.010	5.550	5.060	4.990
2012	5.220	5.010	5.285	5.385	4.865

Source:fiefld investigation

Table 2. Statement of monsoonal lowest sea gauge at Digha sea coast , Purba Medinipur Sea gauge

Year	Jun	July	August	September	October
2005	-1.455	-1.435	-1.735	-1.435	-1.435
2006	-1.435	-1.335	-1.750	-1.435-	-1.450
2007	-1.345	-1.345	-486	-1.960	-1.585
2008	-1.460	-1.335	-1.535	-1.335	-1.550
2010	-1.70	-2.010	-2.250	-1.750	-1.950
2011	-2.050	-2.250	-2.250	-2.450	-2.10
2012	-1.570	-1.850	-1.850	-1.870	-2.250

Source:fiefld investigation

calculating of seasonal sea gauge especially monsoon, it is observed about 2.5m to 5.3m increasing during the last 30 years (Table-1 and Table- 2). The deltaic setting, human intervention, supply of sediments, forming of offshore bar, basement faulting, tectonically very active have also very significant for the local sea level rise, as well as global warming over the last 3 decades. The analysis of remote sensing, sea gauge data and field data of the past 3 decades indicates an increasing local sea level rise at a remarkable rate of 15cm/last 3 decades.

Major cyclonic storms

Sea whether an increase in sea surface temperature is linked to the increase in cyclone intensity. Increasing sea surface temperature over Bay of Bengal during 2006-2009,the region has witnessed 4

Table-3: Number of Cyclonic Storms and Severe Cyclones.

CYCLONIC STORMS

NUMBER OF CYCLONIC STORMS THAT FORMET DURING(1891-1970)

Place	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bay of Ben-gal	**5 (1)**	**1 (1)**	**4 (2)**	**19 (8)**	**39 (26)**	**35 (4)**	**38 (7)**	**26 (1)**	**32 (10)**	**62 (26)**	**68 (33)**	**333 (133)**

(Figures within brackets denote the number of storms which winds exceeded 48 knots)

NUMBER OF SEVERE CYCLONES THAT FORMET DURING(1971-2009)

Place	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bay of Ben-gal	**NA**	**NA**	**NA**	**2**	**6**	**1**	**NA**	**1**	**8**	**5**	**18**	**4**

Source- www.imd.gov.in

Severe to super cyclonic storms with wind speed between 120-260km/hr causing huge devastation in the coastal regions of the State of West Bengal (India).The causes of sea level rise are present rate of temperature rise, thermal expansion of seawater, and higher rainfall. (In

record and evidence of highest sea gauge during the last 30 years generally increasing which relatively 2m to 3m). The rise of sea level made coastal erosion and inundation and a higher surge height during cyclones.

Type of coastal geomorphic hazards

The type of coastal geomorphic hazards on the basis of present study in Chandpur to Mandarmoni coastal tract in the following ways-

1. Beach erosion
2. Dune erosion and shifting of sands
3. Shifting of shoreline

1.Beach erosion

There are little arguments that 70% of the world's sandy beaches are eroding at average rate of 0.5-1.0yr. Some of the reason for this erosion induced increased storminess. Coastal submerged, decreased sediments moves from the continental shelf. Shift in global pressure belt and hence changed in the directional components of wave as well as human activity have a large impact on coastal erosion. The beach widths along the study area are shown (figure-2 and 3).The average beach width was 263.25m in 2006, it was reduced by 15.875m in 2012.

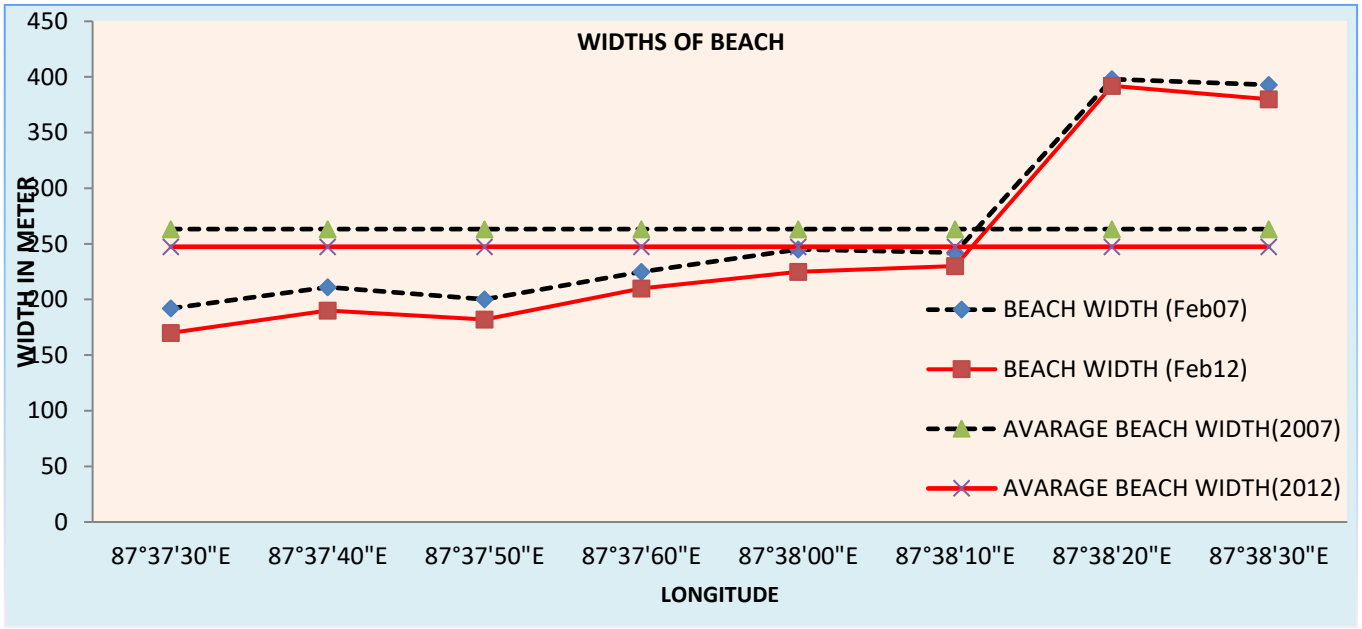

Figure-2: Narrowing beach width along the study area.

Factors recognized as controlling beach erosion

Exclusively human induced

1. Reduction human longshore sand supply because construction of brick wall **2**.Quarrying of beach sediments **3**.Intense recreational use 4.Afforesting on dune

Exclusively natural

1. Sea level rise; **2**.Increased storms (Table-3) **3**.Increased loss of sands shoreward from the beach by increased wind drifting; **4**.Reduction of sands from self to shore ward because beach profile is steep or exhausted ; **5**.Movement of shoreline to land ward;

Other man induced or natural

1. Decreased in sand supply from river because reduced runoff from decreased rainfall & dam construction **2**.Reduction in sands supply from eroding cliff, either natural because they are protected by sea dyke.

Photo No-1 : Narrowing beach width and exposed mud bottom along the chandpore coast

2. Dune erosion and shifting of sand dunes

The dune erosion along the study area are shown (Table no-4).The average dune height was 12.44m in 2005, it was reduced by 8m to 10m in 2012 by high wave action, cyclone and tidal surges etc.

Table No-4: Dune erosion

Location	Dune height (m)	
	2005	2012
Shankarpur	**17.50**	**4.56**
Chandpur	**12.24**	**4.8**
Jaldah	**12.1**	**4.2**
Mandarmoni	**7.95**	**1.30**

Variation of dune height of 2005 and 2012

Source: Field investigation

The shifting of sand dunes along the study area are shown (Table -5).The dunes are maximum shifting to landwards in pre monsoon season. Movements of dunes increased between Chandpore to Jaldah.

Table-5: Shifting Of Sand Dunes of 2004, 2005 And 20012

Shifting of Sand Dunes

Years	Location	Station	Season	Towards land
2004	jaldah	B	Pre monsoon	9.0m
2005	chandpur	A	Pre monsoon	7.0m
	jaldah	B		5.5m
2012	Chandpur to jaldah	A	Pre monsoon	8.2m
	"	B	Pre monsoon	4.3m
	"	C	Pre monsoon	5.0m
	"	D	Pre monsoon	4.0m
	Tajpur	A	Pre monsoon	7.3m
	"	B	Pre monsoon	5.2m
	"	C	Pre monsoon	4.4m
	"	D		5.0m
			Pre monsoon	
	Mandarmoni	A	Pre monsoon	6.5m
	"	B		7.5m

Source: Field investigation

Photo No-2: Dune Erosion And Shifting Of Sand Dunes Of Chandpore-Jaldah Sector

3. Coastal erosion and shifting of shoreline

The geological survey of India (1995) has detected that shoreline positioned 5-15km inland from the present shoreline around 6000years BP. Around 3000 years BP the shoreline position was 2-3km inland from the present shoreline .Further the public works, department constructed and inspection banglo, ½ of km inland from the place, with mouza Digha and Talgachari-I but with transgression of the sea this entire area has gone under the sea. Recently the Digha- Mandarmoni coastal area is landward shifting of shoreline due to local micro level rise of sae level and subsequent coastal erosion. Evidence also suggests that over the last 30 years the problems of erosion and shifting of shoreline have aggravated along this coastal tract (Table-6 and Photo-2, Fig No 3).

Table-6: Average Coastal Erosion Rate (M)/Year.

Coastal erosion

Sectors	Stations	Longitude	Erosion rate(m)/year	status
Chandpur-Jaldah	**A**	**87° 35'00"**	**4.7**	**Erosion**
	B	**87° 35' 15"**	**4.5**	**Erosion**
	C	**87° 35' 30"**	**3.2**	**Erosion**
	D	**87° 35' 45"**	**2.6**	**Erosion**
	E	**87° 36'00"**	**2.8**	**Erosion**
	F	**87° 36' 15"**	**2.0**	**Erosion**
Tajpur-Mandarmoni	**-----**	**87° 37' 00 "to 87° 38' 30"**	**----**	**Accretion**

source: field investigation

The rate of landward shifting of shoreline has been estimated by studying beach profiles and by interpretation of survey of India (SOI) toposheet, satellite images. From the recorded data and comparative study with survey of India toposheet, satellite images and field data it is found that during 1972-2014 the eastern part of this coastal tract from Digha estuary to Jaldah estuary about 13km was under prominent erosion and landward shifting of shoreline.

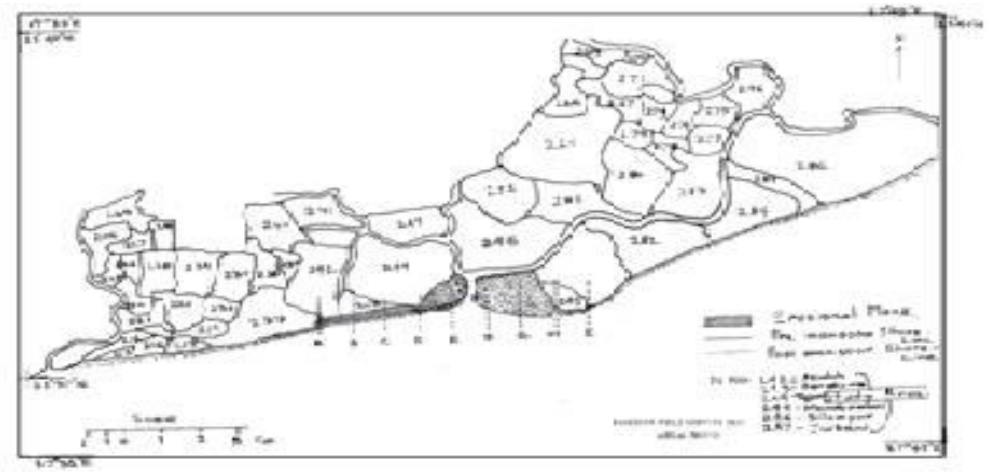

Fig-3: Beach profiles and seasonal shifting of shoreline .

Recent changing physical and socio-economic environment

Recent Geomorphologic changes around Jaldah-Mandarmoni coast:-

- **Sand lost**: sand lost from Shankarpur-Chandpur sector by the cyclonic storms, wave action &anthropogenic activity.
- **Dune erosion**: Costal sand dunes are highly influenced by wave attack at the high tide level in the region, so changes the physiographic of fore dunes include: dune crest recession, dune cliff formation, dune erosion of the sea faces & mobility of sand dune (Figure-5).
- **Bank erosion**: Large scale damage of the flood bank erosion produced by cyclones (1978, 1988-89, 1991, 1995, and 2009) with eroded and inundation in many low land of coastal area.
- **Wetland lost**: at the present time acceleration shore line erosion& it promotes to wetland filling by rate of deposition

- **Vegetation destroyed**: during the cyclonic storms wave action the whole vegetations were over run up by the sea water. As a result of inundation, primary vegetations are destroyed, other vegetations were also uprooted.
- **Saline water extended landward**: in the storm period large scale breaches of saline water flashed the coastal lowland, back dune areas& agriculture land. So agricultural and fish farm are totally destroyed by sea saline water.
- **Attack on coastal habitation**: increasing erosion and storm damage attack on coastal habitation could be severe. So the rehabilitation costs for displaced resident people shared huge of money of other funds.
- **Anthropogenic activity**: By field investigation, we see destroyed the dunes for the purpose of hotels established and also corps cultivation caused by anthropogenic activity.

Conclusion

The Present study shows that the foreshores of coastal profile in many parts of West Bengal are now adapting a new dynamic equilibrium probably due to changed hydrodynamic conditions and sediment characteristics. Frequency of cyclones is increasing, and changing the hydrodynamic regimes of the shores with increased wave events. We have to adopt a long term programme but relatively a sensitive approach in coastal management at present. The study is necessary to understand the behaviour of energy variations, of energy input for the successful implementation of management programmes. It is better to preserve the natural systems (dunes and marshes) by allowing them to adjust to the constantly varying environment of coast. Human use to changing coastal zone should be more scientific.

Recommended policy intervention

- This coastal area development confirm to regional and national government policy.
- Control or prohibition of removal of sand or material, disturbance of coastal vegetation.
- Dune stabilization by planning long rooted grasses.
- Construction of two embankments, one situated on high tide level & second located the200m distance after first embankment.
- Co-ordination between Forest, Irrigation & Digha-Shankarpur development authority.
- Create the five stage wave breakers designed on the seaward slopping concrete slabs.
- Analysis of at least 100 years of tide, waves & wind patterns.

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