

Recent Local Sea Level Changes and its Impact on Geo-Environment of Purba Medinipur Coast, WB-A Geographical Analysis

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ABSTRACT

This paper assesses and analyzed the impact of recent local sea level changes upon coastal Geo-environment especially the beaches, shoreline, coastal sand dunes, mangrove forest, channel bank, fish farms and also agricultural field along Digha to Mandarmoni coastal tract which is a part of Purba Medinipur District, West Bengal. Through the tidal 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. As a result of that the shoreline has been shifted landward and also beaches are narrowing and the entire environment has changed. It has been observed that the front dunes are eroded and also shifted landward at the rate of 6m to 12m/year of this area. Through the field investigation and measuring of erosion data it's have been remarkable increasing in last decade. The dunes are totally destroyed by increasing wave action at many places. The mangrove forest is totally uprooted and destroyed at Shankarpur, Jaldah sector. The channels banks, fish farms and also agricultural land area are suffering due to coastal inundation. Formation of offshore bar, supply of sediment at the mouth of Subarnarekha River and construction of fishing harbour, new building, associated industry, development of coastal tourism and also deforestation along the coast has aggravated Geo-environmental problems.

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1. Introduction

In general terms coastal zone is the meeting place of land, water and air. Coastal zone is the place where the maritime environments influence upon the terrestrial environment (Pethic, 1984). Coastal zone is considerate as a dynamic system. Digha-Mandarmoni costal area is under the Kanthi coastal plain of W.B. This coastal zone was formed by the geomorphologic evaluation during late Holocene period about 6000YBP (Sahoo, 2007). During the recent year's local sea level changes, which is burning issue

for the geo scientists and obviously have direct relationship with geo environmental changes in this coastal area? 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).

al 2004). 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 . As result of that the shore has been shifted, so called shifting of shoreline the rate of 4m to 8m/year and also beaches are narrowing, front dunes are eroded and also shifted land ward 6m to 12m/year. Mangroves forests are totally uprooted and also agriculture land area are suffering high wave action and change of geo-environment.

2. Location and Identification

Digha-Mandarmoni coastal tract over which this study has concentrated is a part of Kanthi coastal plain of Purba Medinipur (W.B) coastal area (Figure-1), having

a length about 15 km from Jatranala channel in the west to eastern end of Mandarmoni in the east, in between latitude $21^{\circ}36'50''\text{N}$ to $21^{\circ}39'00''\text{N}$ and $87^{\circ}29'40''\text{E}$ to $87^{\circ}37'00''\text{E}$ longitude. The north south streches are about 10 km from the sea. Consist of Gram Panchayet: Padima-I, Padima-II, Talgachhari-II and Kalindi. 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.

Geo environmental study of any a coastal area in India appears to be a real challenge because of its 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 physiographic and land use pattern are 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 basic physical environmental problems due to micro level change of sea level.
3. To find out the actual effect of land use pattern and socio-economic processes due to the major environmental issues.
4. To recommend a viable plan on the basis of geo-environmental study of the coastal area.

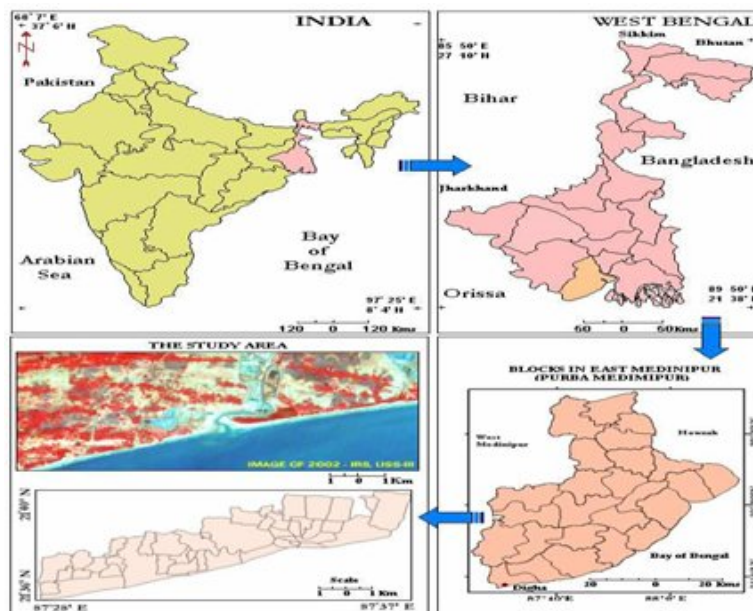


Fig. 1 : Location of study area

Table-1 : Basic Materials used for the study

BASIC MATERIALS	YEAR OF PUBLICATION	PUBLISHERS AND SOURCES
Toposheet-73-O/6 and O/10	1931,32 and 1968,69	Survey of India
Sea gauge data	1977 to 2012	RRI,Digha
Landset-MSS,TM,ETM+ and IRS-LISS- III	2002 TO 2012	National Remote Sensing Agency
Bathymetric map		NHO chart no-351
Field observation data	2002 to 2012	Field investigation

3. Materials and Method

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

The field work was conducted from the December 2003 to November 2012. Different techniques and instruments applied during field work (Dumpy level, GPS, Clinometer etc). During the field work, To assess the recent sea level change and recent geo-environmental problems, Seasonal variation of sea gauge, rainfall, shifting of shoreline, variation of dunes morphology and land use were measured and observed for the assessment. Various field maps were prepared during field work.

Geo-environment data collect through field River Research Instituted (Table-2 and Table-3), Digha - Shankarpur development authority, Dept. Of environment of West Bengal Govt. and field investigation during various seasons has interpreted and use for preparing various maps and figures. Survey of Indian topographical map is geo-referenced in the process to single image rectification. Then the map to image rectification was performed to geo-reference the satellite images with rectified topographical map. Four multi-temporal satellite data from different sensor-MSS, TM, ETM+, LISS-3 are registered to the same geographical datum and map projection (Table 1).

4. Results and Discussion

4.1 Variation of sea gauge and sea level change

At mid 20th century the scientists pointed out a serious trend of Global warming. During the 70s of the last century a sharp rise of temperature was found due to huge increasing human intervention of the earth (Hazra et al, 2004). 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 calculating of seasonal sea gauge especially monsoon, it is observed about 2.5m to 5.3m increasing during the last 30 years (Figure-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.

4.2 Sea level change 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 (GSI, 1995 and Sahoo, 2007). 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.

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 1972-2012 the eastern part of this coastal tract from Digha estuary to Jaldah estuary about 13km was under prominent erosion and landward shifting of shoreline (Chatterjee, 1972). However Jatronala to new Digha about 1km length has under little accretion this period (Figure-3, and figure- 4a, 4b).

4.3 Sea level change and impact on environment

Coastal zone and coastal physiographic are considered as a dynamic system as because it various in width

Table 2: Statement of monsoonal highest sea gauge at Digha sea coast, Purba Medinipur

YEAR	JUN	JULY	AUGUST	SEPTEMBER	OCTOBER
1977	2.97	2.71	2.29	3.09	2.08
1978	2.06	2.44	2.46	2.08	2.00
1979	2.315	2.595	3.505	2.065	2.165
1980	2.030	3.645	3.505	3.375	3.385
1981	2.48	3.74	3.044	3.75	3.49
1982	3.245	3.375	2.925	2.675	2.665
1983	2.985	2.915	3.310	3.215	1.96
1984	2.855	3.155	3.665	2.782	2.782
1985	2.565	1.21	2.715	3.395	4.085
1986	2.28	2.88	3.13	2.24	3.05
1987	3.25	3.21	3.08	2.89	3.26
1988	2.501	2.611	2.381	2.941	3.361
1989	2.521	2.561	2.371	2.561	2.97
1990	2.486	2.206	2.476	2.366	1.176
1991	2.001	1.861	2.311	2.221	1.821
1992	2.201	2.301	2.301	0.790	0.680
1993	1.791	1.911	3.22	2.69	2.64
1994	4.21	2.74	4.215	4.215	2.69
1995	4.01	4.21	4.11	2.74	2.74
1996	1.94	4.21	5.385	2.54	4.86
1997	2.74	4.215	6.385	3.81	2.94
1998	4.69	4.69	6.055	5.355	4.69
1999	5.355	5.355	5.355	4.690	5.964
2000	4.505	4.505	5.355	4.505	4.505
2001	4.505	5.355	5.385	4.010	4.505
2002	4.990	4.750	5.536	5.510	4.750
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
2009	N.A	N.A	N.A	N.A	N.A
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 : RRI Digha)

Table 3: Statement of monsoonal lowest sea gauge at Digha sea coast , Purba Medinipur

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
2009	N.A	N.A	N.A	N.A	N.A
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 : RRI Digha)

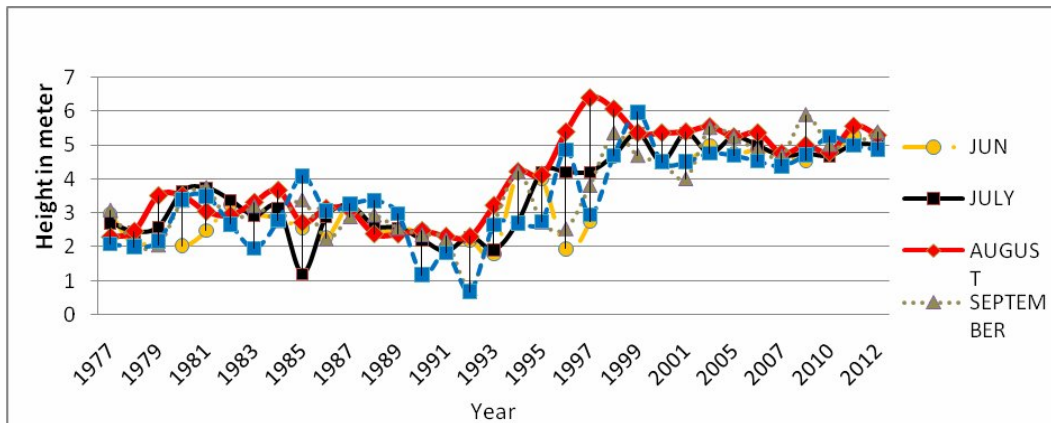


Fig. 2 : Variation of highest sea gauge during 1976-2012

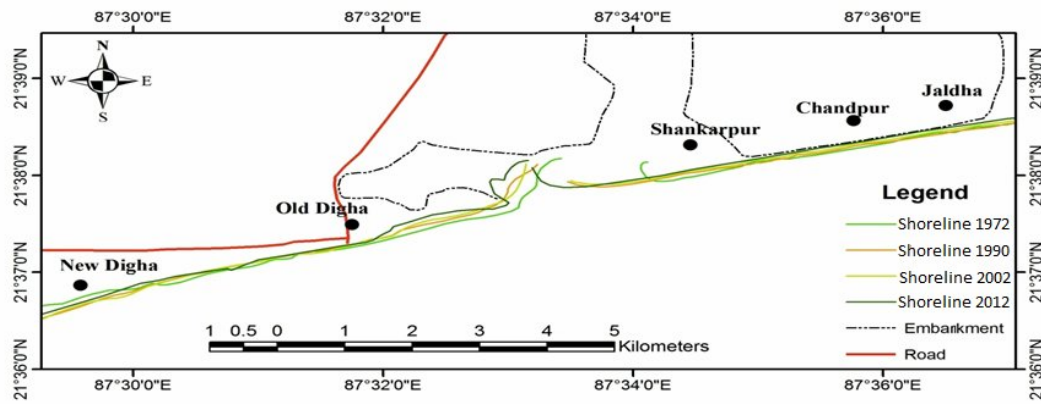


Fig.3 : Shoreline shifting 1972 to 2012 derived from SOI toposheet and satellite imagery



Fig. 4 : (a) landward shifting of shoreline and high tidal mark and (b) Existing damaged sea dyke of Chandpur-Jaldha sector

and deep on shifting both in space in time. During the last century and recent three decade/30 years sea level changes, which is a burning issue for geo-scientist, causes the coastal erosion throughout the world.

Beaches are key sites for recreation and tourism, as well as important coastal sediment stores, which change in response to varying condition of erosion and deposition. Duttapur, Digha, Shankarpur, Chandpur, Tajpur and also Mandarmoni beaches are sandy to loamy type. Beach profile rip channel, back wash ripple, bars, beach face, rill marks, swash marks etc features are found here.

Table 4: Narrowing Beach widths

Location	Feb.2006	Feb.2012
Dattapur	180m	175m
Gangadharpur	125m	117m
Jhmra-Shyampur	95m	80m
Shankarpur	160m	146m
Chandpur-Jaldah	145m	135m
Tajpur	415m	408m
Mandarmoni	394m	393m

(Source: Pual, A and field investigation, 2012)

By field survey and observation indicate existence of such relationship between sea level change and beach width. Last 30 years sea gauge generally increasing about 2.5m to 5.3m in monsoon season, causes by little sea level rise and change. For this reason impact on beach physiographic, viz. erosion and landward shifting of shoreline, all beaches are narrowing, grooving and also beach erosion due to high wave action (Table-4).

Recent physiographic changes due to sea level change around Digha to mandarmoni coast is recorded through maps, charts, air photograph, satellite imagery, field investigation and others records since 1977 in this coastal tract. Physiographic change of foredunes include: dune flattening, wash over dune breaches, cliff formation, crest recession (figure-6), dune erosion of sea face, variation of dune height (Table-5) and complete removal or elimination of dune bodies are most significance environmental impact type to coastal area at Shankarpur, Chandpur. Wider active profile of the monsoonal season are always increasing shoreline with the local sea level rise (Figure-5). Casuarinas trees are uprooted from the front dune barrier and a large part of mangrove forest is also lost by erosional activity (figure 7).

The environmental condition of the coastal tract

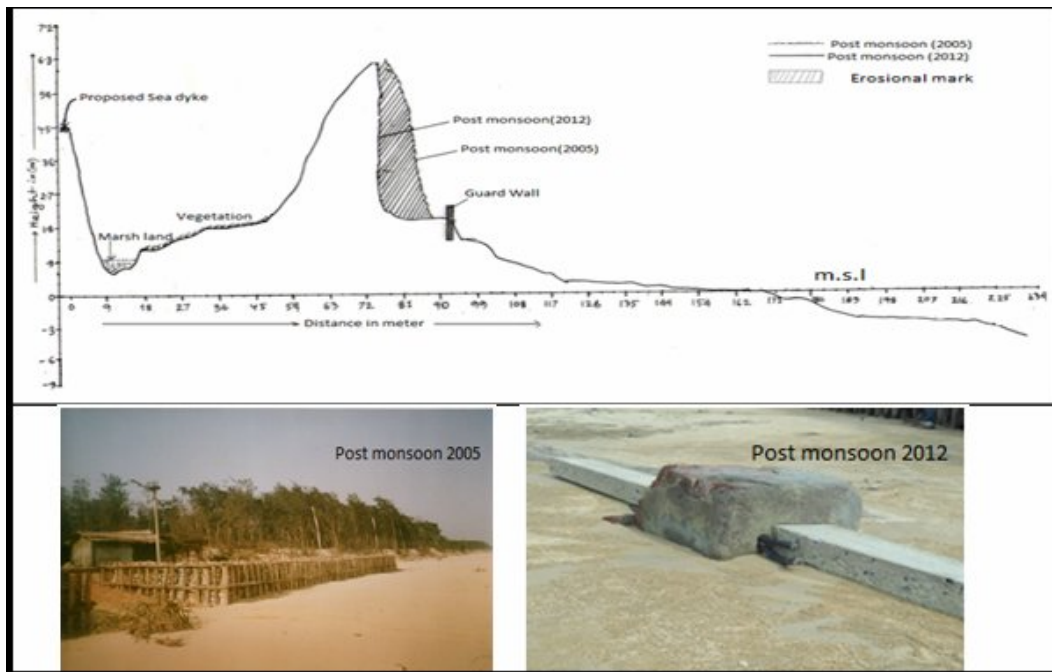


Fig. 5 : Wider active profile of the monsoonal season are always increasing shoreline with the local sea level rise at Shankarpur, Chandpur.

Table 5: Variation of dunes height in 2005 and 2012

Location	Dune height (m)	
	2005	2012
GANGADHARPUR	19.5	6.9
JAMRA-SHYAMPUR	11.93	3.92
SHANKARPUR	17.50	4.56
CHANDPUR	12.24	4.8
JALDAH	12.1	4.2
MANDARMONI	7.95	1.30

(Source: Sahoo, 2007 and field investigation, 2012)

remind very dynamic during the last century especially last 30 years, which influences the ecology and human society (Table 7). Accelerated shifting of sand dunes to landward and also capture the agriculture land, fishing pond at Shankarpur (Table 6 and figure 8).



Fig. 6 : Recession of dune crest at Ghangadharpur to Shankarpur



Fig. 7 : Uprooted Casuarina trees from the shore front dune barrier at Shankarpur

5. Conclusion

The principal objective of the study is to understand the recent local sea level change and impact on geo-environment of the study area. It is observed that there is a tendency of sea level change at a remarkable rate during the last 30 years along Digha-Mandarmoni tract. There is sample evidence and investigation from collected sea gauge data, specially monsoon season and sea level rise at a considerable rate about (5mm/year) in this part during recent years.

Prominent land ward encloement of dune along with the shoreline changes strongly support that local sea level rise is now alarming stage in this area. Shifting of shoreline, coastal erosion (Table 8 and Figure 9), narrowing sea beach and shifting of sand dunes are severe problem of this area and also remarkable change of geo-environment. Human intervention, particular over the last 30 years has also been very significant for the change in coastal geo environment. Construction of fishing harbour, covering a large area



Fig. 8 : Accelerated shifting of sand dunes to landward and also capture the agriculture land, fishing pond at Shankarpur.

Table- 6: Shifting of Dunes in 2004, 2005 and 2012

Years	Location	Station	Season	Towards land
2004	Shankarpur	A	Post monsoon	10.0m
	Chandpur	B	Post monsoon	9.0m
2005	Shankarpur	A	Post monsoon	8.0m
	Chandpur	B	Post monsoon	7.0m
	Gangadharpur	A	Post monsoon	9m
2012	Gangadharpur	B	Post monsoon	9.8m
	Somaibasan	A	Post monsoon	6.0m
	Shankarpur	A	Post monsoon	12.0m
	Chandpur to jaldah	A	Post monsoon	8.2m
	"	B	Post monsoon	4.3m
	"	C	Post monsoon	5.0m
	"	D	Post monsoon	4.0m
	Tajpur	A	Post monsoon	7.3m
	"	B	Post monsoon	5.2m
	"	C	Post monsoon	4.4m
	"	D	Post monsoon	5.0m
	Mandarmoni	A	Post monsoon	6.5m
	"	B	Post monsoon	7.5m

(Source: Sahoo,P and field investigation,2012)

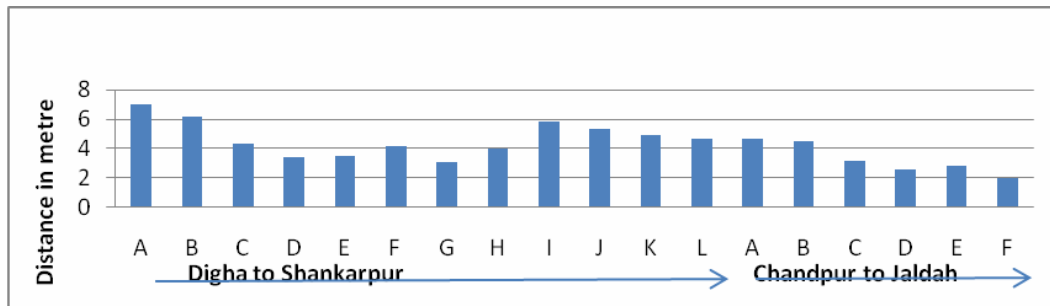


Fig. 9 : Rate of coastal erosion in recent year at various places

a Shankarpur sector development of tourism and associated industries at Digha, Tajpur and Mandarmoni have aggravated environmental hazards.

In this connection it may be stated at several vulnerable locations, the crest width is already narrowed 1 to 2 metre only. Besides, it is also revealed from the records that during high tide, the sea water level started rising abruptly (on an average up to 5m) since 1998 in comparison to that of earlier years when the level usually remain below 3 metre . This variation of levels of sea water obviously cause of severe effect for rapid engulfment of bank line. As a

matter of fact, the sea dyke not only protects a vast area lying on its countryside against flood, but also prevents ingress of saline water to the countryside, which is dangerous for socio economic life. The area is purely agricultural belt, growing valuable crops viz. Betel-leaf, Paddy, Cashew nut, Chilly plants etc. Obviously if any untoward incident happens in the existing damaged sea dyke, particularly during the high "kotal " period when the sea level dangerously surges up to level of 5m to 6m the extent of devastation following failure of the sea dyke could be easily imaginable.

Table-7: Recently sea level change and impact on environment

Observation area	Influence by	Types of change	Environmental impact type
Gangadhar pur	Hydrographic and wind action	Shifting of sand dunes	Capture of agricultural land, wider sea beach
Jamra-Shyampur	Hydrographic and wind action	Shifting of sand dunes and decreasing of dunes height	Capture of agricultural land and fishing ponds
Shankarpur	Hydrographic, Meteorology and anthropogenic activities	Erosion of Front dunes and beaches, destroyed the highest sand dunes, over wash by high tide	Shifting of shoreline, narrowing sea beach, grooving and clay banks forming, uprooted casuarinas trees, salt water invasion to agricultural land
Chandpur-Jaldah	Hydrographic, Meteorology and anthropogenic activities	Erosion of Front dunes and beaches, destroyed the highest sand dunes, over wash by high tide	Shifting of shoreline, uprooted casuarinas trees and mangrove forest, capture of agricultural land and fish farm due to shifting of dunes, salt water invasion to agricultural land
Tajpur	Hydrographic, Meteorology and anthropogenic activities	Erosion of Front dunes and beaches	Shifting of shoreline, uprooted casuarinas trees and mangrove forest
Mandarmoni	Hydrographic and anthropogenic activities and development of tourism industry	Erosion of Front dunes and beaches, destroyed the highest sand dunes, over wash by high tide	Shifting of shoreline, uprooted casuarinas trees and mangrove forest, capture of agricultural land and fish farm due to shifting of dunes, salt water invasion to agricultural land

(Source: Paul, 2002; Sahoo, 2007 and field investigation)

Table 8: Rate of coastal erosion in recent year at various places

Sectors	Stations	Longitude	Erosion rate(m)/year	Present status
Digha-Shankarpur	A	87° 31' 40"	7.0	Erosion
	B	87° 32' 00"	6.2	
	C	87° 32' 20 "	4.3	
	D	87° 32' 40"	3.4	
	E	87° 33' 00"	3.5	
	F	87° 33' 20"	4.2	
	G	87° 33' 40"	3.1	
	H	87° 34' 00"	4.0	
	I	87° 34' 10"	5.8	
	J	87° 34' 20"	5.3	
	K	87° 34' 30"	4.9	
	L	87° 34' 40"	4.7	
	Chandpur-Jaldah	A	87° 35' 00"	
B		87° 35' 15"	4.5	
C		87° 35' 30"	3.2	
D		87° 35' 45"	2.6	
E		87° 36' 00"	2.8	
F		87° 36' 15"	2.0	
Tajpur-Mandarmoni	----	87° 37' 00 " to 87° 38' 30"	---	Accretion

(Source: Field investigation, 2012)

Consequently, considering the very urgency and importance of coastal erosion at Digha - Shankarpur area. Govt. of West Bengal promptly constituted an expert committee under the chairmanship of the Chief Secretary; Govt. of West Bengal which will analyses the coastal erosion problem on the top priority basis and will suggested the solution to check the onslaught thereof. There after The committee has been holding series of meetings and has already worked out a guide line for implementation of various phase wise measures of both short term and long term prospects at different typical segments of the dyke. Accordingly the present estimate is prepared following the said guideline, corresponding to the immediate permanent solution for a length about 11km. from Gangadharpur to jaldah by shifting the sea dyke beyond CRZ 500m.

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