An alarming situation for Digha Shankarpur coastal area, West Bengal- A case study

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Abstract

Coastal erosion is an elongated problem in West Bengal coast, India. In the recent years, the rate of coastal erosion is considerably enhanced in India due to human interference and natural drivers. The coastline of western part of West Bengal is severely eroded. During this period, accretion was recorded up drift of artificial structures, like seawall, groin, pylons and jetties; while, massive erosion was recorded in down drift areas of these structures. The conflict between the artificial structure and high tide line is a considerable problem in this region. Waves can easily over top the crest of the seawall especially in the monsoon month and water level increases rapidly. The present study and investigation helps to understand the trend of water line shifting and its impact on artificial structure. Some important factors are consider to complete the study like wave height data, wind speed and direction data, rainfall data, various satellite imageries, location of seawall etc.

Keyword: Erosion, Accretion, High water line, Littoral zone, Abrasion.

1. Introduction

Digha-Shankarpur coastal stretch which is south western part of West Bengal, India has witness of successive coastal erosion and prominent high tide line shifting. The changes or shifting are gradually because of its high dynamic nature. The shifting is provided by storm and cyclones, various coastal processes, sea level rise, seismic events, high tidal wave, monsoon rainfall, cumulative impact of all such long and short term process cause overall change in high tide line geometry. High tide line shifting rate is important for a wide range of coastal studies such as development of planning, hazard zoning, erosion studies and impact on artificial structure. Medinipore (Digha- Shankarpur- Junput) coastal part of West Bengal is a meso tidal coastal plain (tidal range 2 – 4m) with rows of sandy dunes separated by clayey tidal flats from Sagar Island to Orissa border to the west. Besides the reason for coastal erosion, littoral retreat is always reflected by over wash and/or beach and dune erosion (Bird, 1993). The accelerated rate of erosion on the beach and unprotected eastern side from hotel Sea Hawk to Digha Mohana (mouth) is severely threatened by coastal dune retreat. The western part of unprotected coastal area is under threat of encroaching sea. In the west of Shankarpur beach (from beach up to 100m west) towards Ramnagar Khal is under deposition. Studies based on the analysis of long-term tide-gauge data from various stations along the Indian coastal regions, corrections for vertical land movements included, indicated that sea levels are rising at a rate of about 1.0–1.75 mm per year due to global warming (Pendleton E. A., 2015; Thieler E. R., 1999; Ghosh D., 2001-02) used coastal slope, geomorphology, mean tidal change, sea level rise mean shoreline change rate, and mean wave height for assessment of coastal vulnerability of the United State Atlantic coast (Dinesh Kumar P. K.).

2. Geographical location of the study area

India is blessed by a long shoreline enclosing the State from three sides, i.e. East, South and West. The eastern coast of the Indian subcontinent, experiences lots of dynamism in terms of the coastal stability (Chatterjee, 1995) compared to the western part. The eastern part of India experienced a lots of dynamicity compared to western part of especially Digha Shankarpur coastal region including artificial structure (Fig.1). The latitudinal and longitudinal stretch of the coastline is about 21°36'38.558"N to 21°38'22.692"N and 87°29'8.808"E to 87°35'19.543"E respectively. The beach material is generally siliciclastic and quartzo-feldspathic in composition, with well sorted, medium to fine sand (Friedman and Sanders 1978; Bhattacharya et al. 2003). The coastline of West Bengal is dominated by subtropical humid climate with three variation of south west monsoon, 1) Pre monsoon (March – June), 2) Monsoon (June – October) and 3) Retreating monsoon (November – February) (SudipDey, 2005). Due to effect of south west monsoon, the wind velocity and direction differ from season to season. In pre monsoon to monsoon the wind blows from south to south west direction which contains the maximum moisture with high depression that can be create high wave energy and this wave accelerates the coastal erosion. For the extreme variation of wind this area identified with active erosion and vulnerable zone. In monsoon season, the wind speed becomes up to 170km/hour. The rate of erosion varies from season to season. For the enhancement of coastal erosion, water level rise plays a vital role at entire area. The maximum wave height observed in the month of August (6m) which is devastating in nature. The high wave energy creates a vulnerable impact on the artificial structure which constructed for the purpose of protection.

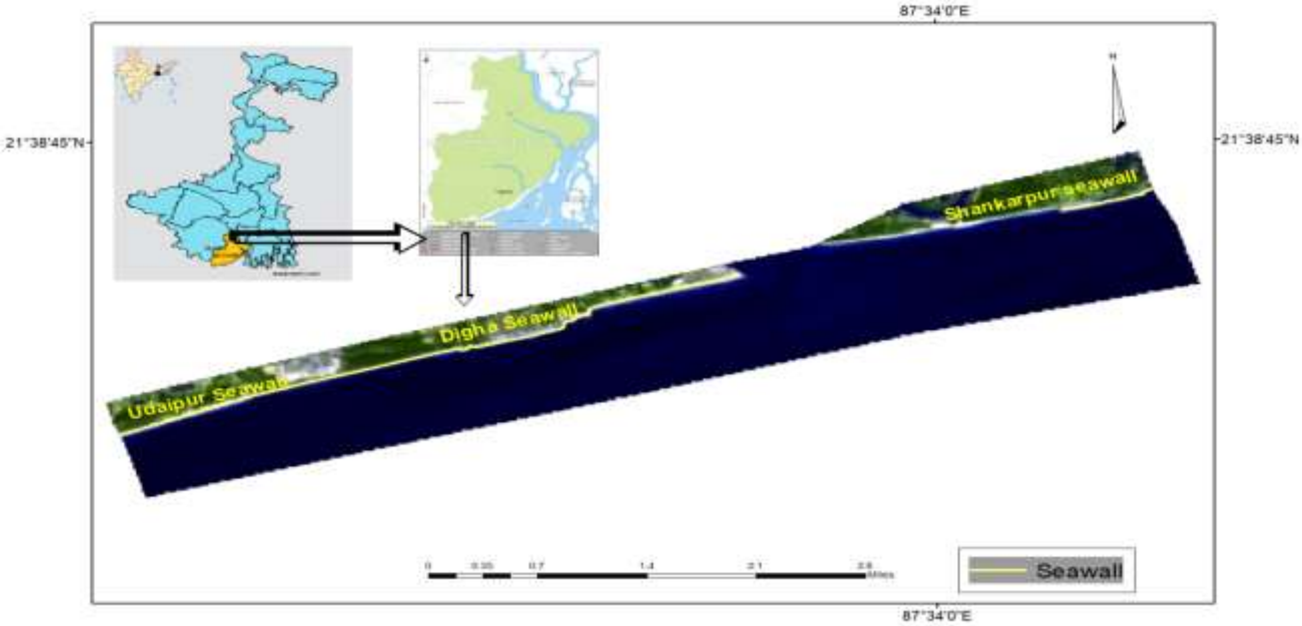

Fig. 1: Geographical location of the study area

3. Methodology

Three parameters are required to conduct the study; these are intensive visits to the study area, extensive literature survey and experimental analysis of different data. Report of River Research Institute Govt. of West Bengal, Irrigation and Waterways Dept. of West Bengal, Survey of India, Digha development authority and recent research papers published in different national and international journals and paper presented in different seminars, etc. are very necessary and important tools to complete this study. Basic materials like, Toposheet 73 O/6, 73 O/10 of Survey of India, satellite images from USGS are used to complete the study. Rainfall data, wave climate data, wind direction and velocity data are analyzed and tried to correlate between them throughout different statistical technique. Different cartographic and GIS techniques have been applied to measure the shifting of high water line in different satellite images and calculate the changes of erosion and accretion rate with the help of GIS software.

4. Data and software used for the study

Table-1: Uses data and software

Sl. No	Data and software	Description
1.	Satellite images	1975, 2000, 2009, 2017
2.	Toposheet	73 O/6
3.	Ancillary Data	• Rainfall Data & Tidal data (RRI, W.B) • Wave Direction & Speed data • Topo-sheet (Survey of India)
4.	GIS	• Arc GIS 10.1 • ERDAS Imagine 2014

5. Analysis of the recent study

5.1. Trend of sea level rise

Coastal plays a significant role in the economy of a country with large shoreline like India. Being a high dynamic part of the earth's surface, coastal area are subject to various types of hazards like coastal erosion, storm surges, tsunami, cyclones etc. Thermal expansion is associated with the sea water expansion and it is the effect of high sea surface temperature (Sanyal P., 2002). The level of the water in the ocean is the result of water volume increase which is caused by increase of sea surface temperature (Nurse L., 2001). According to the Intergovernmental Panel on Climate Change (IPCC) report, the predicted sea level fluctuation of 21st century, gradually increases at the rate of 1- 2mm per year (Scavia D., 2002) where (Sanyal P., 2002) has mentioned that the average sea level has increased in the 20th century is about 1.5 ± 0.5mm per year causing by physical and human-induced climate change. The IPCC reports also have predicted that the sea level may rise in the order of 0.17 m to 0.59 meters in the next 100 years (Fig.2). From intensive field investigation and observation of tidal height in months of monsoon season there is a propensity of recent sea level rise with an extreme rate in West Bengal coast. With the analysis of seasonal tidal data it is observed that the sea level is increased about 3 to 5.8m between the last 4 decades (Fig.3).Various substances are very effecting to inducing local sea level rise, like sediment supply, human activities, ground faulting, formation of embankment are indicates the change of high water level at Digha Shankarpur coastal area.

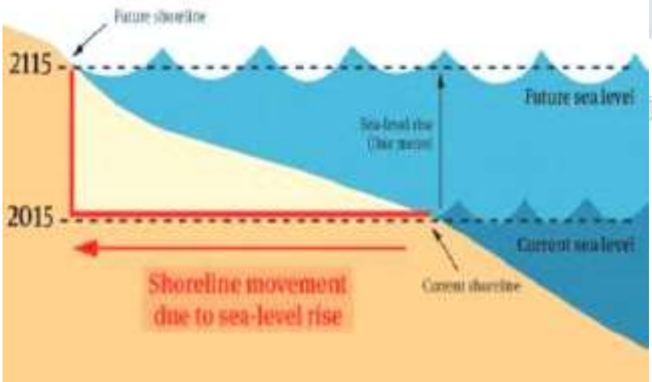

Fig.2: Assessment of future sea level rise (IPCC)

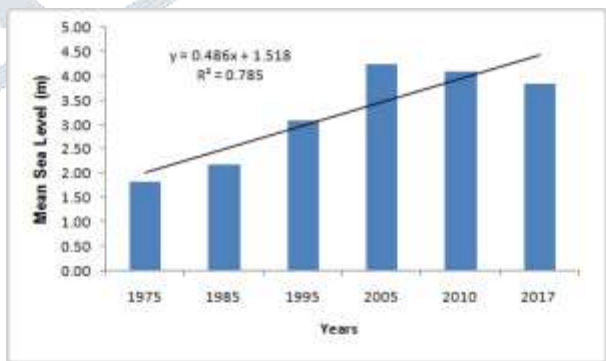

Fig. 3: Sea level rise trend

5.2. Littoral zone of study area and wave condition

The beach area of Digha is known to be a marine erosion prone zone in West Bengal. The report is lying midway between the huge Ganga delta in the east and Mahanadi delta in the west. The materials of beach consist of mainly sand with clay and the dune material is made up of fine sand. The geomorphology of Digha coast depending on its land form and various processes that working on it. Sub-aerial and sub-marine processes working on the littoral zone to form prominent cliff features, sand dunes and organic deposits at the land ward side of the beach. This study area consist different zone. In all littoral zones the back shore zone plays a vital role to increase the erosion. It is the zone known as Berm which normally indicates the zone lies above the normal high-tide level. Gravels, Cobbles and Boulders are found in the backshore zone lifted upward by the excessively high tide level caused by cyclonic storms. These materials normally take part in abrasion and destroy beach scarp in most of the cases under the action of nearly 0.5 high waves (Table 2, 3).

Table 2: Wave condition data

Station	Season	Wave velocity m/sec	Wave length (m)	Wave height (m)	Wave steepness	Wave energy	Breaker type
Digha	Jan -Feb	5-6/sec	15 -22	0.70-0.90	0.05-0.04	Medium	Plunging
Digha	Aug-Sept	6-8/sec	30 -40	0.80-1.5	0.03-0.04	High	Plunging

Source: River Research Institute, West Bengal

Table 3: Wave impact data

Location	Slope type	Slope angle	Wave impact
Old Digha	Gentle Slope	1° 13′ 7″	5° 48
New Digha	Steep Slope	2° 34′ 3″	3° 3′ 35″
Shankarpur	Gentle Slope	1° 52′ 35″	7° 42′

Source: RRI West Bengal and field investigation

5.3. Waterline shifting and its impact on artificial structure

In present analysis, the study area is shifted towards land of high waterline due to recent micro level increase of sea level and regressive coastal erosion. The landward shifting of high waterline has been detected by illustrating of survey of India toposheet, various year wise satellite images.From the present analysis and field observation it is stated that average 14km/year waterline shifted in New Digha area (Fig.4). Old Digha and Shankarpur waterline is shifted in average rate of 13km/year. From the analysis of high water line shifting, it shows that the proportion of erosion and accretion has been continuously changing in the study area (Table.4). Total accretion is considerably less with respect to erosion (Fig.5). Whereas between 1975 and 2000, 100% area were eroded from the coastal surface, but 2000 and 2009 79% accretion area has occurred, again after 2009 this area has under successive erosion (Table 4, Fig.5). This pattern of erosion and accretion indicates that the equilibrium between erosion and ccretion processes in this spatial unit is towards negative, which is rather indicative of relative isostatic instability in near future.

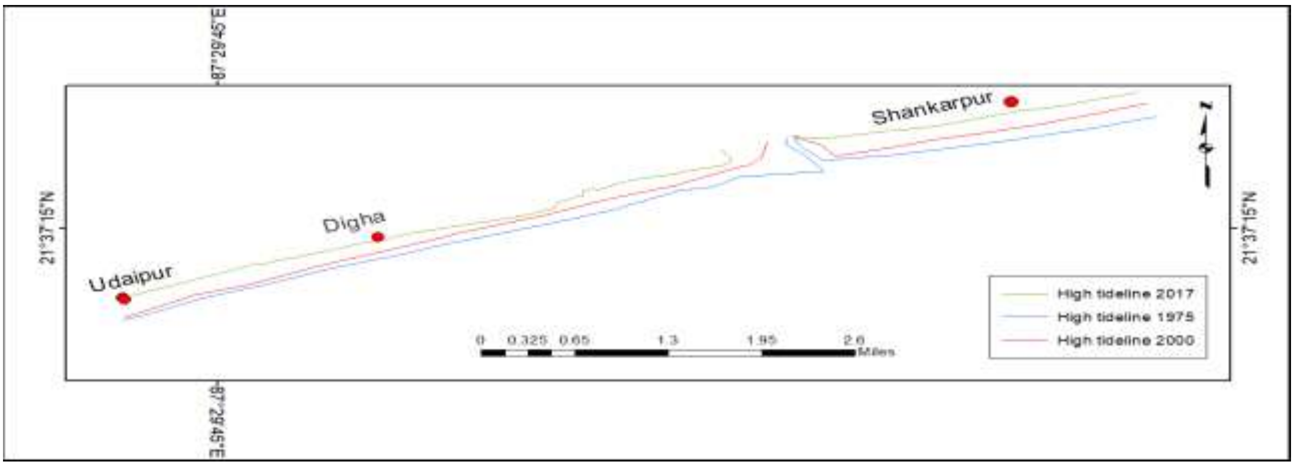

Fig.4: High tide line shifting map

Table 4: Erosion and Accretion rate (1975-2017)

Latitudes	Time Gap	Erosion (%)	Accretion (%)
87°31'35"	1975- 2000	100	0
87°33'3"	2000 - 2009	20.67967	79.32033
87°33'17"	2009 - 2017	97.09168	2.908325

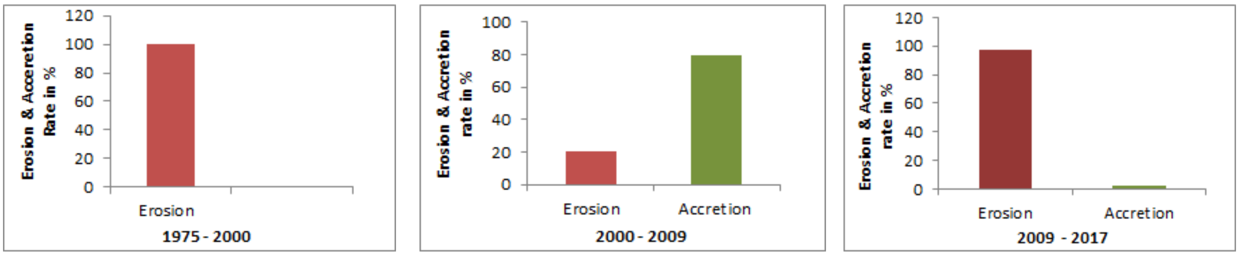

Fig. 5 Erosion and Accretion rate from 1975 – 2017

This shifting of high water line has a major impact on artificial structure. Erosion is being occurred in the down ward side of artificial structure and in this side the beach area is gently sinking (13cm/year) along Digha beach zone. A long boulder wall has been built in Digha-Shankarpur where is a strong long shore movement of materials is noticed and which interferes with this transport. It is a major cause of erosion. In this present study the seawall has been extending from Udaipur to Digha Shankarpur beach area. The height of existing seawall is almost 1to 1.5m. From the analysis it is reported that there are no overtopping or spilling over the seawall in 1975 shoreline change map and from wave data. To analysis from wave data, it is observed that since 1991 there have been cases of overtopping during monsoon month. From the waterline change analysis, it is noticed that the waterline is shifted towards the artificial structure. From the assessment of 1975 waterline and 2017 waterline it is prominently observed how down ward side of seawall has been eroded (Fig. 6, 7, 8).

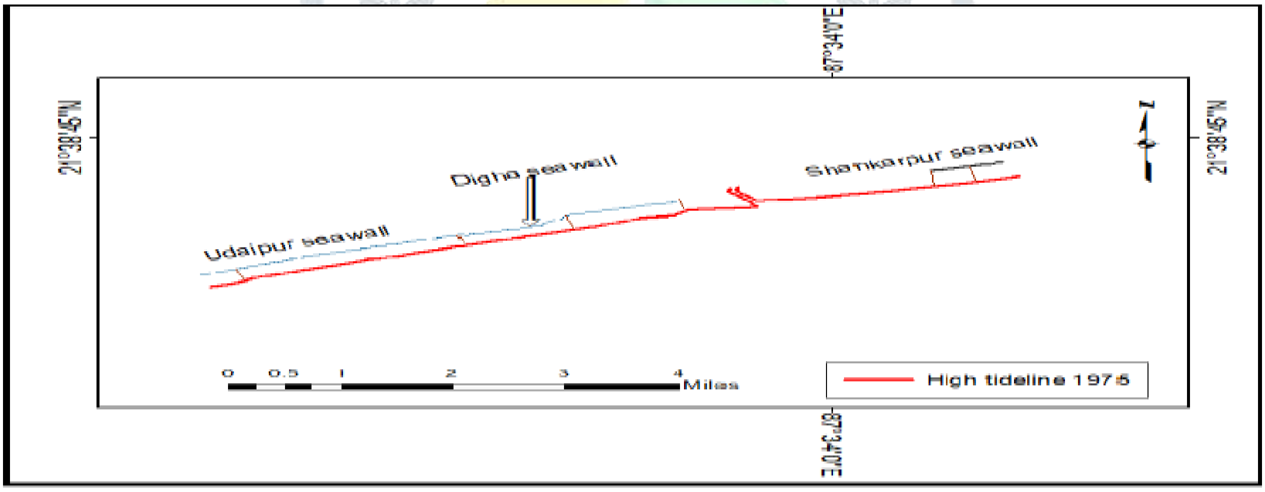

Fig.6 Distance between High tide line and existing seawall (1975)

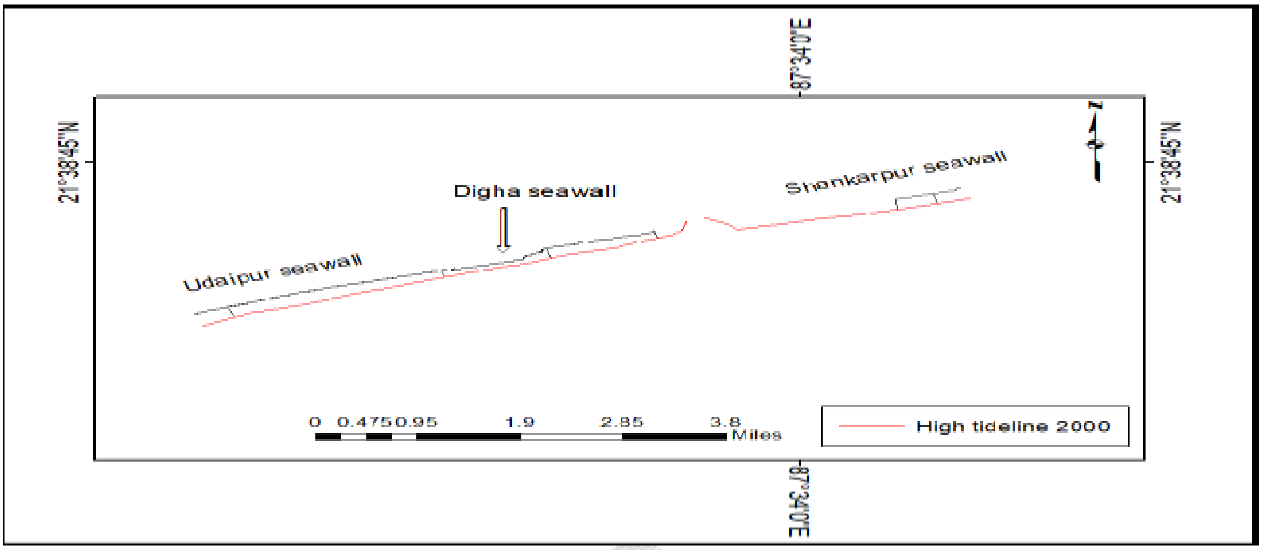

Fig.7 Distance between High tide line and existing seawall (2000)

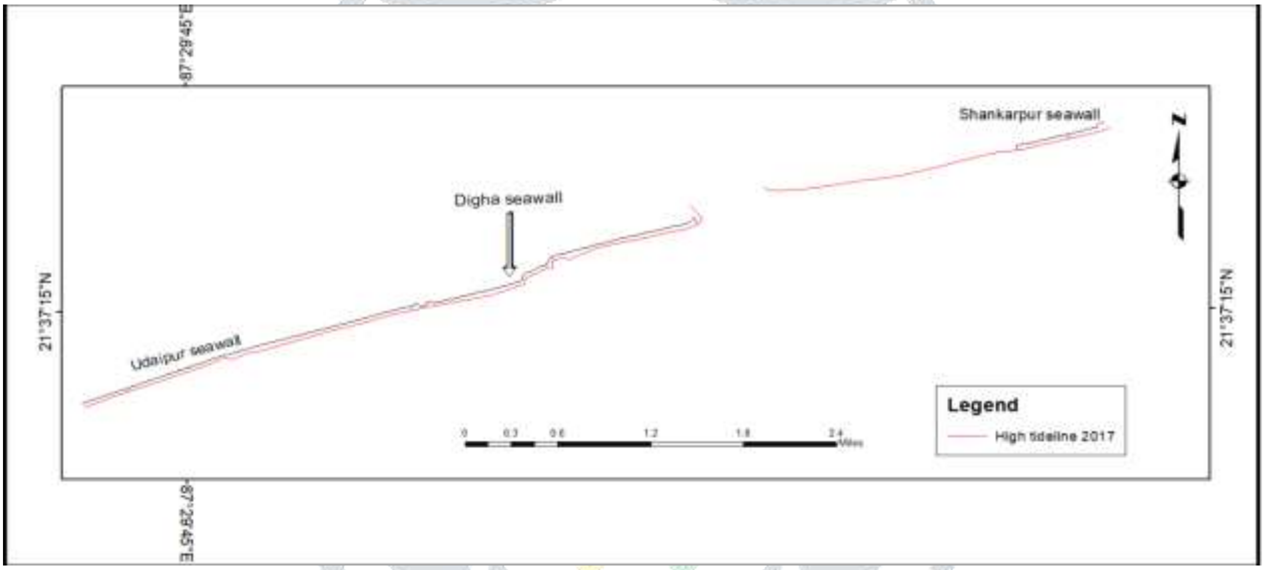

Fig.8 Distance between High tide line and existing seawall (2017)

This shifting trend also creates a major impact on artificial structure because the waterline has now very closer to the structure. This scatter diagram shows the negative trend line between the seawall and the high water line that depending on the wave energy which increases day by day.

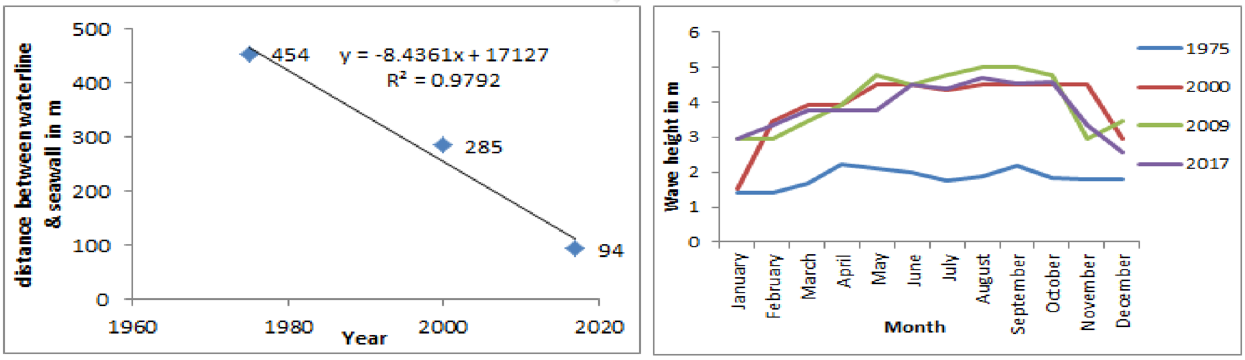

Fig.9 Maximum shifting distance between seawall (1975-2017) and water line and increasing wave height

5. Consequence

The consequence from this study has some impact with short term and long term. From the intense statistical analysis and observing data from different years, it may conclude about sea level rise, coastal erosion accretion proportion and waterline shifting trend. This study also reveals the impact of waterline shifting on artificial structure. From the field investigation and data interpretation it was found that seawall was constructed approx 500m from waterline but in 2017, the waterline comes near to seawall, the distance is only 100m approx. this is very alarming situation for the Digha coast and embankments. In order to maintain the balance of coastal morphology as well as coastal area, special awareness is necessary from grass root to government level. Otherwise the coastal erosion and sea level rise may cause the loss coastal beach and embankment in very near future.

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