Indian Journal of Geo Marine Sciences
Vol. 46 (02), February 2017, pp. 259-265

Coastal vulnerability: A case study along Digha Sankarpur coast, West Bengal, India

Sayanti Sen[1], Goutam Sen[2] & Meenakshi Chatterjee[3]

[1]Bangabasi College, Calcutta University, Kolkata- 700 019, India
[2]School of Oceanographic Studies, Jadavpur University, Kolkata- 700 032, India
[3]Basanti Devi College, Calcutta University, Kolkata - 700 029, India

*[E-mail: sayantisen_ju@yahoo.co.in ; gksju@yahoo.co.in ; mcgks@vsnl.com]

Received 18 September 2014; revised 30 October 2016

This study attempts to study the socio-economic impacts of coastal hazards on the vulnerable zone populace, identify the probable factors that are responsible for inducing worst impact and to suggest methods to manage the impact of coastal hazards to reduce damage on the coastline. Analysis has been carried out by preparing a map of the vulnerable coastal stretch and their related threat on coastal habitation. Prediction has been attempted to indicate points of coastal disaster on the study site. Protection option has an effective outcome with consequent degradation and loss of the beach amenity. Within a framework of increasing population pressure and Greenhouse driven climate change, the potential for conflict between development and the coastal processes will surely increase.

[**Keywords:** Vulnerable, Definitive Relocation, Chronology of Erosion Relocation]

Introduction

The coastline of Digha-Sankarpur is severely eroded. Causes of erosion depend on various factors. Firstly, the monsoon, which in the eastern part of this region lasts from May to September, as the monsoon winds affect the direction and magnitude of the waves affecting the coast line with excessive erosion making the zone vulnerable for the coastal community. Secondly low pressure formed during storm surge or surge wave inflicted by several low-pressure systems moving towards this coast, which also aggravated the situation of coastal inundation and removal of protected dune fields. Stakeholders in this coastal zone include landowners, shrimp farming entrepreneurs, landless laborers and participants in the artesian and offshore industrial fisheries are present. The fishing community, the stakeholders and the inhabitants located on the coastal fringe of the Digha-Sankarpur zone, illustrate an example of the socioeconomic consequences of marine erosion along the coast, and the human and geomorphologic factors involved in the decision for relocating.

The present study also explores the relationship between coastal erosion, the identification of vulnerable zones and several management options such as relocation of the population at risk. Based on these studies, methods and suggestions to manage the impact of coastal hazards could be developed followed by suitable coastal zone management options for planning and regulating the development for the betterment of the coastal inhabitants and the stakeholders.

Materials and Methods

The coast of Digha, is located between Latitudes 21^{o} 36’ 50” and 21^{o} 39’ 00” N, Longitudes 87^{o} 29’40” and 87^{o} 37’ 00” E within the coastal stretches of East Medinipur, which extends from the mouth of Subarnarekha River to the entire zone of Sankarpur and Dadanpatrabar coast, up to Pichaboni Canal, a district in the state of West Bengal, India. Conventionally, the main economic activities in this region have been timber exploitation, fishing, shrimp aquaculture and eco-tourism. The beach along New Digha shows a very gentle slope towards the sea. This area is devoid of any natural forest except for a narrow linear strip of Casuarina plantation present along the coastal belt (Sen et al. 2005).

Results

With increasing emphasis in the 1980s and 1990s, researchers have argued that the impact of natural hazards depends not only on the physical resistance of structure, but on the capacity of people to absorb the impact and recover from loss or damage.

The definition formulated by the International Strategy for Disaster Reduction (UN/ISDR) is one of the best-known and defines vulnerability as: "The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards." (UN/ISDR, 2004)

One major issue of vulnerability is the view of a forward-looking and policy-supporting variable. (Cannon et al, 2003) characterised it, "vulnerability (in contrast to poverty, which is a measure of current status) should involve a predictive quality: it is supposedly a way of conceptualising what my happen to an identifiable population under conditions of particular risk and hazards."

Hence we have tried to bundle this discussion together and focuses on a case study in Digha-Sankarpur coastal belt. To assess vulnerability at different scales under the specific conditions of the case study are the essential topics of this paper.

The east coast of India has witnessed more than 1000 oceanic disturbances and has been affected by a minimum of four high intensity cyclones every year for the past 110 years. 33 cyclones struck West Bengal causing extensive inundations of low-lying plains. The coastal track of Digha-Sankarpur is affected by cyclones averaging 2 cyclones per year. Cyclonic frequencies for last 55 years, shows a sharp rise in the cyclonic frequency during post-monsoon phase and pre-monsoon phase.

The coastal stretch of Digha-Sankarpur experiences an annual precipitation ranging from 2m to 3m. This area from sea front to landward is represented by beach face, coastal dunes, sand-filled inter-dunal depression, older dunes and older tidal flats. However, the western part of the unprotected coastal stretch (from Old Digha to mouth of Subarnarekha river) and part of Dadanpatrabar are under accretion. Coastal erosion and increasing tidal activity, wave interaction, and excess rise of water level during depression are responsible of this increasing erosion (Sen et al. 2005). During post-monsoon at Bay of Bengal, the possibility of generation of storm becomes very prominent as a result of which tidal and wave activity becomes more vigorous.

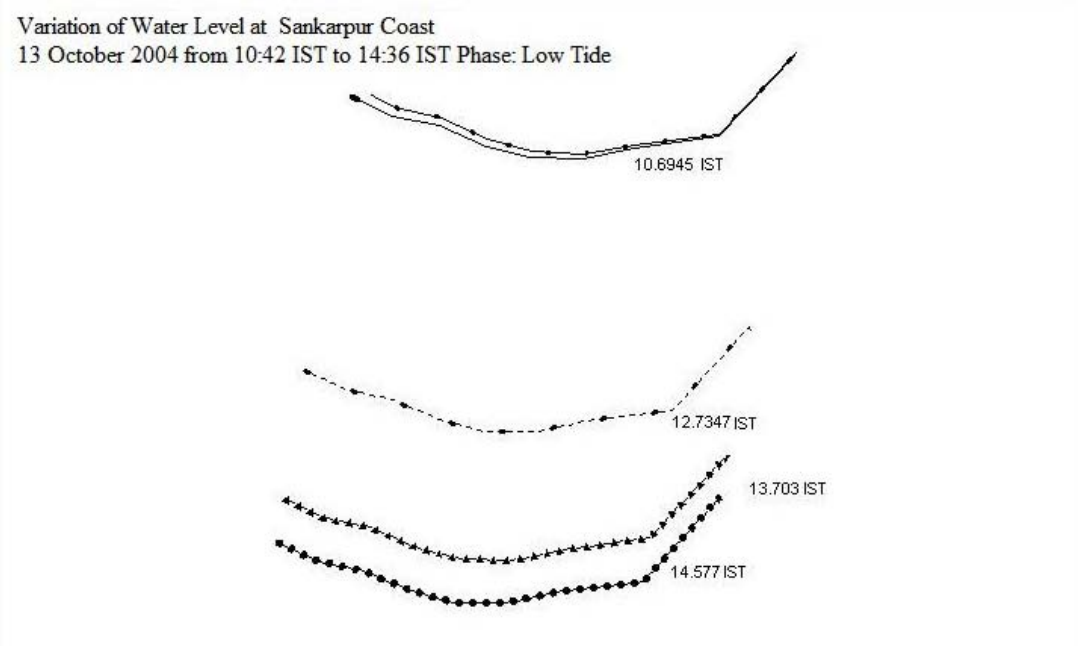


Fig. 1—Variation of Water Level at Digha Coast on October 13, 2004

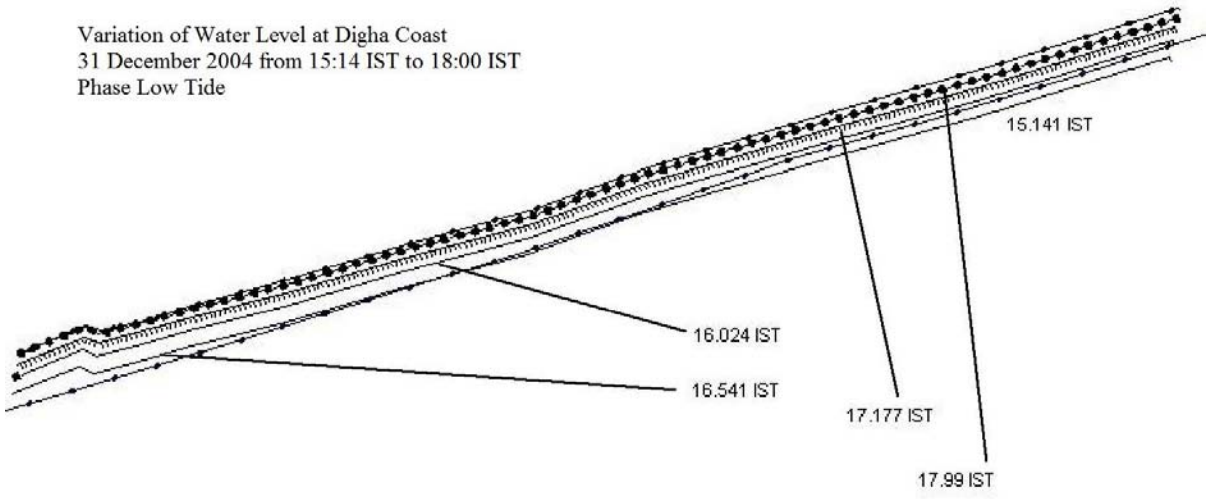
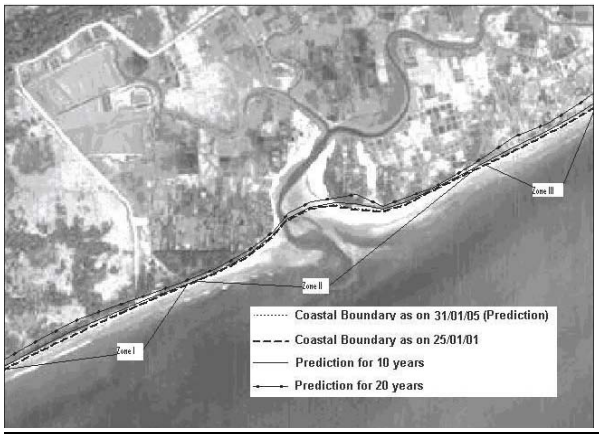


Fig. 2— Variation of Water Level at Digha Coast on December 31, 2004

The figures 1 and 2 above show variation of tide line at Sankarpur coast on October 13, 2004 and Digha coast on December 31, 2004. From the diagrams, the prominent features of tidal range variation during post-monsoon months and winter months are easily discernable. Tidal range is very high in post-monsoon months and comparatively low in winter months (December). If we compare the vigourness of tidal activity in two locations in the post-monsoon months, we find that at Sankarpur, tidal mark activity and its impact is more severe than that observed at Digha. For this reason, Sankarpur region has become a zone of intense tidal activity

It may be noted that asymmetry in flood and ebb flow patterns can cause effective tidal flushing leading to severe coastal erosion. Tidal activity at Digha is less severe than that at Sankarpur. From calculation on the basis of previous tide gauge data, it was found that rate of rise of sea level of this region is nearly 2.5-3 mm year. So, we can also assume that high sea level may be responsible for the flooding, as a result of which rate of erosion accelerated

The region has been divided into five parts according to the rate of erosion and accretion over 4 years from 2001 to 2005



Location Name	Avg.Accretion /Erosion (m)	Highest erosion (m)	Lowest erosion (m)	Risk Zone
New Digha	40.769	110	10	I
Old Digha	-44.074	-100	-20	II
Sankarpur	-38.094	-90	-10	II
Sankarpur1	-33.672	-75.9	-10	III
Sankarpur2	-37.996	-70.5	-10	III

Fig. 3— Risk Zone mapping at Digha Sankarpur beach and Accretion/Erosion levels from (2001-2005)

Fig. 4— a) A house on Sankarpur beach in 2004 and 2005. b) In 2006, the house was swallowed by the sea

Figure 5. a) The sea erodes deep into the coastal tree cover in Sankarpur b) The sea wall that was once built has been broken by the waves at Old Digha c) The concrete path that connects Digha to old Digha has been broken by the waves is being temporarily repaired.

Sankarpur region, which has been divided into two parts according to the vulnerability status, named as Sankarpur1, Sankarpur2. Sankarpur1 has the highest average rate of erosion.

The entire stretch of New Digha to Sankarpur can be divided into three distinct Risk Zones.

- Zone I - New Digha belongs to this zone where the process of accretion is dominating

- Zone II - Comprises of Old Digha on one side and a part of Sankarpur on the other side of Digha Mohana and is dominated by strong erosion process. Specifically, Old Digha has experienced strong erosion and loss of coastal land over the last four years

- Zone III - Comprises of stretches of Sankarpur incorporating Chandpur, Jalda area and exhibits severe land loss due to erosion and other sea induced activities

It is apparent that Risk Zone-II has the maximum risk of being eroded in years to come. The prediction for 10 and 20 years shows a considerable amount of erosion all through the coastal stretch. The change in costal stretch over 4 years identified Risk Zone I and Risk Zone II as the most vulnerable. All the three risk zones are equally prone to risk after a decade.

Discussion

The impacts on life, health and safety on coastal population give us a clear picture of the conditions under which structures, livelihood and health conditions get affected by the coastal hazards. Human activities are placing burdens on the natural resources of the coastal zones beyond their capacity to absorb the impact. The population under the poverty line occupies countless low-lying plains, this section of society bears the recurring loss of livestock and property. Coastal hotels and resorts were inundated and habitations destroyed at Digha in August 1997. The unprotected coastal stretch (from Old Digha to mouth of Subarnarekha river) and part of Dadanpatrabar are under accretion. Property damage increases with successive storms, as observed along the shorelines of West Bengal. The number of displaced people is increasing as more land is eroded following violent storms (Paul, A. K, 2001). New

development in this coastal stretch should not be undertaken unless the areas are protected by structural or other erosion control.

In the coastal stretch of the study area, communication and transportation facilities are mostly paralysed. Roads are often submerged, communication towers get crashed. The damage potential seems to be increasing in various forms as defense structures such as embankments and seawalls are washed away and hence unable to withstand the force of storms. The Digha seawall was damaged to a stretch of 1.5 km due to wave attack and overwash following successive cyclones (Paul, A. K, 2001).

The population of Digha-Sankarpur increases substantially during the summer and winter months because of tourism and the presence of seasonal homes that substantially contribute to the state's economy. The recent property boom in West Bengal has flowed on to real estate prices all along the coast with property prices pushed to previously high levels. Property with direct beach access and/or expansive views is at a premium.

When considering development, the option of choice for the environmental lobby and wider community groups is relocation. This has the perceived advantage of preserving the natural beach environment while allowing the coastal processes to proceed uninhibited.

Relocation becomes the logical approach for undeveloped areas and embodies the principles of ecologically sustainable use of the foreshores for current and future generations. There is a range of ways to achieve relocation:

- Appropriate sitting of new development/subdivision to avoid future conflict
- Physical relocation of existing development landward or elsewhere
- Limited development consents (distance or time based)
- Repurchase
- Allow development to be lost (with or without compensation) (Lord.D, 2002).

Relocation could be the best intention, but there are no good examples of the successful application of relocation. Relocation appears to have different significance in the lives of community members compared with migration because an entire population is being moved to a safer area.

The relocation process of coastal villages in Digha-Sankarpur region is slow and voluntary.

The decision to relocate on the mainland taken by the community of this region is not an easy one because the option of remaining on the danger prone zone is driven by very strong and diverse motivations, like earning factors, convenience of workplace, cultural factors, sentimental factors which are established for nearly a century. To establish these diverse motivations for relocation a participatory approach in the study area was carried on through Focus Group Discussion along the various communities. While organizing focus groups, the main objective was to identify the range of perspective from the community representatives when they were given the idea for relocation from the danger prone coastal stretch to a safer landward location.

Deducing from the Focus Group discussions, we have identified the following factors inhibiting the inhabitants of this region to consider relocation:

- An existing way of life - the villagers 'live' the sea and weather conditions and have accepted this as part of life and want to plan their activities accordingly.
- Tourism as a source of income - an existing tourist infrastructure that has developed as a significant source of income for a large cross section of the population.
- Villagers provide assistance for a fee in case of an emergency for tourists in the area they work as lifeguards on the beach- this is also a type of livelihood for a percentage of population in this region.
- Difficulty in earning their livelihood in other regions due to lack of formal training in other professions.
- Food habit changes are almost certain, as currently they are rice and sea-fish based.
- Ancestral and Emotional attachment with the current location and residence.
- Change in social setup and environment if they migrate to a different region e.g. splits in families, equal sized houses and relief grants.

Among the three risk zones identified earlier, the second zone is the most vulnerable consisting of Old Digha and a part of Sankarpur. This zone is the most economically and socially flourishing one with high tourist activity during tourist seasons and also having a dominant fishing community. The disturbances caused in the sea affects the tidal process along the coastal stretch of Sankarpur making it more vulnerable towards living.

Relocation is expensive due to high population density along the coastal stretch. Without thorough social and cost benefit analysis to justify this outcome, it is unlikely to receive the necessary community and government support or funding. While having the initial objectives of preserving the beach system and community access, unfounded policies of relocation invariably results in the worst outcome. Therefore, for this in-danger coastal stretch, relocation might not be the suitable management option, rather few protection strategies for the coastal stretch could be suitable for the impending risk to the coastal property. The coastal stretch between Digha to Jalda is observed to be continuously eroding including the coastal sand dunes. Based on the above vulnerability analysis and field observation, few protection strategies along the coast have been already been implemented.

- *Risk Zone I*: A groin has been built between Digha beach and the river mouth. In addition, a pair of groins at Digha serves as coastal protection system as well as to enhance tranquil condition for tourism development
- *Risk Zone II and Risk Zone III:* This part of the coast is open to continuous coastal erosion. A part of this stretch is being protected by implementing Geo-tube as sea wall along the Sankarpur coast. It is already recommended by Sundar. V and Sannasiraj.

S.A, in 2007 to provide geo-tubes, as they are environmental friendly measure (Sundar,V2007). Implementation of Geo-tube results in protection of dune field ensuing in re-growth of vegetation along the sand dunes which has been eroded ruthlessly for the past years.

On September 15 and 16, 2008, a low pressure system (TC02B) developed in the Bay of Bengal. The lowest pressure attained by this system was 995 mb when it crossed Orissa coast. It was a weak system but the impact of water surge caused a considerable inundation in many parts of coastal areas in Risk Zone I and II. The coastal stretch from the mouth of Subarnarekha estuary to Pichaboni canal (70- 75 km stretch) experienced the impact of surge which resulted of inundation of agricultural fields, ground floor flooding of many hotels and many weak structures were totally demolished by the thrust of water. This low pressure system caused major coastal surge resulting in increase of water level by about 10 to 12 feet causing significant damage.

40 km stretch of impacted stretch is within the state of West Bengal and Geo-tube was laid on 1 km of coast. Inhabitants residing on the inward side perpendicular to this stretch were saved from the surge water but at Sankarpur (Risk Zone I and II), the geo-tube could not withstand the storm surge, possibly due to manufacturing defects of the geo-tubes.

Figure 6- Geo-tube being constructed along the coastal stretch of Risk Zone II

Inhabitants residing very close to the sea need to be relocated and there needs to be an urgency of extending the task of construction of coastal protection (similar to geo-tubes or any other structure). Key stakeholders should be more concerned about constructing appropriate shelters (no such shelters exists in this area) so that in case of such adverse situation in the future, people can be shifter temporarily. The authors suggests that the present coastal area where geotube is already constructed an additional protection measure, it could be earthen embankments in the landward side could be constructed as a second line of protection so that in case of failure of front line embankment (geotube), the remote villages can be saved from inundation. are grateful to Dr. G. Syda Rao, Director, Central Marine

Fisheries Research Institute, Cochin for providing facilities and encouragement to carry out the above research work.

Fig. 7— Effect of surge on Geo-tube in Zone II

Conclusion

The erosional vulnerability on the coastal zone of Digha-Sankarpur have been triggered or accelerated by tidal levels since 2000, which caused property loss and affects livelihood for many in the coast who are dependent on "fishing and tourism". In terms of immediate Coastal Zone Management priorities, it is obvious that present shoreline erosional trends along the coast are factors that strongly support relocation of villages. However, considering the population of Digha this might not be possible and inhabitants have to relocate according to the site chosen by the government. The site should have better communication and transport facilities and should have proper water facilities, medical facilities, and educational facilities at par or better than currently available in Digha-Sankarpur coastline. In the study area several management options like geotube have been implemented but it is suggests that an additional protection measure, could be constructed as a second line of protection so that in case of failure of front line embankment (geotube), the remote villages can be saved from inundation.

With hundreds of families and their future in question, immediate detailed planning and execution should be undertaken based on scientific studies of coastal behavior. For this purpose it is necessary to a)define landward and seaward boundaries of the coastal zone, for the purpose of management, b) treat coastal zone as a single unit for effective administration and control, c) classify coastal areas based on potential use, d) undertake long term ecosystem monitoring to develop a sound scientific data base, e) develop linkage between scientific findings and policies, f) encourage wide participation from different environmental groups including NGOs, scientist, administrators and individuals, g) evaluate assimilation capacity of specified coastal areas.

Acknowledgement

Authors wish to acknowledge Chairman of Digha-Sankarpur Development Authority, West Bengal, India for providing information about geo-tube and INCOIS, Ministry of Earth Science funded INDOMOD project for providing fund to carry out work at Digha-Sankarpur.

References

1 Cannon T, Twigg J, Roswell J., Social Vulnerability: Sustainable Livelihoods and Disasters, *Conflict and Humanitarian Assistance Department and Sustainable Livelihoods Support Office.*, (Report to DFID) 2003

2 Lord. D., Protect or Relocate? The Primary Contradiction, Coast to Coast, (2002) 254-258, http://www.coastal.crc.org.au/Coast2Coast2002/proceedings [1/06/2004]

3 Paul, A. K., Cyclonic storms and their impacts on West Bengal coast. *Quaternary Sea Level Variation, Shoreline Displacement and Coastal Environment* edited by Rajamanickam, G. V. and Tooley, M. J., (New Academic Publishers, Delhi) 2001, pp 8–31.

4 Sen. S, Chatterjee.M, Sen.G, Study on Coastal Vulnerability of Digha- Sankarpur Region,edited by *Disaster Management* (Narosa Publishing House) 2006, pp 99-106.

5 Sundar, V and Sannasiraj. S.A, Report submitted to Irrigation and Waterways Directorate, West Bengal Shore Protection Works for the Coast of Digha- Numerical Model Study. 2007,

6 UN/ISDR Living with Risk: A Global Review of Disaster Reduction Initiatives. Geneva, UNPublications,(2004) 429