Climate Change Policy Paper II

Climate Change Adaptation in Coastal Region of West Bengal

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Introduction

The 7516 km long coastline of India and associated coastal zones are extremely vulnerable to climate change induced fast and slow onset disasters. Every year, loss of life and property in the coastal areas are increasing due to high intensity cyclones, floods, change in rainfall pattern, cloud burst, saline water ingression and coastal erosion due to accelerated sea level rise.

In the year 2009, the severe cyclone 'Aila' hit the State of West Bengal with 120km/hr wind speed and around 2m high storm surge, devastating extensive areas of coastal Sundarban killing people and flooding agriculture fields by saline water. Later, we were hit by drought though we had a forecast from official agencies of healthy and timely monsoon. Due to concentrated rainfall during post monsoon months (which keeps the statistics of yearly average rainfall close to 'normal') we had extensive floods, in Andhra, Goa, Karnataka and in parts of West Bengal and Assam. Additionally, the increased population pressure and economic activity in coastal zones are magnifying the extent of coastal disasters.

An estimate suggests that in India, nearly 2000 lives are lost every year due to floods, cyclone and heavy rain. However, few coastal states in India have an integrated coastal zone management plan, although none of those that do, have so far been able to link it with a disaster management plan or the national action plan on climate change. The attitude so far has been and still is, to focus more on reactive relief and post-disaster activity than on more responsive disaster preparedness or risk management. Institutionally and otherwise we are not yet ready to accept that the climate is changing, and changing faster than anticipated. We are often confused between 'short term' climate variability (e.g.rate of retreat of Gangotri has been slower for the last three years!) and long term changes in the climate of the world. It is high time to adopt a more scientific method of risk assessment and evaluation and co ordinate efforts towards risk reduction and disaster preparedness anticipated due to climate

change, particularly for coastal zones.

In India, we still consider reacting to 'rapid onset' natural hazards as the primary, if not the only management objective. However, the potential threats of 'slow onset' disasters like climate change, sea level rise, coastal erosion/submergence and water quality degradation remain largely unattended to. Global warming and sea level rise pose a serious threat to the existence of the small islands and island states throughout the world including the Sundarban island system of West Bengal. Though the absolute Sea level rise globally over the last century has been little over 20cm, locally the relative rate of rise is found to be several times more due to deltaic subsidence and siltation. With just a slight rise in sea level, off-island migration of environmental refugees from Sundarban island system of India and Bangladesh may be anticipated. A comprehensive action plan for climate change in India would be incomplete without the inclusion of a definite mission addressing the vulnerable coastal zone, which includes of West Bengal, Orissa, Andamans, Andhra Pradesh, Lakshwadeep, Gujarat and others.

The national action plan on climate change can definitely be improved if we consider rate of sea level rise relative to land differently for different coastal states rather than relying on a 'national average' of 1.06-1.75mm/yr[1] which fails to address the ground realities of subsiding deltas like Sundarban.

In terms of an operational policy framework, a new draft coastal management zone notification was issued by the Government of India (S.O. 1070(E) ,1.5.2008) with an aim to re-designate the coastal zone and demarcate a new 'set back line' as per vulnerability due to sea level rise and coastal erosion. However, this was later withdrawn mostly due to resistance from different quarters and also because it did not indicate scientifically viable methodology for vulnerability assessment related to sea level rise and for demarcating a set back line by the local authorities. Further, the sea level trend proposed was taken as the 'global average' as suggested by IPCC, while the damage, actually taking place along the coast depends upon 'local' factors that controls the 'relative sea level' of the region. Thus , even at the end of 2010, we still do not have an operational policy framework for integrated coastal zone management, which takes into account the problem of climate change , sea level rise, habitat loss or rehabilitation policies for 'environmental refugees' from coastal zones. Government of India formally

Fig : 1

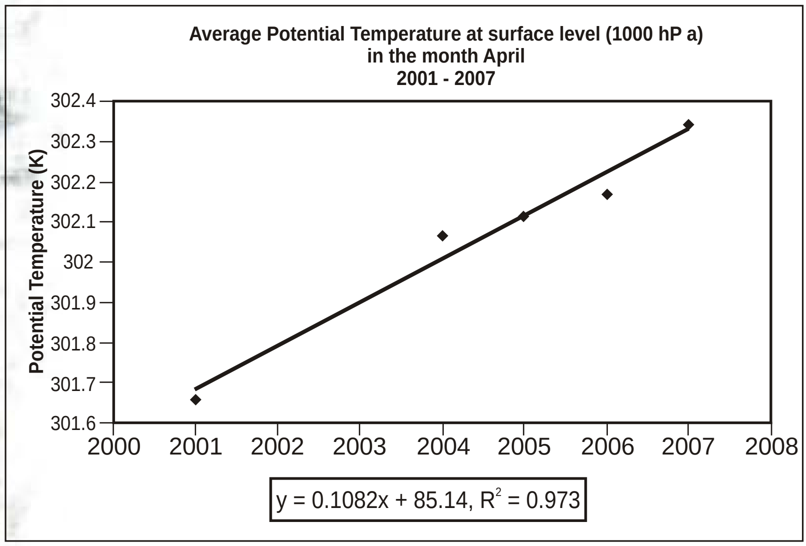
released the final notification on 6 January, 2011 without mentioning a reference base year for demarcation of 'High Tide Line' or elaborating a methodology to delineate the "Hazard Line" or setback line necessary for coastal adaptation to climate change. As of now, 2011 notification remains inoperative in the want of proper delineation and demarcation of various critical lines and zones.

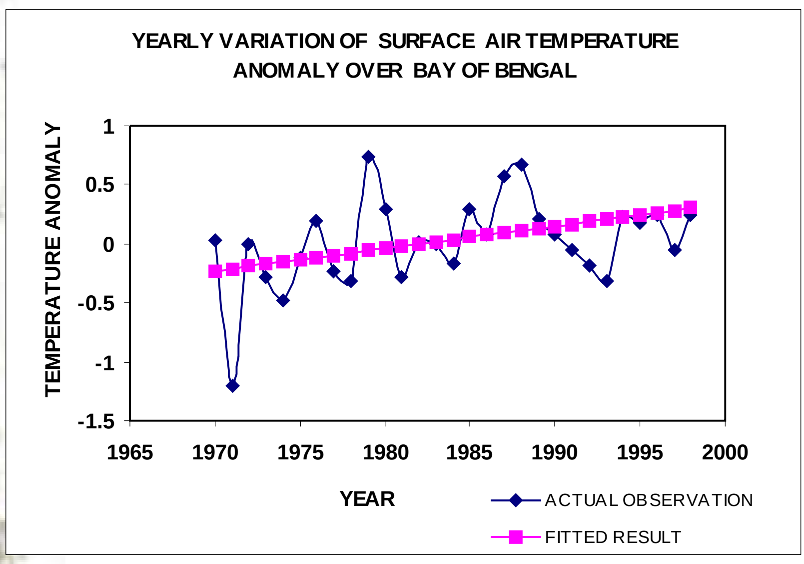
We examine impact of climate change on two coastal system of West Bengal through two case studies: the Open Coastal System of Digha-Sankarpur, and the estuarine system of Sundarban islands of India, focusing on changing temperature, rainfall pattern and rising sea levels. Though there are several impacts of climate change to these areas, the present discussion has been restricted to erosion and shore protection, habitat loss and adaptation options.

Coastal Region

Changing weather and climate

Temperature





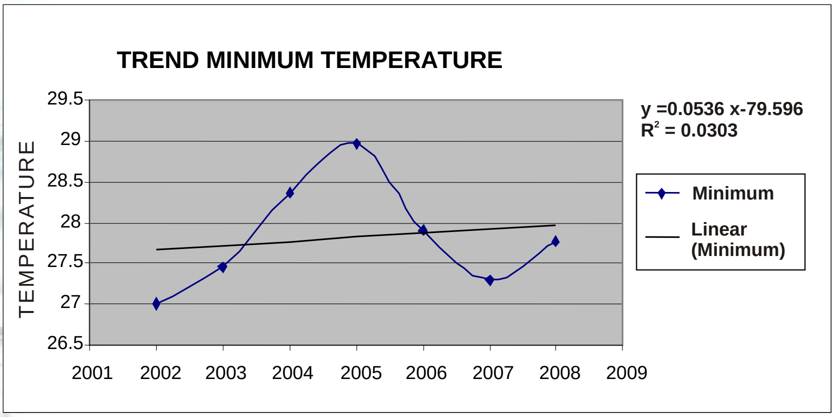
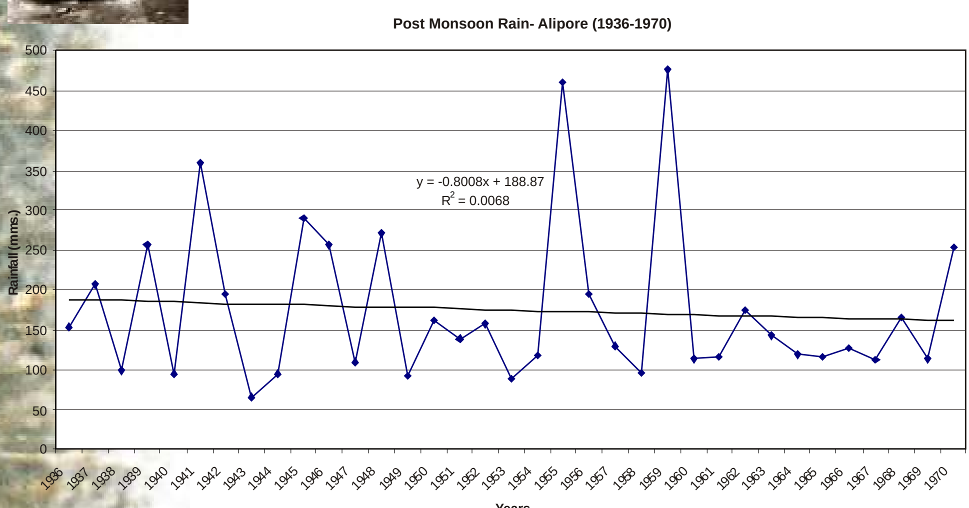


Fig 2. An overall trend of atmospheric warming is evident over the land (a) and sea surface (b) of Sundarban

The Indian Ocean has shown higher than average surface warming, especially during the last five decades [2,3,4]. The observed rise in northern part of Bay of Bengal is @ .019^{0}C per year over the Bay of Bengal during the period 1985-2000[5] (fig 2). A similar rising trend is also observed in the adjoining terrestrial region in the maximum and minimum temperature records collected from the 'sand head' in the Sundarban. If the accelerated trend, as observed for the period 2006-2009 from the MODIS satellite data continues, the temperature in this area is expected to rise by more than 1^{0}C by 2050 and is likely to cross the threshold of 2^{0}C rise by 2100 impacting both the open coastal area as well as the estuarine system of Sundarban islands, by rising rate of coastal erosion, cyclone and coastal flooding.

Rainfall



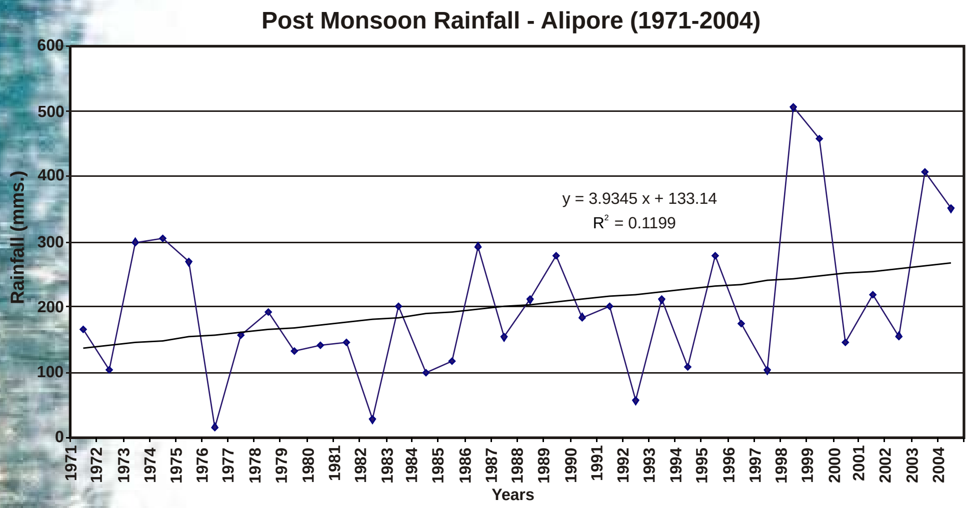
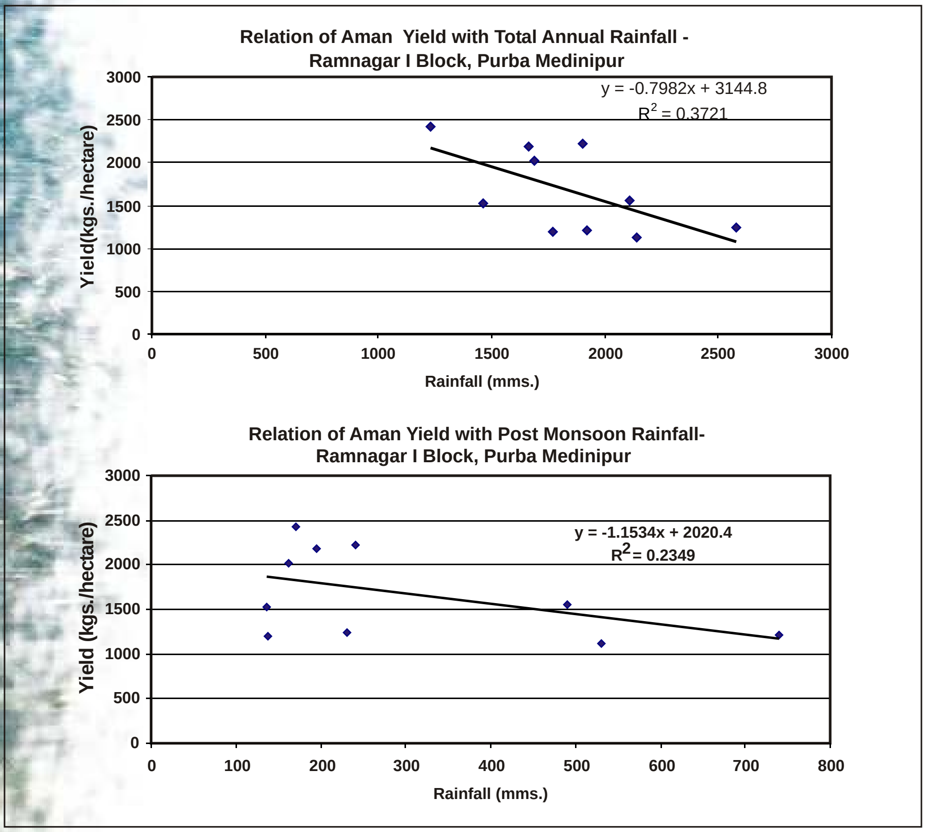


Fig 3. Change in the Post Monsoon Rainfall pattern over West Bengal Coast

The present analysis shows that there is a marginal increase in the monsoon and post monsoon rainfall over the last 10 years. The annual average rainfall of the Sundarban is 1625mm. However in high rainfall years it goes up to 2000mm and falls to 1300mm during the low periods. Intensive rainfall occurs during the monsoon. Humidity varies between 75% and 86%. Decadal variation of rainfall pattern over Sundarban has been studied using the data from Indian Meteorological Department. Within the time window of 1990-2000, both the higher and lower rainfall values are more than the yearly average. A trend of marginal increase in total rainfall can be noticed within this time frame. The post Monsoon rainfall however has increased significantly during the time window of 1970-2005, compared to that of 1935-1970 period (which actually shows a marginal decline) suggesting a shift of high rainfall months (Fig 3).



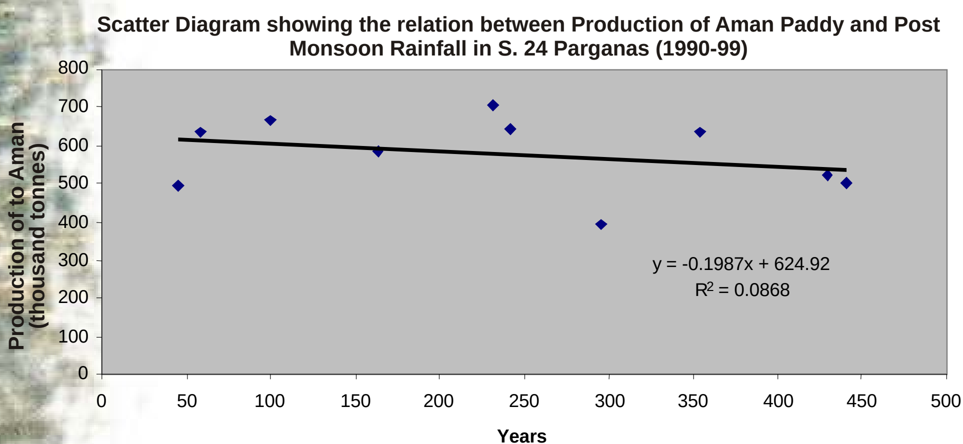


Fig. 4: Decline of Aman Paddy yield with increasing Post Monsoon Rainfall in Coastal West Bengal

This has a potential to affect the rain fed agriculture of the area impacting food security of the coastal zone. The correlation between increasing post monsoon rainfall and declining yield of Aman paddy in both the study areas is indicative in this respect (Fig. 4).

Cyclones

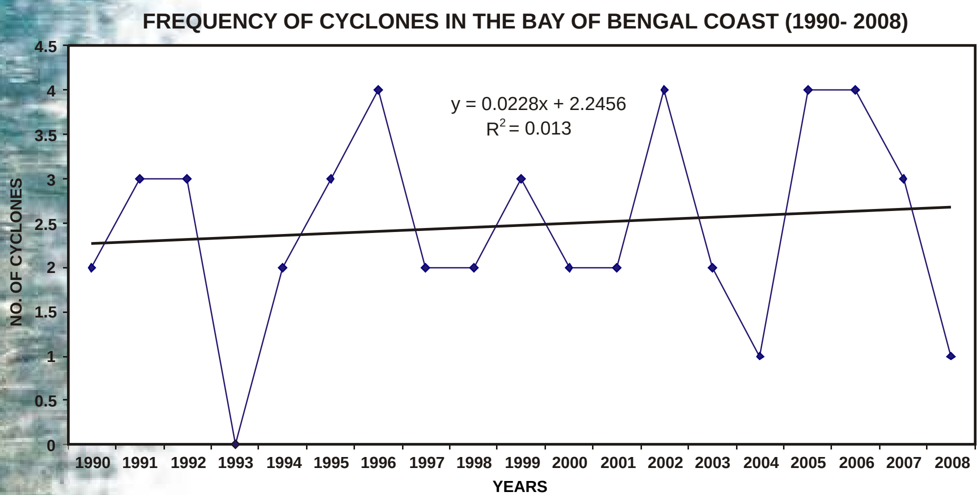


Fig. 5: Rising frequency of Severe Cyclonic Storms Over Bay of Bengal

From the analysis of cyclone and surge data of the northern Bay of Bengal, a rise in the high intensity events like severe cyclonic storms has been observed (Fig.5**)** and consequent damage and flooding can be inferred**.** Using a running average of high intensity cyclone frequencies in the northern Bay of Bengal area, scientists from Indian meteorological Department has observed a 26% rise in the frequency of high to very high intensity cyclones over the last 120 years[6]. This phenomenon has to be analyzed and explained further to see whether an increase in sea surface temperature is linked to the increase in cyclone intensity as found in the North Atlantic. It is worth mentioning that with rising sea surface temperature over northern Bay of Bengal during 2006-2009 (Fig 2), the region has witnessed 4 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), Bangladesh and Myanmar.

Relative sea level

For rapid appraisal, sea level fluctuations have been estimated from the tide gauge data of Sagar island observatory (2131'00"N, 8803'00"E) of Sundarban, a macrotidal coast (where tidal amplitude exceeds 4 m.) within the time period 1985-2000. From the time series analysis of

[1]A similar significant high rate of sea level rise of Sagar and Diamondharbour monitoring station (5.22mm/year) are also available with the Proudman Oceanographic Laboratory, U.K. (PSML,www.pol.uk).

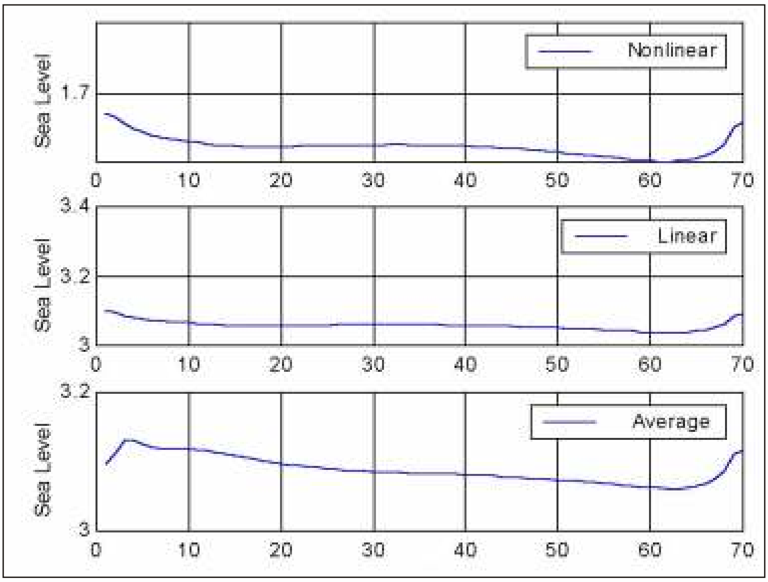


Fig. 6: Computed Mean Sean level (from data of 70 years) along West Bengal Coast

Digha Shankarpur coast, on the other hand, is a mesotidal coast, (where tidal amplitude varies between 2-3 meters). The tide, semidiurnal (i.e. high tide occurs twice a day) in nature, has some diurnal (once a day) influence also regarding height of the daily two high tide levels and low tide levels. Highest tidal position is obtained in the month of August creating maximum impact on the coast. The relative mean sea level computed from the tide data of Digha-Shankarpur, supplied by the Department of Irrigation, Government of West Bengal while formulating the Integrated Coastal Zone Management Plan (unpublished) for the area, shows a definitely rising trend over the last 20 years. The rate of relative sea level rise is found to be over 3mm/year (Fig.6) and this makes some contribution to the coastal erosion over a longer time span.

Considering the present rate of temperature rise, thermal expansion of sea water, and higher rainfall there is a strong probability that the sea level rise will be 50 cm by 2050. This implies higher coastal erosion and inundation, and a higher surge height during cyclones.

Impacts

Coastal erosion, habitat loss and shore protection

Along the open coastal segment of Digha-Shankarpur-Mandarmoni, the major factors causing threat to the human habitat, tourism, agriculture and fishing are retreat of

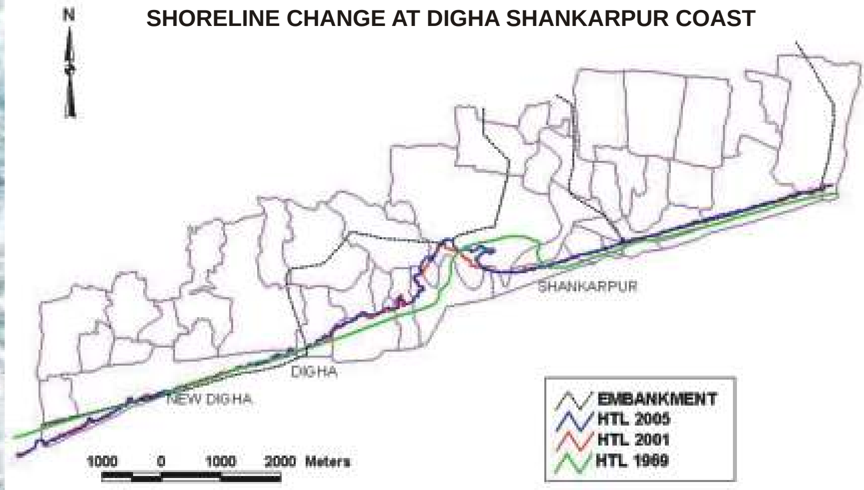


Fig. 7: Recent Shore line Changes at Digha Shankarpur Area

The areas like Shankarpur or Mandarmoni, two potential tourism development zones, which were previously stable or under accretion have been witnessing severe coastal erosion since 1990. This can be confirmed by the damaged new sea wall, destruction of the concrete wave-breakers and the wave-cut dunes. There are incidents of swimming accidents with tourists at old Digha as the sea encroachment towards the backshore gradually has destroyed the bathing sites. In fact there are no safe bathing places at Old Digha during the high tide. Near the Digha river estuary (Mohana) extensive bank erosion has widened its mouth. A comparative study of the shoreline changes from the year 1969-2005 reveals that the entire coastal stretch from Digha to Shankarpur is under erosive action (Fig.7).

Fig. 8: The abandoned house of the Barrister Colony, Front on Digha Coast no longer exists

Recently, a large part of the coastal stretch from Old Digha to Shankarpur suffered significant damage (approximately a 120m stretch) due to devastating tidal surge (Fig.8). Already 9 mouzas (village clusters) under study have been depopulated along the 13 km coastal segment .

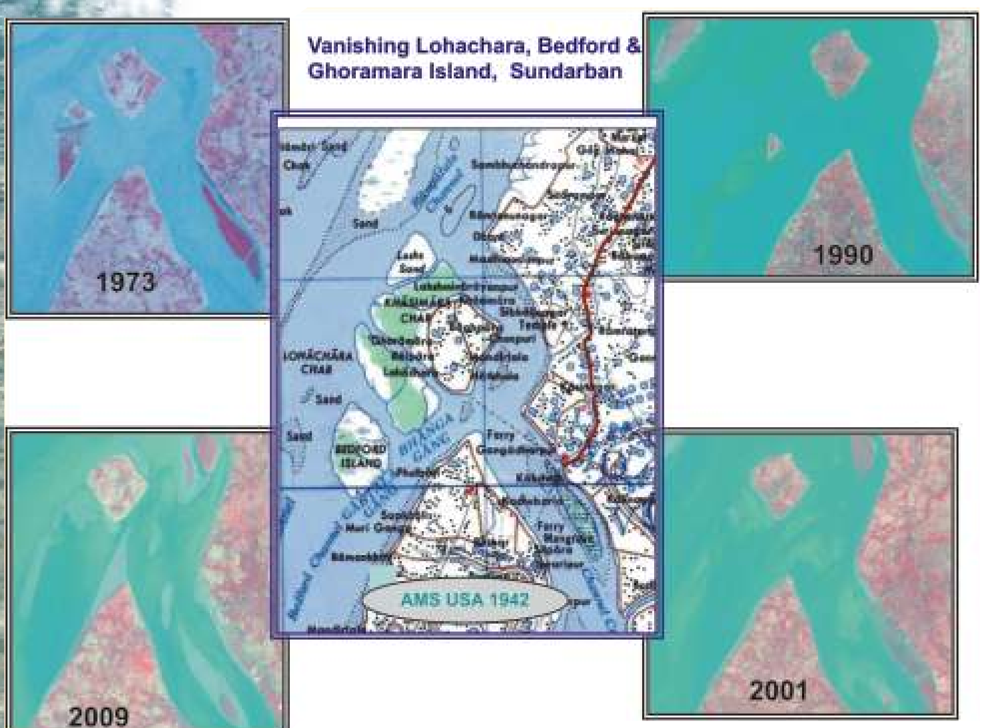


Fig. 9: Sequential changes of the vanishing islands

In Sundarbans, a comparison of the former maps (1942,1969) and more recent satellite images (2001,2006) reveals significant amount of land loss in spite of marginal accretion on the sheltered western banks. Two islands, Lohachara and Suparibhanga (within the estuary, Fig. 9) have already been eroded and submerged making thousands of people homeless. Ten sea facing islands registered a 85 km^2 net landloss in 30 years (upto 2001). Significant land loss has also been observed on the eastern bank of the Hooghly estuary (Kakdwip area).

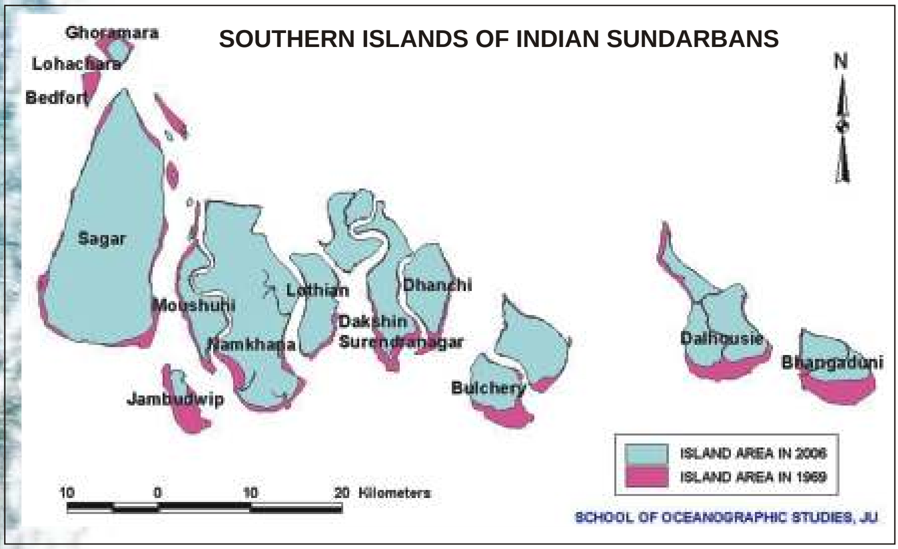


Fig. 10: The ten sea facing vulnerable islands of Sundarban (3 on the eastern part are Tiger habitat)

The establishment of a linkage between the erosion-accretion rate and rate of rise and fall of relative mean sea level is crucial for understanding the vulnerability of Sundarban island system in the perspective of climate change. It has been possible to establish such a relationship using statistical analysis and mathematical correlation studies[5]. These findings and the linkage established have been useful for developing a diagnostic and predictive model of shoreline change. Ten southernmost islands of Sundarban (Fig.10) have been identified as most vulnerable in terms of coastal erosion, submergence and flooding due to surge and sea level rise. With the help of the predictive model using GIS, it has been estimated that these 10 southern islands of Sundarban will suffer further land loss of around 90 Km^2 between now and 2020 with present scenario of sea level rise and storm surges[8].

Shore Protection

Shore Protection: Existing Sea Wall

At Digha, Government of West Bengal constructed a rubble mound seawall of a total length of 3464 m, extending from Jatra Nullah on the west and Sea Hawk hotel on the east, in stages between 1973 and 1982. Although for a certain period of time, the seawall could prevent the sea from encroaching Digha Township, the beach lowering continues. The waves reflected from the seawall might have accelerated the beach lowering. The width of the inter-tidal zone has also reduced gradually. The surface profile of the seawall deteriorated considerably due to moving up and rolling down of laterite boulders by incident wave and back wash (Fig.11). During the summer and monsoon season, the erosion at the toe may be up to a depth of 1 m to 1.5 m.

Fig. 11: Rolling of Boulders of the sea wall at Digha due to wave action

It was reported that there was no overtopping or spilling of the ocean water over the seawall till 1990. But since 1991, when storm surges coincide with spring tide, there have been cases of overtopping during August and September every year. It has been reported that waves reached a height of 1.5 m to 2 m above the seawall crest. Also the sand dunes beyond the east end of the seawall (near hotel Sea Hawk) have been facing strong erosion (around 15-20 m/year) reducing the natural sea defense, which may severely affect the Digha Fisheries Project on the Sankarpur Coast with aquaculture, fishing harbour, fish markets and proposed food processing industries..

Fig.12: Damaged parts of the Sea Wall after tidal surge

In a recent period, the seawall was further extended by about 250m at Old Digha, towards Mohana side. Also, the existing seawall has been covered by mass concrete and the height was raised by almost 1.0m to 1.5m at different stretches. But the same could not protect the coast. During a severe tidal activity some portions of seawall were severely damaged (Fig. 12).

Shore Protection : Existing earthen Embankments

Fig. 13 Exposed and eroded Earthen Embankment of Shankarpur

Brick pitched earthen embankment constructed during the 1930s used to protect the New Digha to Shankarpur area from the encroaching sea. In the central part, the spill basin area, tide was allowed to play in the intertidal zone. Subsequently in the accretional zone of New Digha and Shankarpur area, this embankment was covered by the prograding coastal dune belt. While this embankment, also mapped in the cadastral Map is still can be found under the dune belt a new Digha, at Shankarpur, from 2000 onwards, the embankment got exposed after the erosion of the dune belt and in 2006 it was entirely washed away (Fig 13).

Thus it is apparent that none of the various shore protection structures, earthen or concrete, erected parallel to the coast at Digha-Shankarpur area were found to be an effective solution to protect against the advancing sea, rising surges and coastal erosion. These lessons may be useful when one considers any 'permanent' solution against coastal erosion in the perspective of climate change.

Erosion of shore protection structures in Sundarban

Fig. 14: Overtopping of Earthen embankment by a storm surge in Mousuni Island, Sundarban

Four types of earthen embankments are commonly found in Sundarban; they are: a) 2m high earthen embankments bordering small channels b) 2.7 m high earthen wall with brick pitching on island margins, c) 3m high embankment with brick pitching on wave exposed coasts, d) 3.67m high wall with boulder pitching on eroding stretches. However overtopping (Fig.14), toe erosion, wash over or beach lowering are frequent phenomena with respect to these age old embankments erected in the early 20th Century. Even before the devastating Aila on 25th May 2009, the earthen embankments repeatedly breached. It is a point of major concern as to how far these structures will act as suitable protective measures against the threat of sea level rise, coastal erosion, storm surges and flooding.

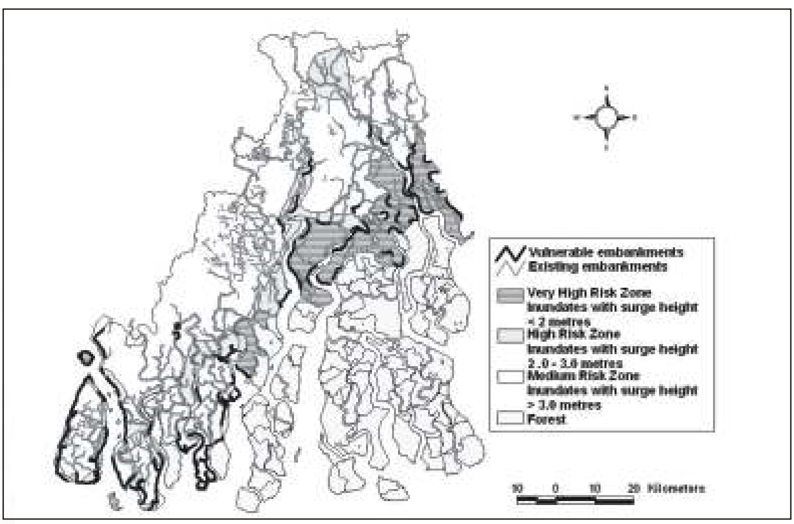


Fig. 15: Risk Zone map of Sundarban

In order to estimate the risk related to sea level rise (SLR) and coastal flooding in Sundarban, a risk zone map (Fig.15) has been prepared considering the elevation of the land, nature and height of the embankment where they exist, amount of coastal erosion and inundation history. Three risk zones have been identified:

i. The 'very high risk zone' is normally inundated by surges of 2 m. height or more. There is no protective embankment here. Although chances of loss of human life is remote here, it mostly constitutes the reserve forest of the tiger habitat.

ii. The 'high risk zone' has a considerable amount of human settlement protected by earthen embankment, damaged at places. The rise in sea level coupled with increased surge height of more than 2.5 meter and embankment failure may lead to total washout in these areas causing colossal loss of life and property.

iii. The medium risk zone is comparatively more elevated and the most thickly populated part of the island system. This is protected by earthen embankment of various strength and height. In the event of rise in sea level and surge height exceeding 3 meter during high tide, this zone may be inundated.

Displacement of People and Socio-Physical Vulnerability

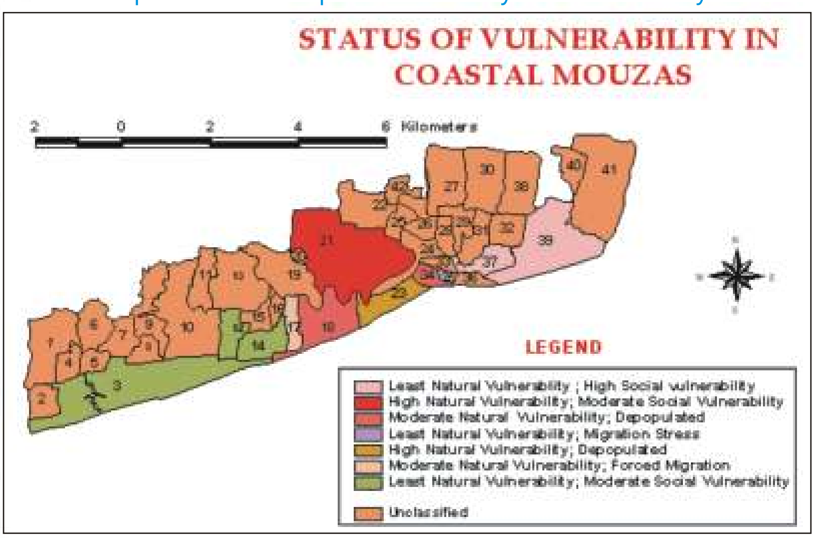


Fig. 16: Vulnerability status of coastal village clusters (Mouza) of Digha Shankarpur area considering infrastructure development and coping capacity vis a vis coastal erosion and climate change

Of 11 coastal mouzas (village clusters) along Digha Sankarpur, 5 clusters have been depopulated during the last decade due to strong coastal erosion and encrochment of the sea. These are, Digha, Atili, Begundiha, Raipur and Jhawa. Four other mouzas (Nilpur, Choto Balarampur, Kiagoria and Birampur) are also found to be depopulated due to related socio-economic reasons (Fig.16).

According to 2001 Census data, the total population of the 42 mouzas of Digha Shankarpur area under consideration, was 32941 persons which is 18% less (40139 persons) than that of 1991. This negative growth, in spite of overall population increase in other mouzas of the Ramnagar 1 block indicates the stress developing on the life and livelihood of the coastal community of the area.

With the help of a risk zone map prepared for the study area, it has been estimated that around 1500 people are under the immediate risk of coastal flooding and loss of habitat and displacement from Digha-ShankarpurJalda coast, unless shore protection measures are taken immediately. The number can significantly increase in the near future along the entire open coastal stretch, if we consider accelerated rise in sea level and an increased frequency of severe cyclones and surges.

In Sundarban, a preliminary survey reveals that over the last 30 years, around 7000 people have been displaced from their original habitat, becoming environmental refugees/migrants[8] due to sea level rise, coastal erosion, cyclone and coastal flooding. These numbers are likely to significantly increase in the future. Considering the number of persons already displaced from the various islands, topography rate of land area loss, habitation pattern and population density of these islands an estimate of the number of persons likely to be displaced from the following sea facing islands of Sundarban by 2020 was made[8]. This indicates a figure of approximately 70,000 people from different vulnerable islands as listed below:

Ghoramara	1600
Sagar	28,000
Mousuni	5700
Namkhana	15000
G-Plot	6000
Dakshin Surendranagar	12700
Total	**69,000**

The projected number of people likely to be affected by SLR, Storm surges and coastal flooding as estimated from the various blocks of Sundarban belonging to the high risk area have been estimated to be approximately 1.4 million. The number of people at risk belonging to medium risk zone stands as 2.4 million. It is to be noted that around 2.3 million people were affected in the Indian Sundarban during the recent storm surge 'Aila'.

Suggested strategy for Adaptation

Adaptation

To cope up with the projected loss and in order to improve upon the resilience and adaptation capabilities of coastal community, several measures (identifying and mapping of potential risk zones, reinforcing shore protection, formulating adaptation mechanism, maintaining record of displaced persons, developing case studies, regulating migration, devising rehabilitation programmes, sustainable development conserving natural resources, utilizing renewable energy to meet the energy need etc.) can be suggested [8].

Conclusion

Thus, there are certain observable changes with adverse impacts on the eco-system and the eco-community of Sundarban. These changes bear obvious relationship with climate change. However, one may always argue that there are 'other' natural and anthropogenic factors responsible for such changes and societal impacts. These possibilities should also be explored. This will help in enriching our understanding about the process-impact interaction of the fragile coastal eco-system like Sundarban which appears as an extremely vulnerable candidate for any 'business as usual' scenario while responding to climate change. It also implies that, with a greater concern reflected at the global,

regional or national level, through comprehensive planning of action, the impact of the slow and fast onset disasters related to climate change can largely be averted. However, India's National Action Plan on Climate Change (NAPCC, 2009) does not propose any mission statement for Sundarban in particular or the coastal region in general. The implementation of the Disaster Management Act, promulgated after the devastating Boxing Day tsunami of 2004, also needs to be synchronized with the NAPCC with provision for rehabilitation, compensation and insurance packages for the environmentally displaced persons from Sundarban and other coastal regions. An integrated coastal zone management plan needs to be formulated for coastal India in general, Sundarban, Andaman and Lakshadeep in particular, to address the challenge of adaptation and sustainable development as impacts of climate change are being felt in a significant way in our backyard.

Recommended Policy Intervention

National Level

- Declaration of a Mission Statement on saving Sundarban, Lakshadeep and Andaman in National Action Plan on Climate Change, 2009.
- Recognising 'slow onset' disaster like coastal erosion and habitat destruction due to climate change and sea level rise under the Disaster Management Act, 2005 and designing appropriate policies for informed retreat, rehabilitation, insurance and compensation for vulnerable coastal communities and environmental refugees.
- Issue and implementation of a separate notification for Integrated Coastal Zone Management and Development incorporating provisions for adaptation to climate change and sea level rise, coastal disaster management and sustainable development with creation of separate Ministries at the national and state level.

State Level

- Designing an appropriate retreat and rehabilitation plan for environmental refugees from vanishing islands and eroding coasts.
- Immediate implementation of shore protection measures with appropriate technology (coupled with bio-engineering and geo-jute application). Dredging of silted river channel and nourishing vulnerable coast and embankment using dredge materials may also be considered. Construction of groins and spurs in appropriate places of the open coast

and estuary to arrest sediment movement and nourish the coast. Retired embankments need to be constructed at the back of existing dune field/coastal mangrove plantation or alternatively 'silt trap' may be created in front.

- Creation of adequate number of cyclone and flood shelters with proper water and sanitation arrangement in vulnerable coastal regions of Sundarban and the open coast.
- Estuarine management mechanisms in place allowing sufficient water and sediment in Hooghly and Subarnarekha estuary with proper flow and flood management.

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Regional Policy Action Platform on Climate Change (RPAPCC)

Climate change can be viewed as one of the most critical environmental problems to confront us as it is most immediately and inextricably linked to wellbeing, development and economic growth. Thus the solutions to it cannot be left to the confines of the environment but needs to seek clarity and consolidate its response relating the agendas and interests of the multiple constituencies.

Recognising the need for a coordinated proactive response to climate change, WWF-India has developed the concept of “Talking Solutions”, which is a process that builds a consolidated understanding, informing a strategic response from among the various key constituencies. As a part of this initiative, a Regional Policy Action Platform on Climate Change (RPAPCC) was formed in the state of West Bengal, India.

Papers in this series are:

1. Climate change adaptation in flood plains of West Bengal
2. Climate change adaptation in coastal region of West Bengal
3. Climate change adaptation in arid region of West Bengal

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