Discussion Paper-I

The Proposal of Strengthening Embankment in Sundarban: Myth and Reality *

Since Aila or the tropical cyclone with a wind speed of 120 km/hr ravaged Sundarban on 25th May, 2009, the Government of West Bengal, as reported in newspapers, has expressed the opinion that strengthening embankments with concrete material would save people from such disasters in future. This hasty opinion emerged in a complete isolation from an understanding of the holistic eco-hydrology of the Sundarban and was not based on any commitment to either science or society.

A tropical cyclone in the Bay of Bengal is a natural hydro-meteorological event which causes disaster because of the socio-technical failure to cope with this natural phenomenon. Disaster management in West Bengal is a reactive programme; it starts to operate after the event strikes. *There* needs *to be a paradigm shift from erstwhile relief-centric and post-event response to a pro-active approach encompassing prevention, mitigation and preparedness-driven disaster management*- declared by the National Disaster Management Authority in its flood management policy of 2008. The Government of West Bengal indeed maintains a Disaster Management Department but it reacts late as usual after the event when the farthest terrains are difficult to approach and the afflicted community is in deep danger. In view of predictions made in the fourth assessment report of the Inter Governmental Panel on Climate Change that there will be more extreme hydro-meteorological events affecting lives and livelihoods of the people living in Indian subcontinent, we need a pro-active disaster management plan.

The 20th century has witnessed 44 tropical cyclones striking the coast of West Bengal but Aila has surpassed all previous records in terms of damage and economic loss. Vast areas of the Sunderban are still under water; cultivation of paddy seems impossible as seeds did not germinate due to salinity of soil above the threshold limit. Most people have not been able to rebuild their damaged huts and are virtually living under the sky. They are *have nots* in true sense. The victims are starving as supply of relief materials was miserably inadequate and now, has almost ceased. A deep sense of despair overshadows lives in Sundarban. Large scale exodus, especially of male working people, has started.

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Damages Caused by the Aila

- Number of villages affected: 4249
- Size of affected population: 25, 62,442
- Number of people missing: 8000
- Number of deaths: Official- 70; Unofficial-300
- Length of embankment breached: 400 kilometres
- Number of cattle lost: 2,12,851
- Total area of agricultural land affected: 1,25,872 ha
- Estimated financial loss in agriculture: Rs.337crore.
- Number of houses fully damaged: 1,94,390
- Number of houses partially damaged: 1,94,701
- Total loss: Rs.1495.63 crore.

Source: Unpublished records of the Govt. of West Bengal.

The Geography of Sundarban

The Sundarban region is extremely vulnerable due to its location, topography, climate and hydrology. People living there constantly fight with many odds and evils that have emerged out of wrongly- directed management plans being followed since the colonial period. Sundarban is an area of intricate network channels and intervening islands. Since the British rule, 54 islands out of 102 were deforested over four phases: these are now home to more than four million people. The remaining islands are still virgin, covered with dense mangrove forests.

The Sundarban was declared as a *Biosphere Reserve* which includes the Tiger Reserve, the National Park and Wild Life Sanctuaries. Geographically, six blocks of the North 24 Parganas and thirteen blocks of South 24 Parganas bounded by Hugli river in the west, the Raimangal - Hariabhanga rivers in the east, the Bay of Bengal in the south and the Dampier and Hodges Line in the north is identified as Indian Sundarban. The following table furnishes the geography of Sundarban at a glance.

Area within West Bengal	: 9630 square kilometres
No. of Islands	: 54
Height above mean sea level	: <3 metres
Tidal Height	: + 5 metres
Mangrove Forest Area	: 4267 square kilometres
Reclaimed Area	: 5363 square kilometres
Area under water	: 2069 square kilometres
Population	: 42 lakh (2001)
Length of Embankments	: 3500 kilometres

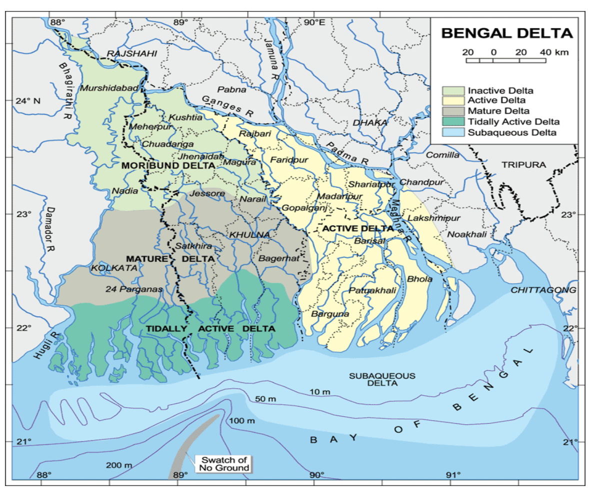
Delta Building Mechanism in the Sunderban

A proper management plan for Sundarban needs to have, to begin with, an understanding of processes involved in delta building, especially the sediment dispersal mechanism during tidal fluctuation. The delta has a long depositional history covering more than 70 million years. It is the area where fluvial and marine land building processes have been working simultaneously with cyclical advancement and retreat of the sea during past geological ages. The sea face gradually retreats southwards and sedimentation continues to build up new land on the continental shelf.

The delta is divided into three parts: the moribund, the mature and the active delta. When the rivers area decayed, the area is described as moribund delta. That part of the delta which it is elevated above highest high water level is identified as matured. This area gets sediment deposit only during flood. A large part of the sediments reaches the sea through two marginal estuaries- the Hugli in the west and the Padma-Meghna in the east. But the tides push back a portion of this sediment load through creeks and rivers. The silt-laden water spills over flood plains during high tide and recedes during low tide and thus land along the floods plain of these rivers gets elevated. Thus Sundarban area is identified as active delta.

The Sundarban is a part of the tidally active delta where the land building process is incomplete till date. Numerous interlacing channels, intervening islands with the elevation of less than three metres above mean sea level and dense mangrove forests have given this littoral tract a distinctive geographical identity. The Ganga- Brahmaputra system carries suspended sediment load amounting to more than one billion tonne per year. This is most conservative estimate as some experts estimate the load as 1.67 billion tones.

The subaqueous delta, as seen in the satellite image, extends far south from the coastline into the Bay of Bengal. Despite receiving such sediment load, there has been no appreciable growth of new land along the coast during last three centuries. There are various factors which are together responsible for this condition of the delta. It is reported by the experts that delta building is impeded due to siphoning of sediment away from



the coast through the Swatch of No Ground or the submarine canyon of the Bay of Bengal. Secondly, destructive waves continuously attack the southern littoral tract and erode land. Thirdly, slow subsidence due to auto-compaction of newly deposited sediment surpasses the effect of accretion.

Encroachment on the Pre-Mature Land

After the battle of Plassy in 1757, Mir Jafar conferred to the East India Company the area covering 882 square miles lying south of Fort William to the east bank of Hugli river. Shortly after that, the forest cover over extensive areas were cleared and the land was divided into smaller zones, which were numbered as *lots* and given to farming within the legal frame of the feudal *Zamindari* system of land management. Premature land reclamation in Sundarban was completed in four phases from 1770 to 1971:

(1) First Phase	1770 -- 1780
(2) Second Phase	1780 -- 1873
(3) Third Phase	1873 -- 1939
(4) Fourth Phase	1945 – 1971

The clearing of forests did not facilitate beginning of agriculture on the flood plain which was subject to submergence under saline water during high tides. The British built embankments along the bank of creeks to prevent ingress of saline water. Thus the spill-over of silt-laden water on floodplains was restricted, but the practice impeded the dynamics of sedimentation. As a result, silt was trapped within the embankments and river beds were filled up to make the channels increasingly shallow. While river beds were elevated, the flood plain remained at the same height. Rainwater falling on the floodplains remained stagnant for a longer period. The tidal inflow was transformed into a tidal bore which had the power to breach the embankments.

Now water levels in many embanked creeks remain at least two metres above the adjoining flood plains during high tides. The destructive waves during Aila not only breached a 400 kilometre stretch of embankments but also overtopped at many places. The water remained stagnant and marooned more than two million people for several days. The word 'disaster' seems a rather weak expression to describe the distress of the afflicted community.

Since Aila ravaged the land, people have been living under subhuman conditions. Supply of drinking water has become the most serious challenge. It was 'water everywhere' but there was not a single drop to drink. Most of the thatched houses have either collapsed or have been damaged. The farmland has gone under saline water making it non-productive.

Embankment as a Protective Measure

The creeks of Sundarbans are classed as meso-macro tidal, having an amplitude ranging from 2 to 5.5 metres. It is important to note that height of most of the areas in the active delta or Sundarban is less than 3 metres above mean sea level. Most of these creeks do not have any fresh water supply from upstream areas. The term 'fresh water' includes both rain and snow melt water. The water of the Ganga-Brahamputra basin covering more than 1.50 million km^2 is discharged into Bay of Bengal through two marginal estuary of the delta- the Hugli in the west and the Padma-Meghna in the east. Out of the eleven intermediate estuaries of undivided Sundarban, Sapatamukhi, Zamira, Matla, Bangaduni and Gosaba drain the Indian Sundarban and have no supply of upstream fresh water. These creeks are beheaded and replenished by tidal flow.

The efficacy of embankments as flood control measures have already proved inadequate in many parts of this subcontinent. The embankments in Sundarban caused increasing sedimentation on the river bed which gradually went high above the floodplain. The water level goes further above the crest of the embankment during cyclonic upsurges. The impinging waves scour the base and cause breaches in the embankment. The wave achieved a height of three metres during the Aila and overtopped the barrier.

Moreover, the reversal of gradient causes stagnation of water on floodplains for a protracted period till evaporation or infiltration. So the proposed concrete embankment is not a solution to present drainage congestion in Sundarban, nor will it ensure any security to the people. Since deposited sediment layers of Sundarban are not yet fully consolidated and the area is slowly subsiding, the overlying load of concrete embankments may cause a collapse of the bank.

Further, deep foundation of embankments would impair the dynamic relationship between ground water table and the river as both the influent and effluent seepages would be retarded. The concrete embankment on the bank may be affected by the hydrostatic pressure causing uplift and dislodgement of such structures. The scouring of the bank along the concave side of meander and heavy weight of overlying structure would possibly lead to collapse of the banks. Application of polymer geo-tube packed with sand as a bank protection measure may be more effective but it is neither a cost effective nor an eco-friendly option.

Comparison with the Netherlands

Delta management in the Netherlands is often compared with the case of Sundarban. But the delta of the Netherlands is hydro-geomorphologically entirely different from Sundaban. The notable differences are:

1. The estuaries of the Netherlands are aligned in an east- west direction but those of the Ganga are aligned north-south and allow easy invasion of tide far inland. The off-shore currents in Netherlands flow parallel to the coast while Coromondal and Martaban currents of the Indian Ocean flow northwards and strike the southern face of Ganga-Brahmaputra delta.
2. The sediment load carried annually by the Ganga- Brahmaputra system into the Bay of Bengal is about 1000 million tonnes and this is more than four times the load carried by all European rivers together.
3. The maximum possible tidal amplitude in estuaries of the Netherlands is <3.5 metres and those are classed as meso-tidal, while many estuaries of the Sundarban are said to be macro-tidal having a maximum tidal amplitude close to 5.5 metres.

Comparison with US: Hurricane Katrina

In the month of August in 2005, hurricane Katrina devastated thousands of lives in southern Florida, Louisiana, Mississipi, and Alabama in the United States. One of the worst affected cities was New Orleans, home to nearly 1.4 million people where storm surges were more than five metres above normal tide levels. Despite a large-scale pre-disaster evacuation, thousands of people had decided to stay behind, mostly the poor and the sick; these people and were trapped by rising waters. The death toll was around 1500 (Kelman, I, 2007, Peck, 2008).

The city of New Orleans is geographically situated below the nearby water levels of the sea, river and lakes. Levees protecting the city failed miserably, resulting in flooding that was several metres deep (ibid). This is much comparable to the situation in Sunderban after Aila. Talking of Katrina, Economist dated September 10, 2005 opined:

> "The disaster has exposed some shocking truths about the place: the bitterness of its sharp racial divide, the abandonment of the dispossessed, the weakness of the critical infrastructure" (quoted in Peck, 2007).

Sustainable Options

1. The plugging of breaches is an immediate necessity to prevent further inflow of water into the floodplain. The height of embankments should be determined based on highest recorded storm surge which may be more than five metres above high tide level. Since the area is environmentally fragile and ecologically sensitive, no non-biodegradable material should be used as far as possible; the local soil and bamboo can be better options. But presently soil is being borrowed from the river front creating hollows at the base of embankments. This makes the embankment vulnerable.
2. All the embanked creeks of Sundarban should be allowed wider spill area to reduce the hydrostatic pressure on embankments. The suspended solid in the creeks is estimated to be 15mg /litre. It should be learnt from experience

that unless we allow spill over of suspended solids carried by the river, the decay of rivers are inevitable.

3. There should be a long-term sustainable planning for the Sundarban. The greatest challenge is to combat the reversed slope between river and floodplain caused by uninterrupted sedimentation on the river bed.

There are two options:

a) A dredging of the channel to a depth below the adjoining floodplains. This is neither an economically viable nor a technically feasible solution. The depth of water in many creeks remains less than the draught required for plying of the modern dredger. Moreover, in view of tide velocity asymmetry, dredging is not a foolproof solution. Water travels fast towards the north during high tide for about four hours and retreats at a slower speed during subsequent eight hours, leaving behind substantial sediment load which was carried up. So spill over of the sediment on the floodplains can be the best possible option which will again elevate the land to the desired height. Note that the non-reclaimed part of Sundraban (i.e the forest area) now stands above reclaimed part as the land building processes were not impaired there.

b) We need to construct retired embankments about 500 metres away from the older ones and allow a regulated spill of silt-laden water in the tract lying between the old and new embankments. The settlements trapped between embankments should be evacuated and temporarily rehabilitated elsewhere until land is elevated to the desired level by the process of accretion. Plantation of mangroves along the banks of rivers can ensure protection from bank failure.

The management of Sundarban does not need any foreign collaboration. There is no reason to depend on the expensive technology of using geotubes. We can combat the challenge with indigenous materials (mud, bamboo etc) and local labour force. It is a long-term or perhaps unending project which may offer rural employment guarantee. The project can be included in the National Rural Employment Guarantee Scheme. (NREGS).

The agrarian economy of Sundarban has been facing a serious challenge due to ingress of saline water. The natural process of flushing out of salinity from the top soil may take two or three rainy seasons. This has been causing large scale exodus of labour force from Sundarban. Exhaustive research is urgently needed before introduction of salinity resistant crops. The area which remains perennially waterlogged may be used for aquaculture.

However, before adopting any management plan, we must have a clear understanding of the hydro-geomorphic processes operating in Sundarban and also bear in mind the long-term development implications of any such plans on the socio-economic conditions of the millions of lives involved.

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