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Tidal River Management (TRM) and its implication in disaster management: A geospatial study on Hari-Teka river basin, Jessore, Bangladesh

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ABSTRACT

The study area lies in the south-western coastal belt of Bangladesh under Jessore district, is a unique brackish water ecosystem comprising the districts of Satkhira, Khulna, Bagerhat and the southern part of Jessore. It introduced a compartmentalized polder or enclosure system in the south-west tidal areas in 1960 under coastal embankment project (CEP). As consequence of this continuing process of sedimentation over the years, many of the rivers/channels/canals in the area lost its conveyance causing severe drainage congestion. The study area became severe waterlogged in the 1980's due to gradual siltation of rivers. From their own experience and observation, people identified the polders as the main cause of water-logging and began to present their reasoned arguments for breaching or cutting away polders to allow tidal flows. Their logic was that if tidal flows can be made free, the navigability of the rivers will be restored, the enclosed lands will be free from water-logging, alluvium will accumulate inside the polders, and as a result the level of land will rise. This concept is known as Tidal River Management (TRM) system. After the predication of IPCC, south-west coastal region is highly vulnerable to climate change induced disaster due to sea level rise. This study presents an empirical analysis of the TRM in disaster management of south-west coastal region. The study attempts to illustrate the effectiveness of TRM in disaster management by applying of Social survey, Global Positioning System (GPS) survey, Geographical Information System (GIS) and Remote Sensing. The present research has revealed that, TRM is the most effective method to raise land and make it cultivable, mitigate the water-logging crisis, increase the navigability of rivers and protect the coastal region from the threat of sea level rise.

Keywords: TRM, Hari-Teka River Basin, Disaster Management, Geospatial, Bangladesh.

1. Introduction

South-west coastal region of Bangladesh is a unique brackish water ecosystem comprising the districts of Satkhira, Khulna, Bagerhat and the southern part of Jessore. It introduced a compartmentalized polder or enclosure system in the south-west tidal areas in 1960 under coastal embankment project (CEP). As consequence of this continuing process of sedimentation over the years, many of the rivers/channels/canals in the area lost its conveyance causing severe drainage congestion. A mechanism was developed by local communities in the decades of 90's to solve the severe drainage congestion which is known as Tidal River Management (TRM) (Kibria, Z. and Mahmud, I., 2010).

2. Objectives

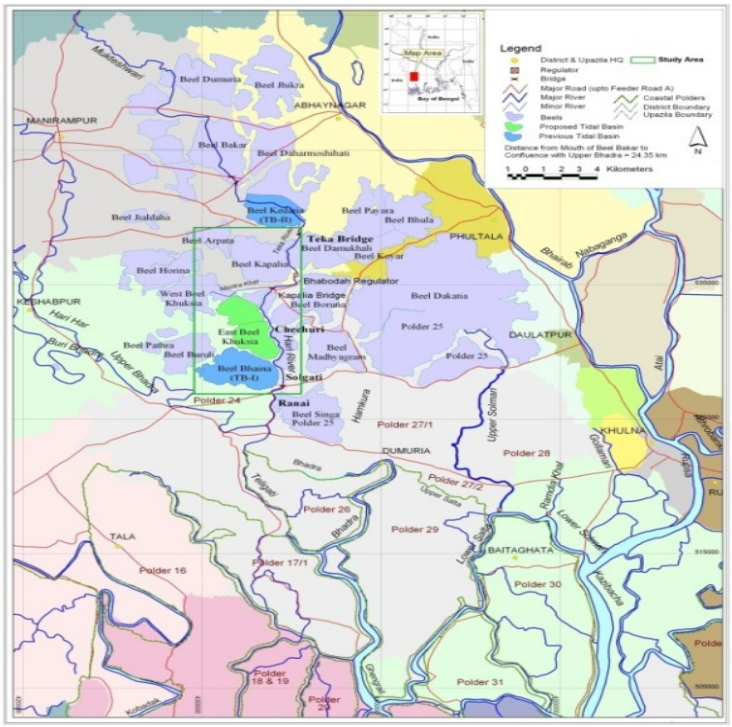
The main aim of the study is to know the Tidal River Management (TRM) and its implication in Disaster Management: A Geospatial Study on Hari-Teka River Basin, Jessore, Bangladesh. However, the specific objectives are:

- To study the main concept of TRM
- To study the changing pattern of bed level of Hari River with different time frame.
- To study the land reclamation status of Hari-Teka River basin using Remote Sensing Data
- To study the application of TRM in Disaster Management

3. Study area

The study area lies in the south-western coastal belt of Bangladesh under Jessore district. Three beels (beels are natural depression in the flood plains and are not embanked) of three upazilas of Jessore district were selected as the study area to know the Tidal River Management (TRM) and its implication in Disaster Management. The selected study area is considered as the ideal sites to know the mechanism of TRM. On the basis of different criteria these three sites were selected as i.e. Beel Bhaina (previous tidal basin), East Beel Khukshia (present tidal basin) and Beel Kapalia (future tidal basin).

The present study area is located in between 22°´85' N to 22°96' N latitude and 89°30' E to 89°36'E longitudinal position. The total beel area covered about 2246 hectares of land (Figure 1). The study area included with 6 villages of 4 unions of 3 upazilas in Jessore districts.



Source: Banglapedia, 2003 and IWM, 2011

Figure 1: Location map of the study area

4. Data sources and methodology

The present study is based on both primary and secondary data. Grounded Theory Approaches were applied in this study. Primary data were collected through conducting FGD, IDI, opinion survey, case studies, expert interviews and nature observation techniques. Different field visit in different seasons (wet and dry season) were conducted ensuring people perceptions. Primary and secondary data were used to provide an idea of possible remedial options to explore the impact of TRM in climate change adaptation. Moreover, secondary data sources both published and unpublished records such as books, thesis papers, news papers, articles, magazines, reports of NGOs, different govt. and non govt. project works etc. were used to enrich the study.

Data that was collected from different sources and field survey has been analyzed through MS Excel. Maps of the study area, changing pattern of river dynamics, water-logging condition, delineation of tidal basin etc. of desired study area were prepared by using Arc GIS 10 and ERDAS Imagine 10 (Remote Sensing software). Satellite images of three different time period i.e. 6 March 1997 of Landsat TM (Spatial Resolution 30m x 30m), 4 April 2001 of IRS-1D LISS III (Spatial Resolution 24m x 24m) and 28 March 2002 of Landsat ETM+ (Spatial Resolution 30m x 30m) have been used to understand the land use and land cover changes of Beel Bhaina. Hydro-morphological data from different sources i.e. BWDB, CEGIS and IWM used to measure the average water level, maximum velocity, river bed level, tidal volume data, cross-sectional area, sedimentation rate etc. from the year 2004 to 2011 of the study area.

5. Results and discussion

5.1 Changing pattern of bed Level of Hari river

Bed level of Hari River is changed with different time frame. In 6th September 2006, river bed level declined to carry normal water volume. Because of, then sedimentation took places only on channel beds. Black curves also showing the bed shape of the Hari River which measured in 6th September 2006 (Figure 2). From the data of 1st February 2007 bed level has changed. In this time few initiatives were taken to remove the sediment from channel beds. Pink color shows the bed shape of the Hari River. From the data of 9th May 2007 bed level has dramatically changed. In this time various initiatives were taken to remove the sediment from channel beds. Green color also shows the bed shape of the Hari River (IWM, 2007).

5.2 Identification of Water-logging Extent at the Hari Basin

The impacts of the drainage congestion have been assessed as an integral part of the study. Because of water-logging is the result of hydro-morphological changes of Hari-Teka River (CEGIS, 2003). However, severe water-logging problem was prevailed in the Bhabodaoh area from October 2005 to November 2006 due to discontinuation of operation of Beel Kedaria tidal basin for TRM (Kibria, Z. and Mahmud, I., 2010 and Field survey 2011). The inundated area due to drainage congestion was about 18,100 ha in September 2006 (Source: Manirampur, Keshabpur and Abhaynagar Upazila offices). The inundated area includes agricultural land, homesteads, schools, colleges and roads under the three Upazilas (Manirampur, Keshabpur and Abhaynagar) of Jessore District. Details of which are furnished in Table 1.

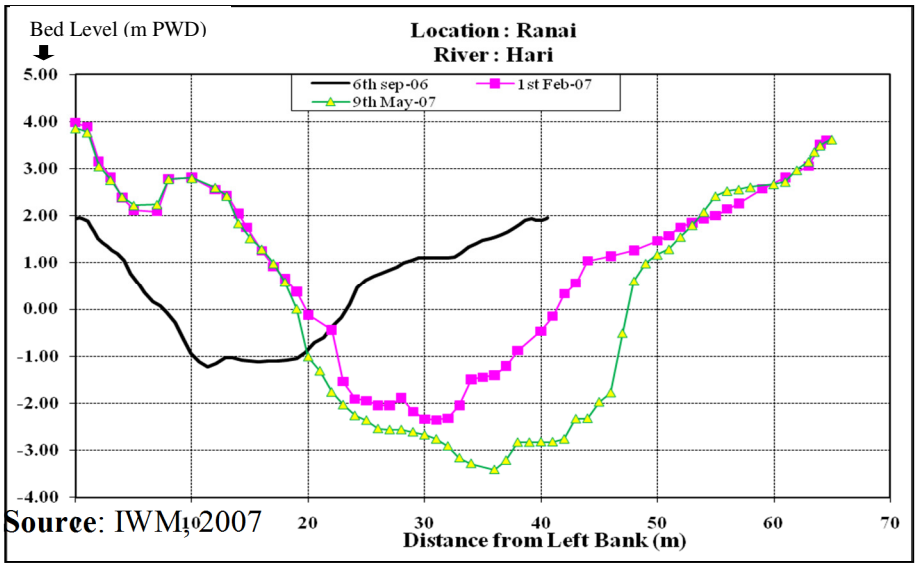


Figure 2: Changing Pattern of Bed Level of Hari River with Different Time Frame (2006-2007)

Table 1: Upazila-wise Affected People by severe water-logging under KJDRP in 2006

Sl.No.	Upazila	No. of affected union	No. of affected village	Number of people in the Upazila	No. of affected people
1	Abhaynagar	4	42	1,36,146	68,848
2	Manirampur	11	90	3,71,529	1,40,697
3	Keshabpur	6	61	1,66,257	1,03,500
Total		21	193	6,73,932	3,13,045

Source: Manirampur, Keshabpur and Abhaynagar Upazila offices and IWM, 2007

The inundated area under 3 Upazilas during September 2006 is shown in Figure 7 (a). About 42 villages in 4 unions of Abhaynagar Upazila, 90 villages in 11 unions of Manirampur Upazila and 61 villages in 6 unions of Keshabpur Upazila were affected due to water-logging problem. Maximum villages are located under Hari basin (IWM, 2007).

5.3 Causes of water-logging

In 1959 thirty-nine polders were constructed in the Active-Ganges delta to increase crop production. Since 1983 rapid sedimentation and water-logging problems have been started in different parts of the coastal areas as well as within the polder areas (Ali and Ahmed, 2001). However, human interventions without proper understanding of the system often create disastrous situation in the coastal region of Bangladesh. Due to the lack of proper understanding of the flow dynamics in the delta, several problems were encountered after implementation of development activities (Figure 3). In the late '80s, the drainage congestion became very acute in the Khulna-Jessore area.

5.4 Tidal River Management (TRM)

TRM concept is beels are to act as tidal storage basins which allow natural tidal flows up and down in the river system. During high tides, the large volume of water flows into the beels and huge sedimentation occurs in the beels area. This sedimentation would have been occurred into the riverbed if the beels are not being utilized for storage. This tidal storage basin makes river alive by keeping tidal flow characteristics in the downstream river system and thereby prevents silt deposition in the river bed (Figure 4). This is in fact a natural water management process with very little human interventions but it needs strong participation and consensus with a great deal of sacrifice by the stakeholders for a specific period (3 to 5 years or even more depending on the tidal volume and the area of the beel) (Ullah and Rahman, 2002).

Source: Google Map

Figure 3: Image shows (box) the most discussing development activities i.e. Bhabodaoh regulator which installed on Hari-Teka River.

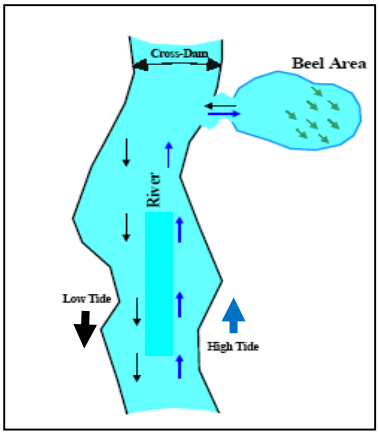
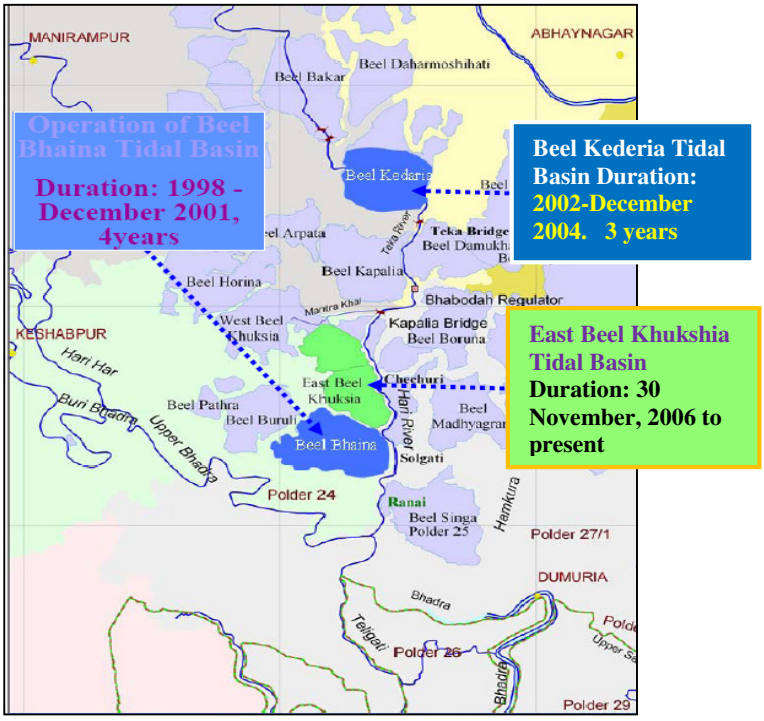


Figure 4: TRM Mechanism

The TRM in any basin allows in huge volume of water along with the sediment during the flood tide. These sediments settle down into the basin due to reduction of velocity and flocculation due to high salinity. TRM prevents sediments deposition on the riverbed and ensures the drainage and smooth navigation in river channels (IWM, 2007).

5.5 TRM in Hari-Teka River Basin

The implementation of TRM Plan under Khulna-Jessore Rehabilitation Project (KJDRP) through operation of a beel as a tidal basin solved the prolonged drainage congestions from 1998. Beel Bhaina was used as a tidal basin from 1998 to December 2001 (four years) and Beel Kedaria was brought under operation for TRM from January 2002 and continued up to February 2005 (three years). It has been seen that these beels were functioned very well to maintain the drainage capacity of the Hari River and to keep the area free from water-logging until the closing of these tidal basins (Field Survey, 2011). TRM in Hari-Teka basin area is shown in Figure 5. Furthermore, any other potential beel could not be taken up for operation as a tidal basin for TRM after closure of Beel Kedaria Tidal Basin.



Source: IWM, 2007 and Field Survey, 2011
Figure 5: TRM in Hari-Teka Basin Area

5.6 Application of TRM in Disaster Management

TRM is most discussing matter in south-west coastal region in Bangladesh. People have mix perception on TRM in the study area. In Beel Bhaina, the poverty situation has improved as a result of the improvement in the drainage situation and related livelihood opportunities (mainly agriculture and fishing (Tutu, A.A., 2005). Thus TRM is blissful phenomenon at Beel Bhaina, but TRM is burden for the people of East Beel Khukshia. Because live and livelihoods are seriously hampered during TRM operations at East Beel Khukshia (Field Survey, 2011). The different applications of TRM are discussed below in a sequential manner:

5.6.1 Sediment deposition at two tidal basins during TRM

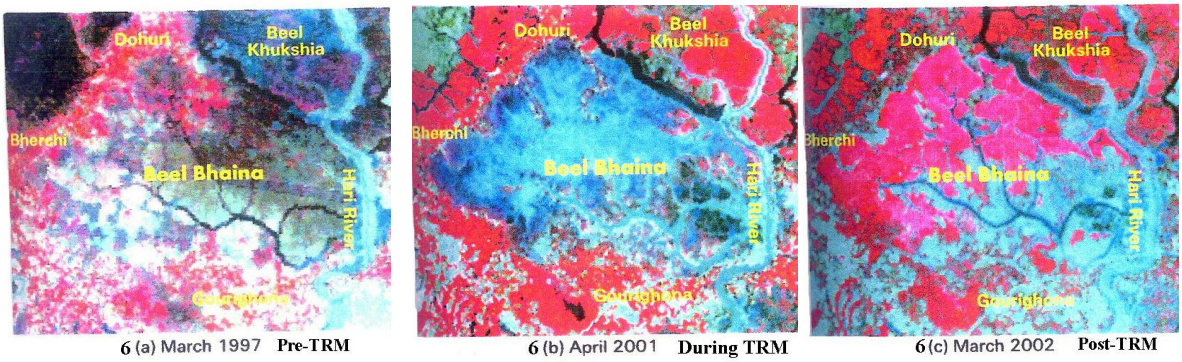
Sediment concentration in the tide-dominated rivers is not dependent on the supply from the upstream. Rather, it is controlled from downstream. Both sedimentation and sediment distribution in the tidal basin are important aspects in the TRM. Sedimentation determines the life span as well as the rate of raising the land topography. On the other hand sediment deposition in the basin is high at close to the opening and less at the furthest end of the basin, which varies from few 10 of cm to more than 2 m at Beel Bhaina (Ullah and Rahman, 2002). After closing of Beel Bhaina tidal basin, the beel has been brought under agriculture practices. However, the uneven sedimentation is causing drainage congestion in some parts of the beel (Field Survey, 2011).

5.6.2 Land Reclamation by TRM in Hari-Teka River Basin

Remarkable land reclamation has done by TRM in Hari-Teka river basin. Firstly about 600 hectares of land in Beel Bhaina was reclaimed during 1997-2001. Above all 17,254 ha land reclaimed under KJDRP project during 2006 - 2011 (Figure 7 b).

In November 1997, local people decided to open the Beel Bhaina of the Hari River System and the embankment was cut in two places. One of these cuts was closed towards the end of 1998, but cut again in February 1999. In the process, Beel Bhaina started to function as tidal basin. Both cuts are closed in 2001 (Alam, A., 2005). During this period about 600 hectare land of the beel area reclaimed from severe water-logging (CEGIS, 2003). Three satellite image (Figure 6a, 6b and 6c) Shows the land reclamation of Beel Bhaina.

According to Field Survey, The water-logging conditions improved significantly within November 2011 due to implementation of Immediate and Short Term drainage improvement activities. Due to operation of East Beel Khukshia tidal basin and dredging/excavation of critical reaches of Hari River, about 93% (17,254 ha) area has reclaimed till early September 2011 (total water-logged area was 18,100 ha) which shown in Figure 7(b). All the homesteads, schools, colleges, roads and other infrastructures of the study area were free from water-logging problem at the end of November 2011. Most of the small beels and peripheral parts of large beels were brought under Boro crop.

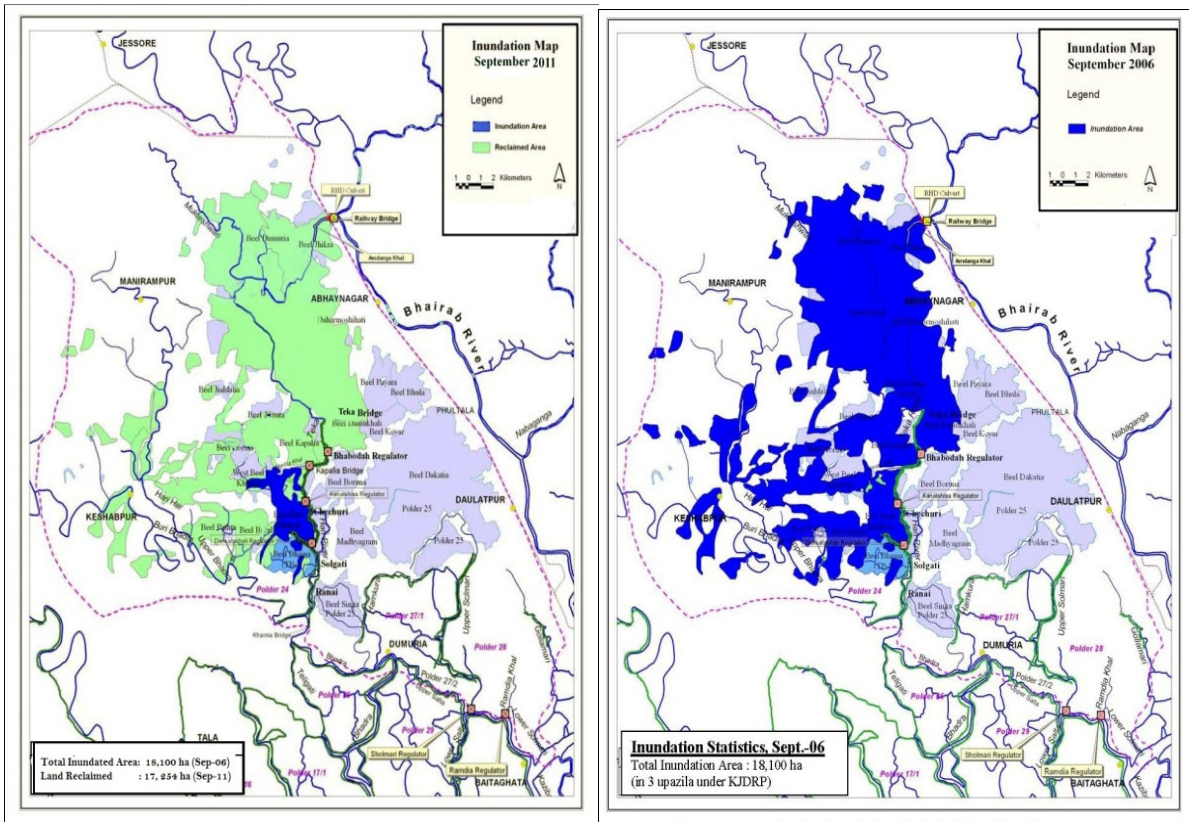


6 (a) March 1997 Pre-TRM 6 (b) April 2001 During TRM 6 (c) March 2002 Post-TRM

Source: CEGIS, 2003

Figure 6 (a): the dark grey to black tone and greenish brown tones in the 1997 image of the Beel Bhaina represent waterlogged areas with and without aquatic vegetation respectively (pre-TRM situation). **Figure 6 (b):** In 2001, as result of TRM, tidal water inundated the entire beel. The tidal waters appear blue due to presence of suspended sediments (TRM operating situation). **Figure 6(c):** In 2002, due to improvement of drainage, a major part of the beel

came under boro crop cultivation. The boro crop in the beel area is seen in the pink to red (post TRM situation).



Source: IWM, 2007 and Field Survey, 2011

Figure 7 (a): Inundated Area Due to Water-logging in 2006 and **Figure 7 (b**): Land Reclamation by TRM from Water-logging in 2011

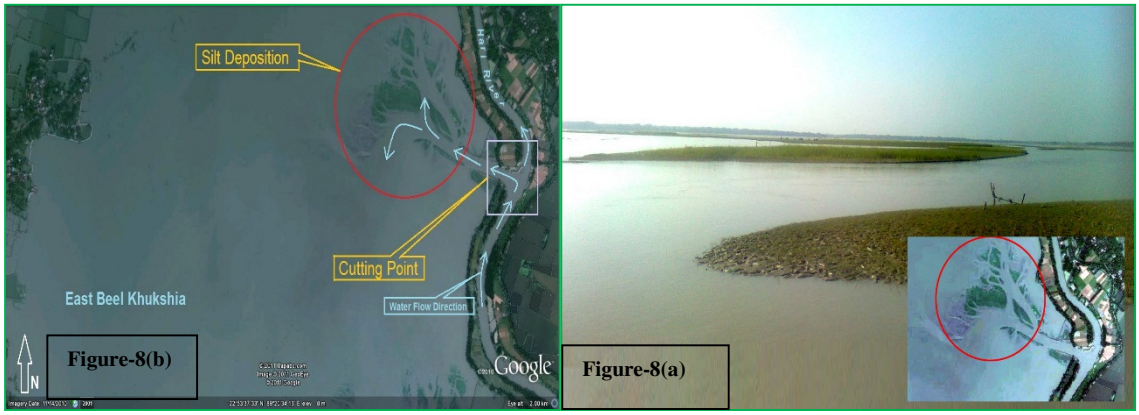


Figure 8 (a): Raised Land in East Beel Khukshia tidal basin (EBKtb) by silt deposition, Inset satellite image of silt deposition (red marked) in front of cutting point. Photo was taken from present cutting point (second cut) of EBKtb. **Figure 8(b):** Silt deposition at cutting point of EBKtb by TRM mechanism

About 0.9 million-m³ siltation took place in the tidal basin during 5 month operation (December 2006 to April 2007) of the East Beel Khukshia tidal basin (IWM 2007). It is apparent that deposition occurred mostly near the downstream area (nearest to the cut point) of the basin. Silt deposition comparatively higher at cutting point than other places (Figure 8a and 8b).

5.6.3 Hydro-morphological changes of Hari River during TRM at East Beel Khukshia tidal basin

Hydro-morphological changes of Hari-Teka River have noticed in during TRM operation. In order to assess the drainage capacity and erosion/deposition in Hari River and Dier Katakhali Khal, monitoring of cross-sections at selected locations was carried out in two different periods (February and May 2007) during the operation of TRM (IWM, 2007). The following photo also showed the dramatically hydro-dynamic changes of Hari River during TRM operations in 2006 to 2011 (Figure 9a and 9b).

Figure 9 (a): Hari River near Babodaoh regulator before TRM **Figure 9 (b) :** Hari River near Babodaoh regulator after TRM

5.7 Major obstacles of TRM

Although TRM technically feasible and socially acceptable. The present TRM carried out few problems. According to field based social survey, few major obstacles are identified of TRM which shown in below

1. No payment of land compensation
2. Lower rate of land compensation per *bigha*
3. Irregular monitoring by governmental institutions
4. Lack of proper co-ordination between Water Management Association (WMA), Water Management Committee (WMC), local peoples, Governmental Organizations (GOs) and Non-Governmental Organizations (NGOs).
5. Lack of proper maintenances of tidal basin
6. Corruption of Government Organizations (GOs)
7. Bureaucratic problem to get land compensation
8. Fishing structures (*putta,* embankment of *gher* etc.) obstruct the silt deposition.
9. Mismanagement of sluice gates and willful misuses of land and water by the Bangladesh Water Development Board (BWDB).

10. BWDB ignored the compensation for affected people and the Environment Management Plan (EMP) of GOs.

5.8 Recommendations

From the above results and discussions, it would be listed few important recommendations to implement TRM in disaster management. The recommendations are shown in below

1. For devising long-term drainage solution of south-west coastal region, an integrated drainage study for the south-west region is essential.
2. Prohibiting shrimp *ghers* from link canals and rivers.
3. TRM implemented at the initiatives of local people is such a method which can be used to raise land at low cost and keeping the natural process unaffected.
4. Planning and investigation of utilizing all potential *beels* for sequential operation as tidal basins for TRM.
5. Embankment must enclose the target beel. The river channels must be kept open as far into the beel as possible. The tide must be allowed to enter and return to sea freely. This ensures that the incoming tide brings with flow cannot go anywhere further and the sediment therefore drops to the floor of the beel. Above all exclusion all human interventions which constrict the natural flow route of the rivers and drainage creeks.
6. Establishment of mechanism for crop compensation for the land owners for smooth functioning and duration of operation of tidal basin may be increased from 3 years to 6 years of crop compensation; re drops to the floor of the beel and stays there.
7. TRM can be implemented at a broader scale. Actually isolated TRM operations can't carryout long-term solution in the south-west coastal region. Present TRM practice continuing with isolated way, it is limited within a micro unit (beel). Now it is needed to operate the TRM basin-wise/ basin-to-basin (Uttaran, 2006). For example, TRM should have operated in whole Hari basin within certain period. After finishing Hari basin, then have to plan for next river basin i.e. Bhadra, Kopotaksho etc. (Rahaman, S., 2009).
8. Intensive consultation and a clear agreement from concerned communities and affected landowners is a precondition for selection of a beel for next rotation.
9. All the organizations and agencies connected with the different stages of the development process must be responsible for promoting TRM as people-oriented approach and needed a good co-ordination between GOs and NGOs to implement the TRM.

5.9 Conclusion

The local people understand nature and nature's self-management which is called 'people's wisdom', must be given due importance, particularly in coastal river basin management. As TRM considered as people's traditional wisdom, tidal approaches seem to be an effective and sustainable way forward under this scheme. A certain low-lying area within the polder is allowed to act as a retention basin, allowing the tidal prism to spread over throughout the basin during high tide. By this process, silt is deposited on the low-lying areas making them higher; fluxes of water leaving the basin during low tide are silt free thus help to keep the tidal channels deepening. Now it is needed the implementation of the traditional wisdom and local scientific knowledge for disaster management. TRM is most feasible and more effective for disaster management in south-west coastal region. Government and NGOs should make an integrated plan and policy for this disaster prone region.

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