MANAGING THE SEDIMENT LOAD IN TIDAL RIVER MANAGEMENT (TRM)

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ABSTRACT

Bangladesh has a large number of tidal rivers in the South-West region which are characterized by erosion and sedimentation and all of them discharges into the Bay of Bengal. Tidal River Management (TRM) which is a concept based on indigenous knowledge and sediment management practice is one of the key factors for river basin management in this region. Raising of low lying land inside the beel (depressed area) and maintaining proper drainage capacity of the rivers are the two main objectives of Tidal River Management (TRM) process. It was observed in the previous TRM practices in Beel Kedaria and East Beel Khuksia of South-West region that the sedimentation inside the beels were not uniform due to technical and operational problems in the TRM process. The present practice of TRM operation, a link canal is constructed to connect the beel with the river. This results in sediment deposition at the mouth of the link canal, preventing uniform sedimentation inside the wider area of beel. Technical feasibility of this option has been assessed in this paperby a cohesive sediment transport model namely MIKE21 FM. The option which has been selected for sediment management inside the beel during TRM operation is such that one link has been constructed to connect the beel with the river. Deposition volume in Beel Baruna in Jessore district has been assessed. From the simulation results, it has been found that sedimentation inside the beel is not uniform with the present TRM practice. The deposition volume shows linear variation from 0.68Mm3 to 2.28Mm3 through the four consecutive years but the deposition pattern within the beel is non-uniform. The sediment deposition continues to increase even after four years in all areas. So it is necessary to implement a better functional technique for uniform and effective sedimentation inside the beel areas to overcome the long term drainage congestion and water logging problem from the study.

1.0 INTRODUCTION

The South-West coastal region of Bangladesh is a region to be one of the hardest hit by climate change predicted by experts. Many depressed land have been raised in this area by using a unique indigenous knowledge of river management and collective efforts of local community. An indigenous knowledge based on tidal and sediment management concept is introduced which is popularly known as Tidal River Management (TRM) concept. TRM is a key to river basin management in South-West region of Bangladesh (Kibria and Mahmud, 2010). Around 650 hectares of land in Beel Khukshiya floodplain on Hari River basin, has been raised by 1.5 meters in three years by using this TRM concept(Paul et.al,2013). In Beel Khukshiya TRMwas being implemented by Bangladesh Water Development Board (BWDB). BWDB learned the concept of TRM in 1990s from the local communities. About 31.32 square kilometers of land has been raised by local communities themselves in Beel Bhayna and Beel Dakatiya applying TRM (Kibria, 2011).

After implementation of coastal polders in the sixties, the rivers in the South-Western part of Bangladesh gradually started to silt up (Nowreen et. al, 2014). Moreover, decrease of the flushing fresh water flow from the upstream rivers accelerates the sedimentation process in the area. The presence of polders restricts the natural tidal flows and prevents sedimentation on low-lying lands. This results in sedimentation in the peripheral rivers of the polders and reduced their drainage capacity. As a result, the areas inside the polders have been suffering from

water logging and drainage congestion problems for a long time. To overcome these long-standing water logging problems, Khulna-Jessore Drainage Rehabilitation Project (KJDRP) was implemented during 1994-2002 by BWDB (IWM, 2010).

In TRM process, natural movement of tidal water into a beel is allowed and the beel functions as a tidal basin. During flood tide, tidal flow carrying sediments enter the tidal basin and the sediments are deposited due to reduction of velocity in a wider beel area. During ebb tide, the tidal water flows out of the beel with reduced sediment load and erodes the river bed by hydraulic dredging. In this process, an adequate drainage capacity of a tidal river is maintained naturally (IWM, 2009). After implementation of the KJDRP, the prevailing drainage congestion and water logging problems were partially solved and agricultural, social and economic benefits were achieved (SMEC, 2002).

The South-West area of Bangladesh consists a large number of beels which may be potential for TRM process. A sequential operation for TRM process is needed for long term solution of drainage congestion in the area (IWM, 2010). As dredging of river is an expensive operation, it cannot be a long term solution. A technically feasible solution is required for exclusion of drainage congestion problem by managing the sediment. In TRM process, usually one or two link canals are constructed that connect the beel with the river. In this process, sediment deposition occurs mostly near the mouth of link canal; it obstructs spreading of sediment in the wider beel area and creates a non-uniform sedimentation. Non-uniform sedimentation causes uneven land development and people's unwillingness to give up their land for 3 or 4 years. In this research work, the feasibility analysis of sediment transport in Beel Baruna for the current TRM practice in South-West region has been simulated by using MIKE 21 FM modeling system.

2.0 TIDAL RIVER MANAGEMENT IN BANGLADESH

Beel Kedaria tidal basin started its operation on January 2002. Monitoring results for Beel Kedaria tidal basin shows that it performed as an effective tidal basin in maintaining the design drainage capacity of the Hari River during its operation time from January 2002 to January 2005. The net sediment deposition in Beel Kedaria tidal basin from 2002 to May 2004 was about 0.49 million m3 over an area of 524 ha. It has been apparent that deposition took place almost over the whole area but the deposition was not uniform over time and space. Sediment deposition near the opening of Beel Kedaria tidal basin was about l.0m higher compared to other areas (IWM, 2005).

TRM process in Beel Bhaina started from October 1997and continued upto December 2001. Monitoring result showed that its tidal basin generated about 10 times higher tidal volume than that generated by the Beel Kedaria basin. This higher tidal volume generated in Beel Bhaina was mainly due to the location of the basin. Beel Bhaina tidal basin is located downstream of East Beel Khukshia.The tidal range in the location of Beel Bhaina was more than 1.0 m, whereas it is about 0.15 to 0.20 m in the Beel Kedaria tidal basin. The higher tidal range at the mouth of Beel Bhaina caused higher flow and flow velocity that led to river bed erosion and siltation in the basin. So, location and proper selection of beel is very important for successful TRM (IWM, 2002).

Operation of TRM in East Beel Khukshia started from December 2006 and continues for two years. River bed scouring and sedimentation in the beel was found satisfactory. It was found that the river at this location is still adjusting with tidal prism to reach a new equilibrium under changing morphological condition. The conveyance of Hari River at Ranai increased remarkably after 5 months of TRM operation. It was also established that the drainage capacity of the Hari River at the downstream reaches of the basin increased from its design drainage capacity (IWM, 2007).

3.0 METHODOLOGY

The methodology of this research study has been formulated in a logical sequence to carry out the work properly. It includes study area selection, data

collection, and identification of sediment management option and development of a sediment management transport model.

3.1 Selection of the Study Beel Area:

Beel selection criteria mainly depend on its location and operable area of tidal basin. In consideration of these two criteria, Beel Baruna is selected as a very potential beel for TRM (IWM, 2010). The selected study beel area is located in between Latitudes 22°49°40.3°°N and 23°6°27.1°°N and Longitudes 89°13°32.46°° E and 89°26°15.43°° E. It is situated in the South-Western region of Bangladesh under Jessore and Khulna districts. Beel Baruna is located just downstream of Bhabadah regulator and upstream of East Beel Khukshia. It is situated almost parallel and in the opposite bank of East Beel Khukshia. Beel selection was also guided by the availability of secondary data. The present TRM practice is verified with the help of a numerical model which will analyze the efficiency of that exercise.

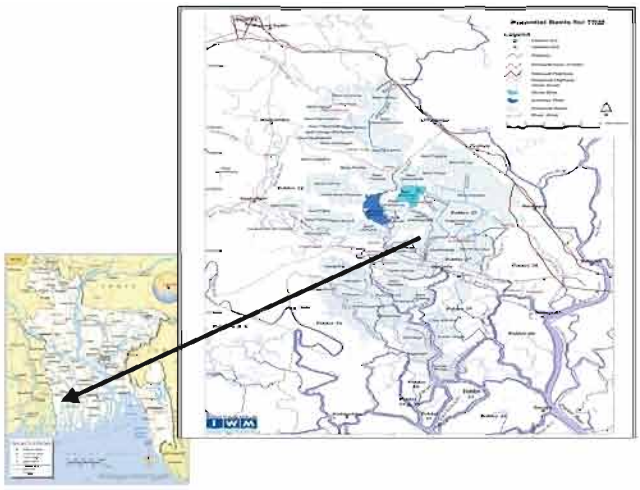

Fig-1: Location Map of the study area (Source: IWM, 2010)

3.2 Secondary Data Collection:

The secondary data were collected from Institute of Water Modelling (IWM), Bangladesh Water Development Board (BWDB) and Center for Environmental and Geographic Information Services (CEGIS).

3.3 Identification of Management Options and Development of Model:

The option which has been selected for sediment management inside the beel during TRM operation is such that one link has been constructed to connect the beel with the river. This process has been considered to know the sedimentation in the present TRM condition.For this option beel has been connected by a link along Noimuddir Khal (length=750 m) alignment.

In order to know the sedimentation inside the beel, a two dimensional sediment transport model has been developed using MIKE21 FM Modeling system which was calibrated and validated with measured data. At first, the hydrodynamic model has been developed, then the developed model was coupled with a sediment transport model. As the sediments are cohesive in nature (average grain size less than 0.063 mm), a cohesive sediment transport model has been developed. The numerical sediment transport module solves the two-dimensional, depth-integrated governing equation for sediment transport. The integrated hydrodynamic and mud transport model was simulated parallelly. The governing equation for sediment transport was solved on the same mesh (computational grid) and implies information on water levels and currents from the hydrodynamic module to calculate the sediment transport.

The numerical model has been developed integrating the main Hari-Teligati-Gengrail River system and Beel Baruna tidal basin. Model has been calibrated with the observed data at Hari River and simulated for the identified option. Sedimentation inside the tidal basin has been assessed from the simulation results of cohesive sediment transport model for the identified options.

Topographic data of Beel Baruna has been used to develop the bathymetry for the model. Water level and discharge time series data have been used in Hydrodynamic (HD) module to set the boundary condition and to calibrate the model. Cross section and bathymetric data of river have been used to develop bathymetry of the river. Suspended sediment concentration data of river are required to develop boundary and calibration of the cohesive sediment transport model. Time series data of suspended sediment concentration have been used in Mud Transport (MT) Module to set boundary condition and calibration of the model.

4.0 RESULTS AND DISCUSSION

For the selected option, at first location of link canal has been constructed to connect the beel with the Hari River. Figure 2 shows the schematization for Beel Baruna.

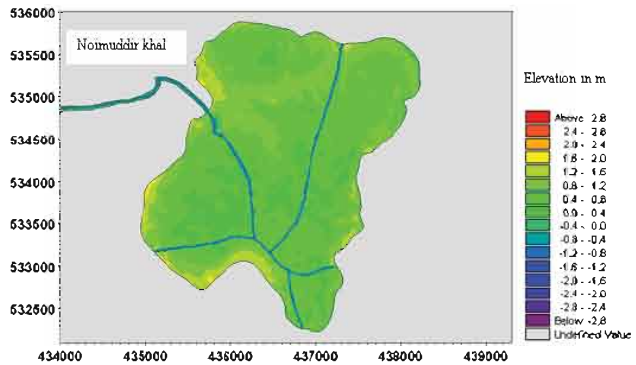

Fig 2: Schematization of Beel Baruna for TRM

After set up and calibration of the model, the cohesive sediment transport model has been simulated for four years. Continuous four (4) years model simulation for tidal river is quite complex and time consuming. For this reason simulation has been done for the dry season as major sedimentation occurs in this season. Similarly, simulation for the next year has been done with the updated bed level of the previous year. Thus, total deposition inside the beel has been found for four years.

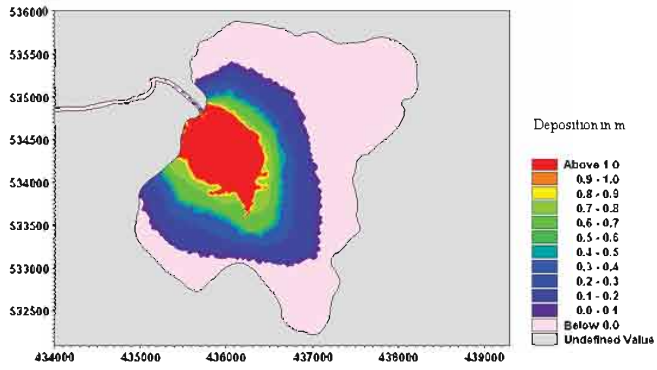

Fig 3: Simulated deposition pattern inside the tidal basin after first year

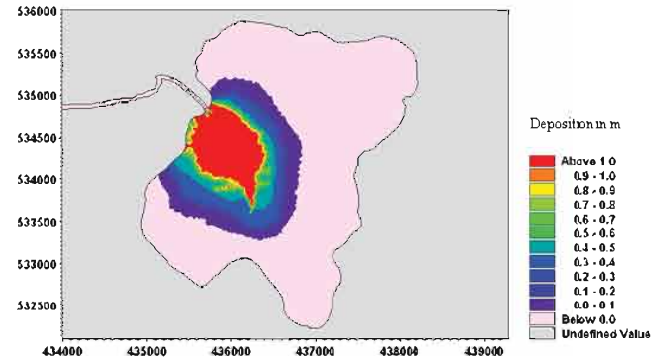

Fig 4: Simulated deposition pattern inside the tidal basin after second year

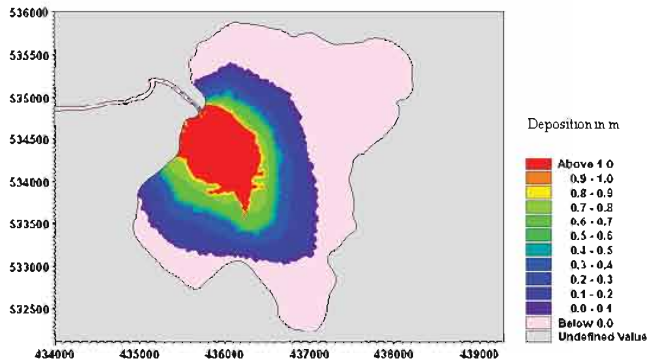

Fig 5: Simulated deposition pattern inside the tidal basin after third year

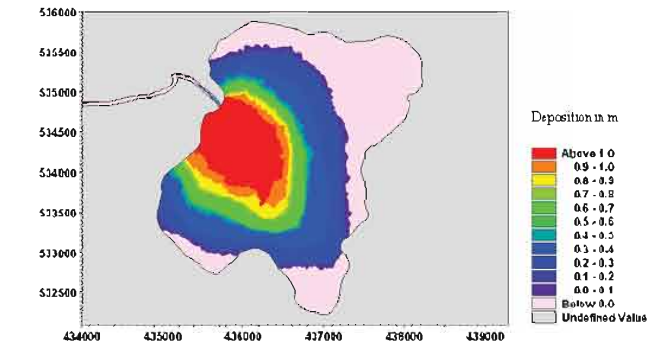

Fig 6: : Simulated deposition pattern inside the tidal basin after fourth year

Figure 3 to Figure 6 show simulated results after first, second, third and fourth year. In the simulated figures sediment deposition pattern and thickness of deposited sediment on bed of Beel Baruna are shown. Sediment deposition has been calculated from the change of bed topography from the base condition.

From the above simulated results shown in Figure3 to Figure 6, it can be seen that maximum sedimentation takes place at the mouth and near the mouth of the link canal. Thus in this way silt cannot spread out in the areas far away from the link canal. These figures also indicate a non-uniform sedimentation in the basin. Calculated deposition volume after first, second, third and fourth year are given in Table 1. Deposition volume for Beel Baruna tidal basin after simulation for the selected option has been calculated according to change of bed thickness from the base condition. Provision of dredging is considered for all of options.

Table 1: Deposited volume for the selected options

Deposition Volume in Mm^3			
At 12 months	At 24 months	At 36 months	At 48 months
0.68	1.22	1.76	2.28

From the simulated results and deposition of sediment, a plot of deposited area versus time has been prepared. The plot is prepared for three levels of deposition: net deposition greater than 0.50 m, net deposition greater than 0.80 m and net deposition greater than 1.0 m. Figure 7 shows time versus deposition area plots. It is seen from the plot that the deposition area covers 485 ha. All areas where the net deposition depth is greater than 0.5 m, 0.80 m and 1.0 m, continue to increase even at 48 months, from the inception of the operation.

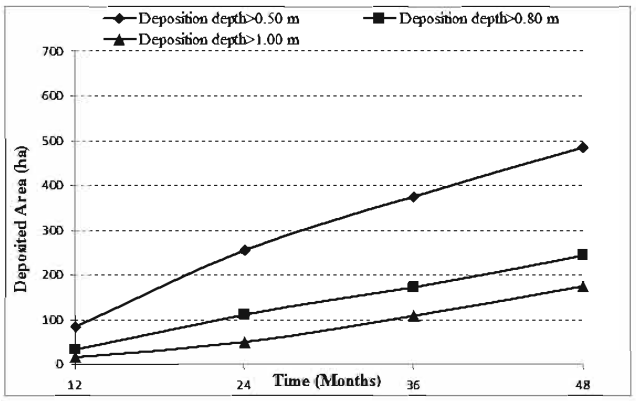

Fig 7: Deposited area with time

5.0 CONCLUSION AND RECOMMENDATIONS

The techniques of Tidal River Management (TRM) is a popular and proven process to solve water logging problems in the tidal river area having low lying beels or tidal basins. It is an effective process and has been applied in the Khulna-Jessore Drainage Rehabilitation Project (KJDRP) in South-West zone of Bangladesh. Uniformly raising the land inside a beel and maintaining proper drainage capacity of the river are the two main objectives of TRM. From the MIKE 21 simulation, it has been found that the sedimentation inside the beel is not uniform with the present TRM practice. Non uniform sedimentation inside the beel area makes the local people unwilling to allow their land for TRM operation. It can be seen from Figures 3 to 6 that sediment depth varies from nearly 0.01m to more than 1.0m. The deposition volume shows linear variation from 0.68Mm3 to 2.28Mm3 through the four consecutive years but the deposition pattern is non-uniform. The covered deposited area and the amount of sediment deposition are very less. The sediment deposition continues to increase even after four years in all areas. This has happened mainly due to technical problems and operational limitations during the TRM process. By considering all aspects it can be established that the current practice of TRM is not technically feasible in the study area. To solve this problem, a better functional technique for uniform and effective sedimentation inside the beel can be adopted to overcome the long term drainage conges tion and water logging problem

from the study area with the improvement of both social and environmental conditions.

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