SUSTAINABLE SEDIMENT MANAGEMENT IN A SELECTED BEEL IN SOUTH-WEST REGION OF BANGLADESH

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ABSTRACT

The southwest coastal region is highly vulnerable to erosion - siltation of river estuaries, water logging, coastal land subsidence and salt water intrusion etc. Excessive sedimentation by the incoming silts from the downstream sea with high tide adversely affect the river system of southwest region especially during the dry season. The Khulna-Jessore Drainage Rehabilitation project (KJDRP) is an example to mitigate water logging problems created by the coastal polders. It is of utmost importance to solve the drainage congestion and water logging problems in this area. A popular concept based on water management practice, known as Tidal River Management (TRM), which deals with natural tide movement in rivers, was adopted. From observation and monitoring of TRM processes inside East Beel Khukshia (EBK) and Beel Kedaria, it has been found that the sedimentation inside the tidal basins was not uniform and people were not satisfied to allow their land for TRM operations. So in order to find an effective as well as technically feasible TRM process, two management options have been analyzed in this paper by using MIKE 21 FM modelling simulation to verify the efficiency of these options for uniform sediment deposition. Beel Baruna was selected as a potential beel based on its location and operable area of tidal basin. In first option the beel has been divided into three compartments by constructing embankments and allowing sedimentation inside these compartments one after another by connecting to a river with an artificial link channel. Second one is constructing embankments along both banks of main khal through the beel and thereby allowing sedimentation by cutting the embankments part by part from upstream to downstream. Technical feasibility analysis of the two options have been performed through numrical modelling simulation. Non-uniform distribution of sediment was the major disadvantage of the current TRM practice. From mathmatical modelling simulation of two options, it is found that sediment distribution is more uniform in case of option 2. To the contrary, sediment deposition mainly takes place near the mouth of the link canal and volume of deposition is coparatively less in case of option 1. So option 2 is found more feasible to solve the water logging and drainage congestion problem and for proper sediment management in this area.

Keywords: *Southwest coastal region, Sedimentation, Tidal River Management (TRM), MIKE 21 FM.*

1. INTRODUCTION

Bangladesh has become one of the most climate vulnerable countries in the world due to climate change (BCCSAP, 2009, GermanWatch, 2011 and Islam et al., 2014). The coastal region in the southwest area of Bangladesh is considered to be maximum effected due to climate change. It will be directly affected by storm surges, drainage congestion, and sea level rise (Kibria, 2011 and Kibria et al., 2015). The problems of the southwest region including erosion - siltation of river estuaries, water logging, coastal land subsidence and salt water intrusion have become very severe (Islam et al., 2014). Salinity intrusion from the Bay of Bengal already penetrates 100 kilometers inland during the dry season (Huq et al., 2008).

The southwest region of Bangladesh is characterized by numerous morphologically active tidal rivers which form the main drainage network for coastal polders and low-lying beels (depressed land locally known as beels). The entire river network of this region is vulnerable to excessive sedimentation by the incoming silts from the Bay of Bengal with high tide especially during the dry season (Gain et al., 2017, Islam et al., 2014, IWM, 2010). The sedimentation effects of southwestern rivers and floodplain interventions were described by Sarker (2004). The reduction in flushing the fresh water flow from the upstream sources started to take place due to siltation up of the rivers in this region after the construction of coastal polders in the early 60s (Nowreen, 2014). To solve the long-standing water logging problems caused by such situation the KJDRP was implemented during 1994-2002 by BWDB (IWM, 2010). But this project could not solve the drainage problems effectively.

Later, a popular concept based on water management practice, known as Tidal River Management (TRM), was adopted. TRM deals with natural tide movement in rivers taking full advantage of the rise and fall of water within a tidal period. During flood tide, sediment borne tidal water is allowed to enter into an embanked low-lying area (tidal basin) where the sedimentation takes place during long storage period and thus acts as a sedimentation trap. During ebb tide, the water flows out of the tidal basin with greatly reduced sediment load eroding the downstream riverbed as well as increasing the drainage capacity. The natural movement of flood and ebb tide along the tidal basin and the surrounding river maintains a proper drainage capacity of the river in the above-mentioned way (Amir et al., 2013.).

TRM concept was practiced in Beel Bhaina and Beel Kedaria under Jessore and Khulna districts during 1997-2001 and 2002-2005, respectively (Figure 1). Beel Bhaina generated higher tidal volume inside its tidal basin than Beel Kedaria because of having higher tidal range compared to Beel Kedaria. The morphological changes of Teka-Hari River system due to closure of beel Kedaria tidal basin causes severe water logging in the Bhabodah and adjoining areas (IWM, 2007). Later on, operation of East Beel Khuksia for TRM was started in 2006 and monitoring results of East Beel Khukshia (EBK) TRM process showed that sedimentation inside the tidal basin was not uniform and people were not convinced to allow their land for TRM operation (IWM, 2010).

Local people allow their land to be used for TRM without any compensation, hoping that the land will rise after three or four years and they can cultivate more crops. But monitoring results of previous and present TRM practices revealed that sedimentation inside the tidal basin does not occur as expected almost in all cases. This results in people’s unwillingness to allow their land for TRM (Amir, 2010). So, these areas require further attention for satisfactory and uniform sedimentation inside the beels during and after the TRM process. In this paper, an attempt has been made to verify the technical feasibility of two sediment management options by a cohesive sediment transport model using MIKE21 FM modeling system of beel Baruna in Jessore area.

2. METHODOLOGY

The methodology of this research work is arranged in a systematic way which includes study area selection, data collection, identification of sediment management options and development of a sediment management transport model.

2.1 Selection of the Study Beel

The study beel area which is Beel Baruna 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 (Figure 1). Beel Baruna is a very potential beel for TRM considering its location and operable area of tidal basin (IWM, 2010). It is in the southwestern 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 a set of criteria devised in line with the objectives of the study and considerations of 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.

2.2 Secondary Data Collection

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

2.3 Identification of Management Options with Development of Model

Two options have been selected for sediment management inside the beel during TRM operation. In Option-1 sedimentation is allowed in the divided compartment of the beel one after another. In this option divided three compartments has been connected with three different link canals according to location of compartments. When one compartment has been allowed for sedimentation, other compartments have been remained closed. Thus, this option has been selected to fill up the beel by different link canals. In Option-2 an embankment has been constructed along both banks of main khal in the beel. Then a link canal has been constructed to connect with the river. In this process sedimentation has been allowed by cutting the embankment part by part, gradually from upstream to downstream. Thus, this option has been selected to fill up the beel from upstream distance area to near the mouth of link canal.

A two-dimensional sediment transport model has been developed using MIKE21 FM Modeling system and duly calibrated to know the sedimentation inside the beel. 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 of Hari River and simulated for the identified options. 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 of Beel Baruna for the model.

3. RESULTS AND DISCUSSIONS

3.1 Schematization of Identified Options

In option 1, the areas of the compartments have been calculated 211 ha, 258 ha and 246 ha for compartment A, B and C respectively. For this Option, Noimuddir Khal has been used as a link canal for compartment A, Deakula Khal has been used as a link canal for compartment B and Tungir Khal has been used as a link canal for compartment C (Figure 2). All link canals are connected with the Hari river. In Option-2, embankment has been constructed along both banks of main khal in the beel. Link canal has been constructed along Noimuddir khal. At first step, embankment has been constructed for a length of 3800 m and sedimentation has been allowed for the first year. Then the embankment has been removed for 1000 m and sedimentation has been allowed for the second year. Similarly, in the third year the length of the embankment has been become as 1800 m and there was no embankment in the fourth year. Finally, sedimentation in the last year has been occurred as no embankment condition. Step by step construction of embankment with schematization for Option-2 are shown in Figure 2.

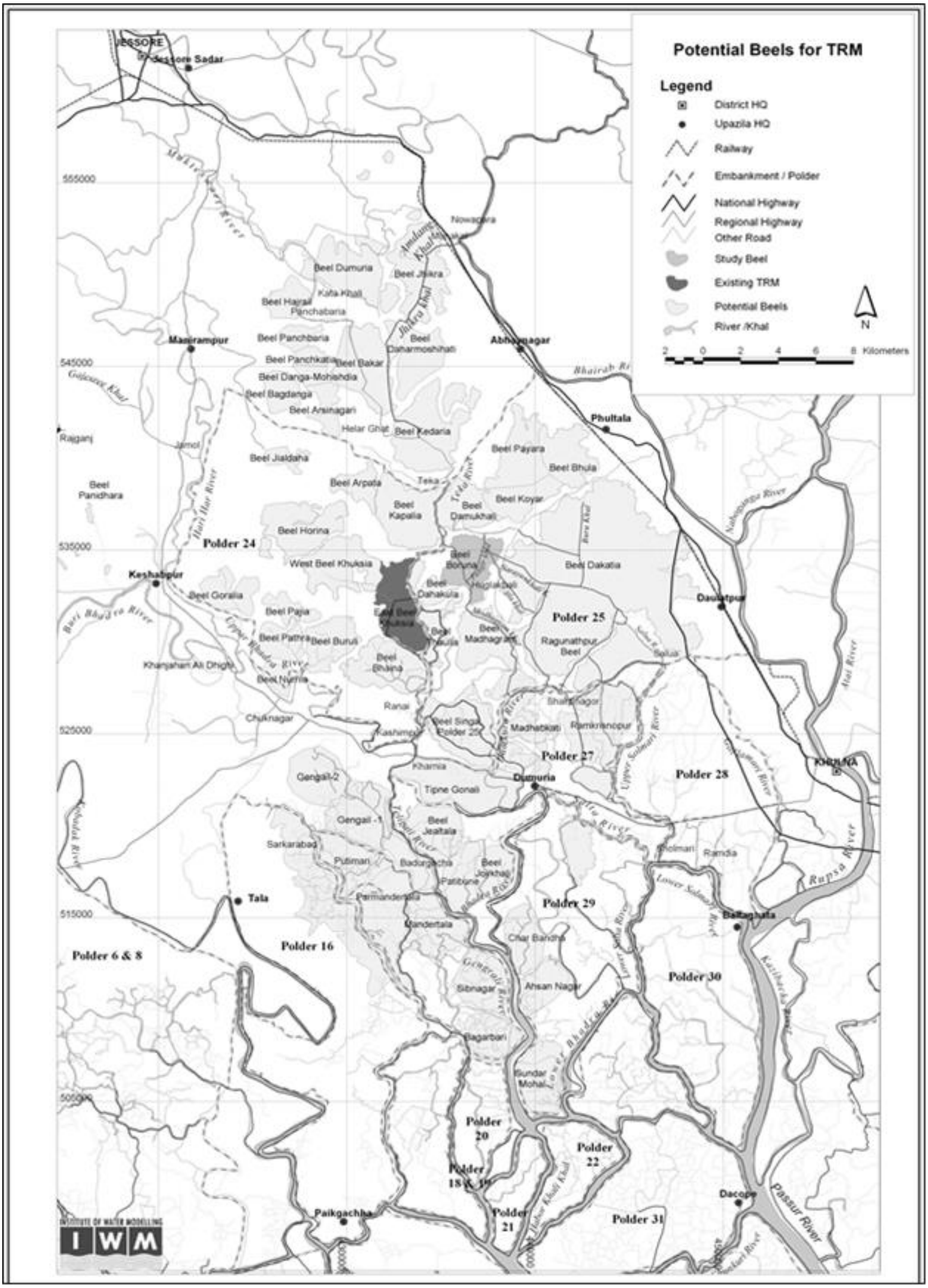
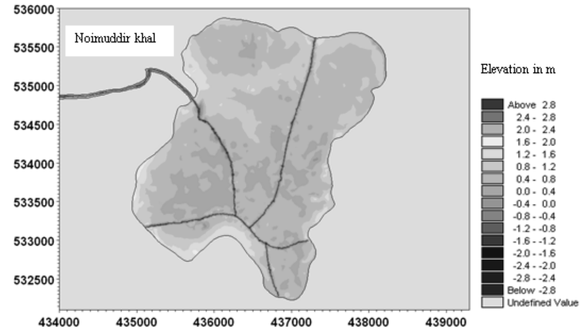
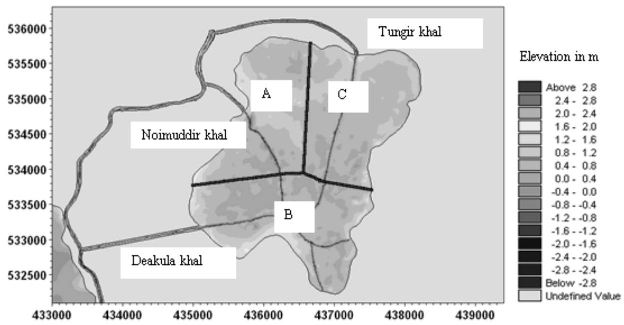


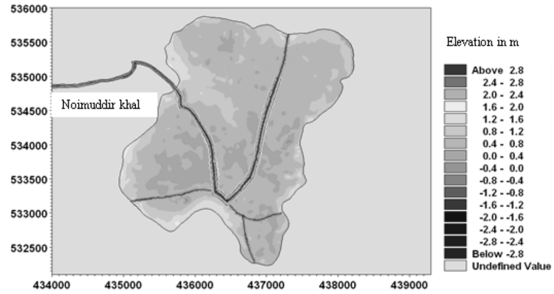
Figure: 1: Location Map of the study area (Source: IWM, 2010)



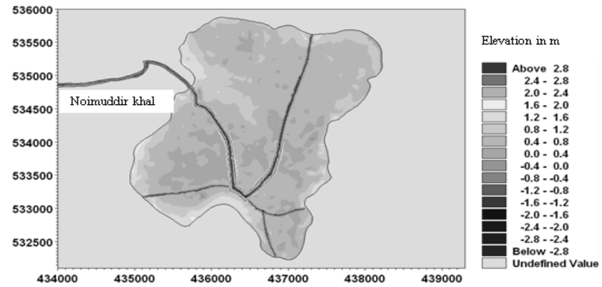
Base condition



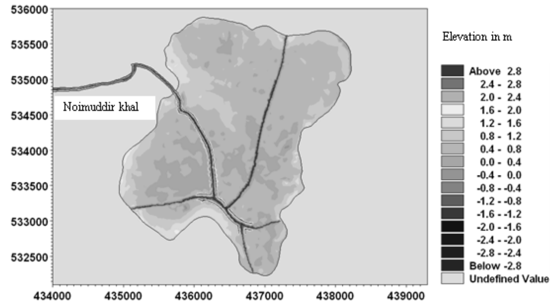
Option 1



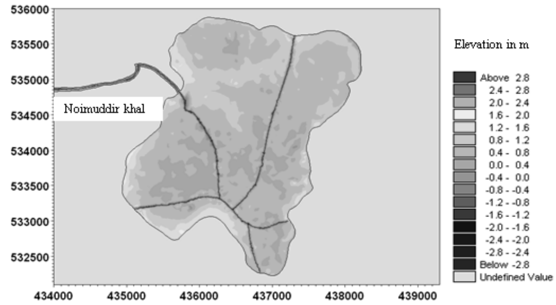
Option 2 with 3800 m embankment



Option 2 with 2800 m embankment



Option 2 with 1800 m embankment



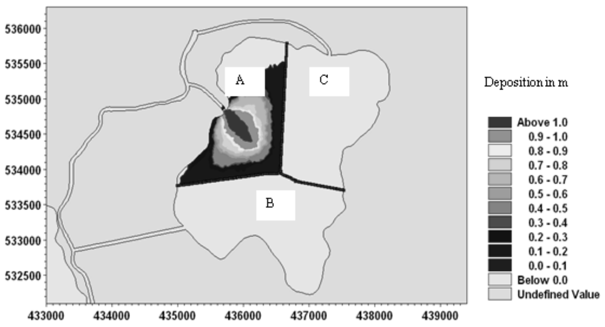
Option 2 with no embankment

Figure 2: Schematization of Beel Baruna for options 1 & 2

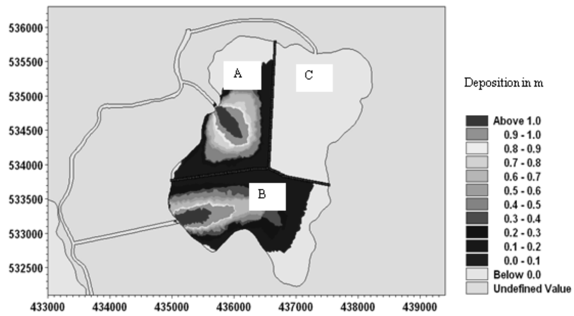
3.2 Analysis of Results from Option Simulation of Beel Baruna

After set up and calibration of the model, it has been simulated for the selected two options to find the most feasible option for sediment management and uniform deposition of the beel. The cohesive sediment transport model has been simulated for four years. Continuous 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 with respect to base condition.

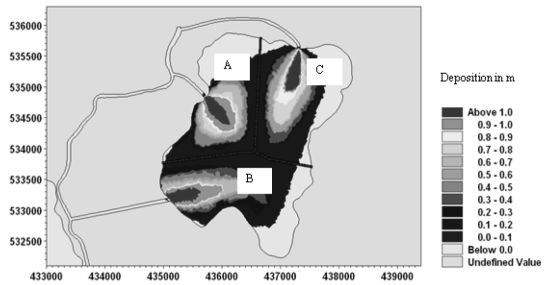
Simulated results for option 1 & 2 have been presented in Figure 3 for consecutive 4 years.



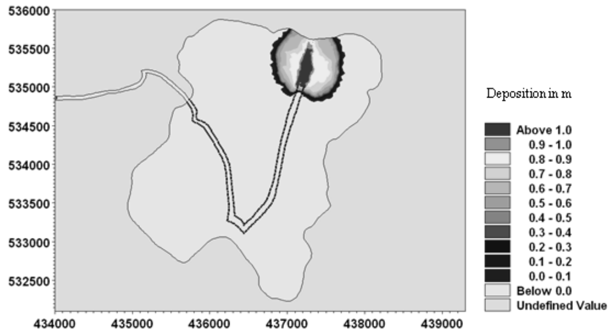
Option 1 (0-16 months); A is in operation,B & C closed



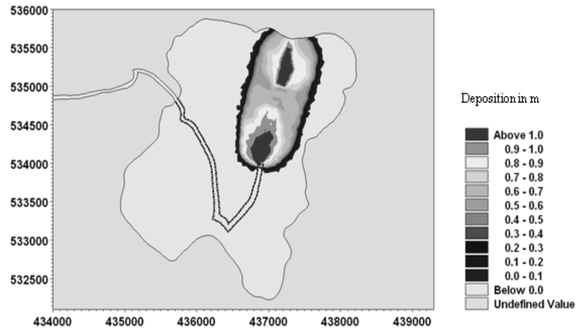
Option 1 (17-32 months); B is in operation, A & C closed



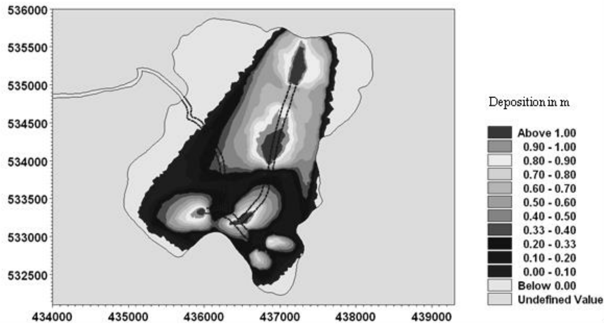
Option 1 (33-48 months); C is in operation, A & B closed



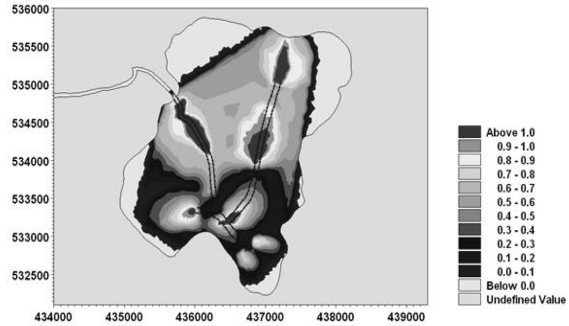
Option 2 after 1st year with embankment length 3800 m



Option 2 after 2nd year with embankment length 2800 m



Option 2 after 3rd year with embankment length 1800 m



Option 2 after 4th year with no embankment

Figure 3: Simulated deposition pattern inside the tidal basin for option 1& 2 for 4 years

From the above simulated results, for option 1 it is seen that most sedimentation takes place at the mouth or near the mouth of the link canal and sediment distribution is not uniform. Thus, in this way silt cannot spread out in the areas far away from the link canal and also results in a non-uniform sedimentation in the basin. From the simulated results of options 2, it is seen that after fourth year simulation sediment spreads comparatively uniform and almost the whole area of the beel.

3.3 Deposition Volume

Deposition volume for Beel Baruna tidal basin after options simulation for the selected two options have been calculated according to change of bed thickness from the base condition. Provision of dredging is considered for all of options. Estimated deposition volume for Option-1 and Option-2 are shown in Table 1. More deposition is observed for Option-2 for the study beel.

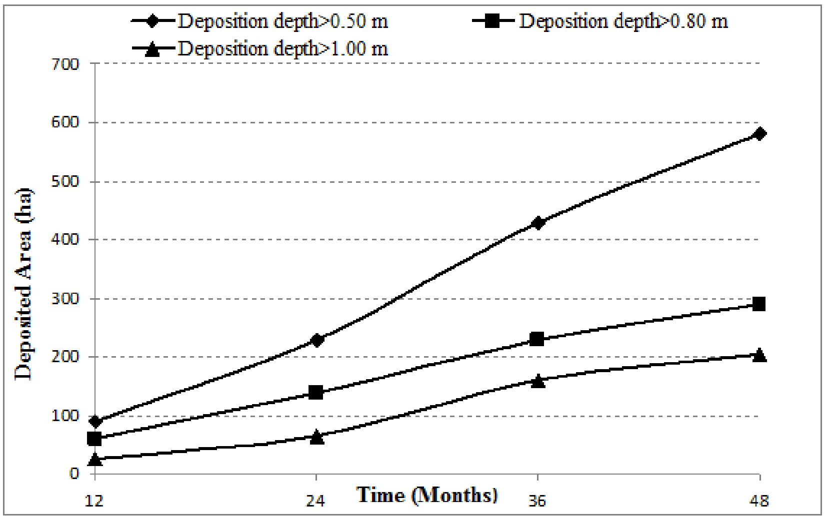
Table 1: Deposited volume for the selected two options

Option	**Deposition Volume in Mm^3**			
1	After 16 months in Compartment-A	From 17-32 months in Compartment-B	From 33-48 months in Compartment-C	After 48 months in Compartments-A, B & C
	0.82	1.11	1.04	2.97
2	After 12 months	After 24 months	After 36 months	After 48 months
	0.52	1.26	2.42	3.12

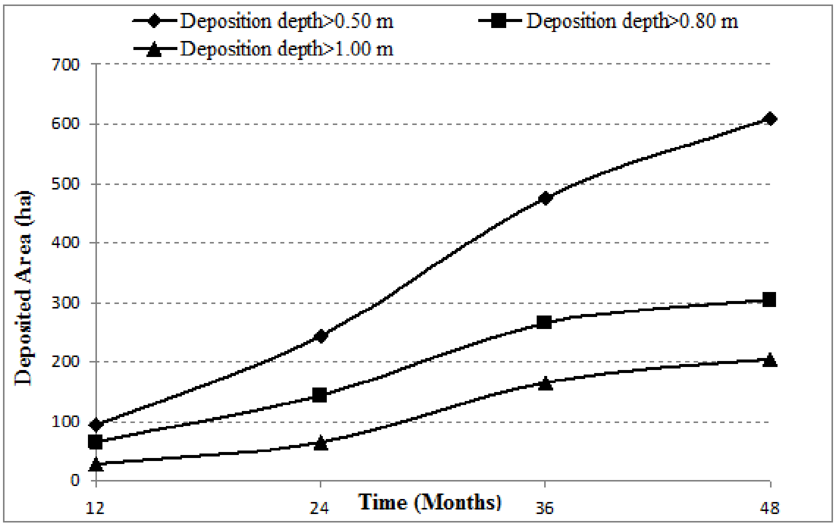
3.4 Deposition Area

From the simulated results and deposition of sediment, two plots of deposited area versus time have been prepared for the two options (Figure 4). The plots are prepared for three level 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 4 show time versus deposition area plots for Option-1 & Option-2 respectively. It is seen from the plots that more deposition area (610 ha) covers for Option-2 comparing with the area (585ha) for Option-1.

Plots for Option-2 shows that for deposition depth greater than 0.80 m and 1.0 m, sediment deposition does not increase significantly after almost 36 months. But further deposition will occur under 48 months in areas where the net deposition depth is greater than 0.5 m.



Option 1



Option 2

Figure 4: Deposited area plot for Option 1 & 2

4. CONCLUSIONS

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 which has been simulated in this research paper for two different options in Beel Baruna. It has been found from the simulations of different options that sediment deposition inside the beel is not uniform in the present TRM practices which will make people unwilling to allow their land for TRM operation. Maximum deposition volume and area are found for Option-2 and comparatively less deposition area and volume are found for Option-1. Sediment deposition is more uniform in Option-2. So, in technical consideration, it appears that Option-2 is preferred in the area.

ACKNOWLEDGEMENTS

The author is highly grateful to Prof. Dr. M Monowar Hossain, Executive Director, Institute of Water Modelling for providing necessary supports to conduct the mathematical modelling simulation using MIKE software packages. The author is also grateful to Md. Zahirul Haque Khan, Director, Coast Port and Estuary Management Division, IWM and Md. Mobassarul Hasan, Associate Specialist, CPE, IWM for providing valuable guidelines related to numerical simulation throughout the study period.

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