

Hydrodynamic and Morphological Response to Dredging: Analysis on Gorai River of Bangladesh

Afeefa Rahman¹, Dr Anika Yunus²Graduate Student, Department of Water Resources Engineering, Bangladesh University of Engineering and
Technology, Dhaka, Bangladesh¹Associate Professor, Department of Water Resources Engineering, Bangladesh University of Engineering and
Technology, Dhaka, Bangladesh²

ABSTRACT: Being a principal distributary of the Ganges River, Gorai is the main source of fresh water within the Bengal Delta area. Owing to the reduction of upstream water flow after construction of Farakka Barrage, huge amount of sediment loads are settling down on Gorai river bed, hindering the safe passage of flow which contributes to the change in hydrodynamic and morphological characteristics of the river. In this study work, the hydrodynamic, morphological and salinity parameters of the river Gorai has been investigated on the basis of dredging with the help of Delft 3D flow module. A 25 km reach of the Gorai River, 5 km downstream from the off-take was selected for the analysis. Simulation was performed with three different dredge section that varied in base width, depth and side slope. The simulated parameters were compared before and after dredging to assess the functionality of each dredged bathymetry. It was found that for the deeper dredging having a base width of 200 m, side slope of 1:20 and depth of 13 m hydrodynamic performance, specifically, flow augmentation is maximum (9.632%) with a hint of increased instability and greater expense. The deepest dredging strategy can be defined as the most efficient section having velocity increase by 9.82%, water level decrease by 14.98%, total sediment transport increase by 5.5%, erosion increase by 2.6%, deposition decrease by 4.53%, chloride concentration decrease by 3.42%. It is hoped that this study will help the river regulation authority to undertake appropriate future developments projects for the river restoration.

KEYWORDS: Gorai River, dredging strategy, Delft3D, Flow augmentation.

I. INTRODUCTION

From the time immemorial, rivers have played a significant role in forming the life line for the country, Bangladesh, which recently is facing problems due to natural and anthropogenic reasons. In general, diversion of river flow in the upstream, salinity intrusion, excessive sedimentation causing disturbance in navigability and flooding are the major problems relating to rivers in our country [1]. Most rivers in south-western region (SWR) of Bangladesh depend on water flow from the Ganges, a mighty trans-boundary river. Many of the branches of Ganges are blocked off from it due to water intake at upstream of Farakka Barrage built in 1975. Thus the flow volume of Ganges river declines during the dry-season that affects the development-abandonment process of its distributaries, thus impact the region including coastal zones and Sundarbans. [2] [3].

Gorai River is the major distributary of the Ganges River in the right bank and a main source of freshwater within the Bengal Delta area having a catchment area of 15160 km² and located between 21° 30' N to 24° 0' N latitude and 89° 0' E to 90° 0' E longitude, covering partly or fully areas of Pabna, Chuadanga, Kushtia, Rajbari, Faridpur, Gopalganj, Jessore, Jhenaidah, Magura, Norail, Pirogpur, Borguna, Bagerhat, Khulna and Sathkhira districts of south western region of Bangladesh [4]. The river takes off from the Ganges at Talbaria, north of Kushtia town and 19km

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

downstream from the Hardinge bridge and discharges into the Bay of Bengal through the Madhumati and Baleswar Rivers [5]. Implementation of the Farakka Barrage results in reduction of flow through the Gorai River and deposition started ensuing in the off-take. As a result, two types of environmental impacts have been created in the Gorai catchment area [6]. The sediment particles are settling down on the river bed rapidly, which is one of the major problems of Gorai River morphology. On the other hand the saline sea water is pushed up in the upstream area due to capillary upward movement. As the Gorai is the main lifeline of Southwestern Bangladesh dredging efforts can be taken to de-silt its off-take and the upper reach to augment the flow coming from the Ganges River [7].

Dredging operations involve the removal of bed material and associated vegetation from a river channel with an objective of increasing the river channel capacity and its ability to convey water [8]. The exact ramifications of river dredging upon river hydrology and geomorphology is a function of the river topology, sediment characteristics, the dredging technique employed, existing floodplain connectivity and antecedent environmental conditions. Channels which have been deepened by dredging silt-up more frequently as they return to their pre-dredged state leaving an impact on river discharge, flow velocity, water level and channel bed erosion-deposition [9]. In this study, realizing the importance of rivers in Bangladesh in general and understanding the predicament of river Gorai in particular, efforts have been ensued to address analyses on hydrodynamic, morphological and salinity parameters of the river Gorai with respect to dredging as a part of solution of sediment problems and flow augmentation. Hydrodynamic parameters including discharge, velocity and water level, morphological parameters including total sediment transport, cumulative erosion-deposition and chloride concentration as the salinity measuring parameter were compared before and after dredging and portrayed in the graphs and charts. Physics-based nonlinear morpho-dynamic model Delft3D of version 3.28.50.01 was used as a modeling tool to develop the scenarios.

II. RELATED WORK

Being an important water course for Bangladesh, Gorai River has drawn attention of different national and international researchers. Islam and Karim (2001), Clijncke (2001) and Sarker (2002) tried to predict the downstream hydraulic geometry of the Gorai river and morphological changes due to dredging and morphological changes in response to the declining flow respectively [10] [11] [12]. Islam and Gnauck (2012) studied on water shortage in the Gorai river basin and damage of mangrove wetland ecosystem in Sundarbans [13]. Shamsad, Islam, Mahmud and Hakim (2014) studied on "Surface water quality of Gorai river of Bangladesh" in which some important characteristics of water quality of Gorai river system were evaluated [14]. Horeet (2013) focused in his study on the morphological development of Gorai river off-take for the restoration of the river flow. Several modeling studies have been conducted to understand the river behavior. Biswas and Ahammed studied on hydrodynamic characteristics of the river Gorai using CCHE 2D [15]. Kader (2000) studied on effectiveness of pilot dredging in the Gorai River which depicts effectiveness of the pilot dredging on the basis of pre and post dredging bathymetry using MIKE21C [16].

III. METHODOLOGY

To conduct the analysis first of all cross section data for the year 2009-2010, time series discharge data at the Gorai Railway Bridge (SW-99), Water level data at Kamarkhali (SW-101) and Kamarkhali transit (SW-101.5) have been collected from Bangladesh Water Development Board (BWDB) and Water Resources planning organization (WARPO) with a view to set up a model of the study area.

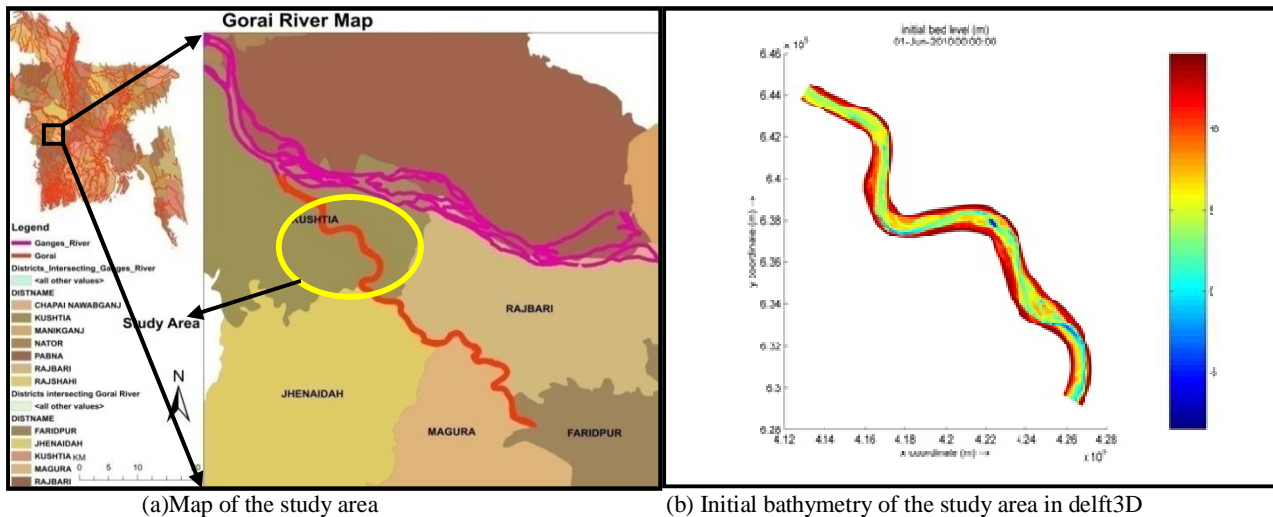


Figure 1: Map of the study area and the initial bathymetry of the model

The study area covers about 25 km reach of the Gorai River flowing from 10km downstream from the Ganges-Gorai off-take within the kushtia district to the 5 km upstream of the Kamarkhali transit within the Kamarkhali sub-district. Figure 1 shows the Google map of the study area and initial bathymetry after the model setup in Delft3D. A numerical model was simulated for 25 km long River reach with an average width of 800 m; started from 6 km downstream from the Ganges-Gorai off-take and ended at the Kamarkhali transit. The reach was discretized by 720*36(m*n) grid cells. After developing the study area with good quality grids, collected cross section data were processed to prepare sample and were imported into the mesh nodes, afterwards it has been interpolated and diffused using triangular interpolation and internal diffusion toolbars to obtain a spatially varying depth file.

After preparing the river bathymetry calibration of the model has been done using the setup of model from 1st of June, 2010 to 31st of August, 2010 and the model was verified for the hydraulic condition of the rest part of the year ranging from 1st of September to 30th of November. Manning's roughness coefficient has been adjusted after several trial of the model during calibration to an average value of $n = 0.025$. The value of eddy viscosity has been considered as 10.0 m²/s. Then the model has been validated at the Kamarkhali for the period 1st of September to 30th of November that shows a good agreement with the observed data. After completing the calibration and validation of the model, Delft3D Flow and the DELFT 2D-MOR module have been used for morphological simulation and salinity modeling for the year 2010 with the original bathymetry (Initial bathymetry of April 2010 has been taken as base for simulation). Mean sediment diameter (D50) has been assumed as 0.150 mm and as the sediment boundary the monthly average sediment data for the year 2010 was given as the input. Morphological scale factor (Morfac) has been taken as the calibration parameter and sensitivity analysis was done using the combination of the Manning's n and Morfac (1, 5 and 10) which shows that Morfac= 10 produces mediocre results.

Selected hydrodynamic, morphological and salinity parameters have been recorded and after simulation of parameters with existing bathymetry, 3 different dredge section has been individually inserted. Length of the river to be dredged is from the Gorai railway bridge to the Kamarkhali 25km with an average width of 600m as obtained from the bathymetry data. Configurations for the 3 proposed dredged sections are as follows. Figure 2 shows the pattern of proposed dredging sections comparing with the virgin bathymetry condition.

1. **Strategy1:** Base width of around 200m with side slopes of 1:20 and 13 m deep from the side banks(deeper dredging)
2. **Strategy2:** Base width of around 150m with side slopes of 1:15 and 12.5 m deep from the side banks
3. **Strategy3:** Base width of around 100m with side slopes of 1:10 and 12.0 m from the side banks(shallower dredging)

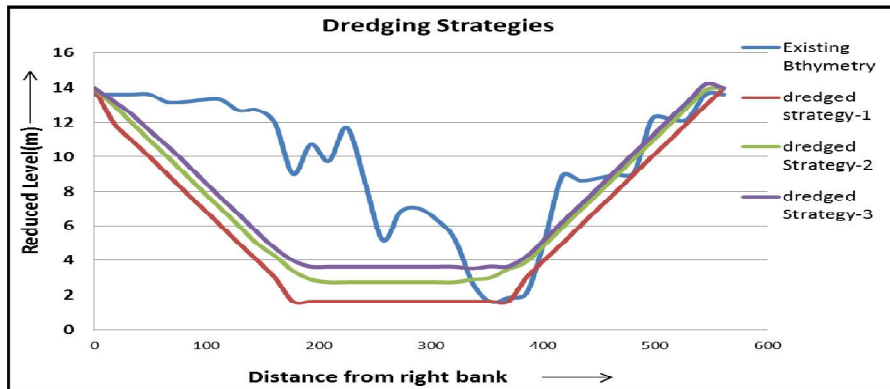
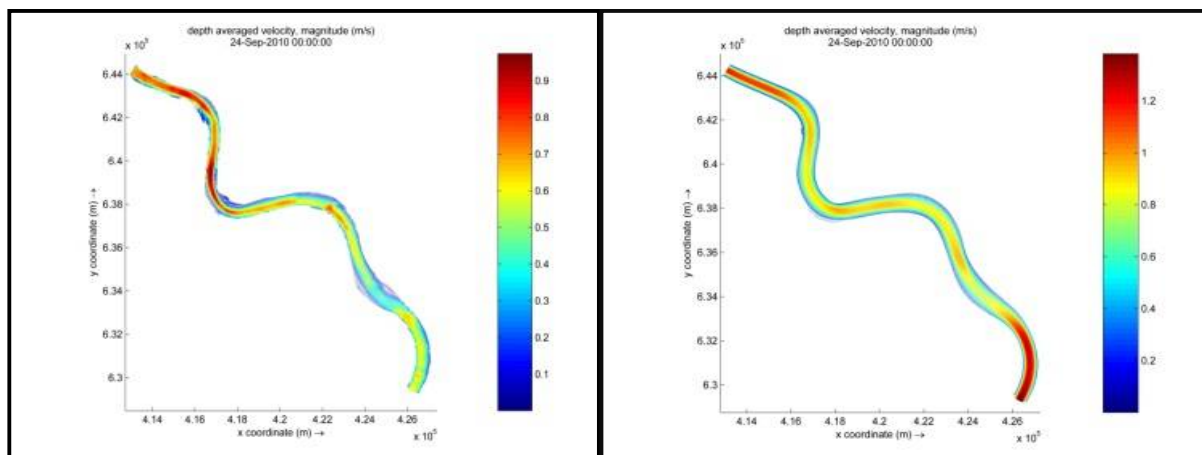


Figure 2: Three Different Dredging section comparing with the original bathymetry

IV. EXPERIMENTAL RESULTS AND ANALYSIS

A dredging strategy remarkably alters the bathymetry. It induces a change in flow parameters. As the river bed deepens by dredging, it provides a more smooth passage for the flow. Seasonal variation in the flow volume also causes a change in the velocity time to time. The Figure 3 (a), 3(b) show the comparison of depth average velocity of the study reach of the river for the conditions of pre and post dredging option 1 during the wet season. It can be visualized from that during both the wet and dry season for the year 2010 there is a higher velocity of flow in the main channels and flood plains in case of dredged bathymetry. The velocity in the main channel is obviously greater than the velocity in the side channels.

During the wet season flow velocity throughout the study reach varies from 0.3 m/s-0.9 m/s in case of original depth profile whereas the range of velocity increases to 0.4 m/s-1.1 m/s in dredged bathymetry. During the lean period flow velocity falls within the range of 0.06 m/s-0.16 m/s that increases to 0.30 m/s to 0.65m/s in dredged bathymetry. To compare the velocity before and after dredging option 1, simulated velocities in both the cases at the previously set up monitoring points (points named bend-1 to bend-5 at an approximately uniform interval of 5 km) have been exported as time series data and averaged to obtain the mean velocity for the study area for the year 2010. Figure 4 shows the comparison of velocity at the virgin and modified condition due to installation of dredging option 1. Similar observations have been made for the second and third available dredging options and for both dry and wet period.



(a) Velocity at Pre-dredging condition (b) Velocity at Post-dredging condition

Figure 3: Depth average velocity during wet season

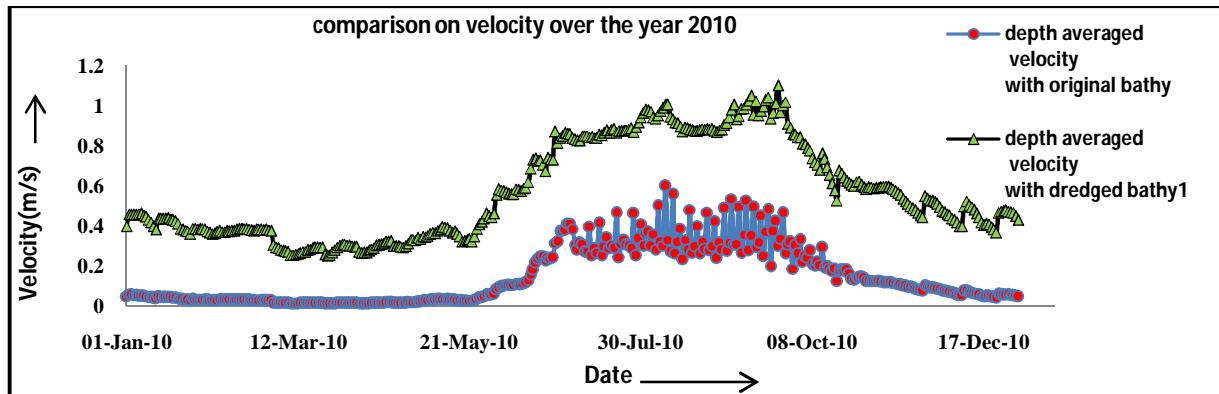


Figure 4: Velocity Profile before and after dredging option 1

As the flow velocity increases due to dredging, it induces an increase in discharge along the study reach that augments both the dry and wet season flow. Plotting of the depth averaged unit discharge during wet season and dry season before and after dredging shows that the depth averaged discharge in wet season for original depth profile ranges upto $9-10 \text{ m}^2/\text{s}$ whereas the value increases to $12 \text{ m}^2/\text{s}$ for dredging option 1 during peak flow. It can also be shown that during the lean flow, dredged bathymetry induces a significant increase in depth average discharge, without dredging discharge is around $0.4 \text{ m}^2/\text{s}$ to $1 \text{ m}^2/\text{s}$ and post dredging work the value boosts up to $0.70 \text{ m}^2/\text{s}$ to $1.2 \text{ m}^2/\text{s}$. To compare the instantaneous discharge in m^3/s before and after dredging, simulated discharges in both the cases at the monitoring points have been exported as time series data and averaged to obtain the mean values for the study area for the year 2010. Similar observations have been made for the second and third available dredging options.

As dredging result in narrowing and deepening of the channel, the still water level drops. The effect of dredging on the water surface elevation of the study reach of the river Gorai in both dry and wet seasons have also been recorded. It can be visualized that during both the wet and dry season for the year 2010 there is lower water depth in the main channel in case of dredged bathymetry comparing with the original depth profile. Due to dredging, channel navigability increases contributing more water flow through the main channel, thus the water level drops in both the main channel and in flood plain in the case of dredging. To compare the water level throughout the year 2010 before and after dredging option 1, simulated water levels in both the cases at the previously set up monitoring points have been exported as time series data and averaged to obtain the mean value. Similar observations have been made for the second and third available dredging options.

Sediment transport capacity of the river is responsible for the morphological changes induced by erosion-deposition. If discharge is higher it produces greater velocities as well as carries huge amount of sediment and there by increases the sediment transport capacities of the river. The sediments are deposited in where the velocity is low. As a result the bed level of the channel rises. Comparison of sediment transport at pre and post dredging work shows that the sediment transport rate can be considerably enhanced by dredging. It is evident from the analysis that in case of natural bathymetry, erosion occurs along the deepest channel (thalweg) and the deposition of sediment occurs near the bank lines. On an average cumulative erosion of the deep channel within the study area ranges from 0.05m to 0.10m and the sedimentation of the sides of the channel ranges from 0.20m to 0.25m . On the other hand in dredged channel the cumulative erosion and deposition along the thalweg and channel sides lies below 0.03 m . During the dry period of the year 2010 (mostly in January) change in cumulative sediment deposition along the study reach is minor due to very less discharge. As in dredged bathymetry discharge increases sediment deposition decreases and erosion along the reach increases. It is evident from the analyses of velocities and cumulative erosion and deposition that the zones with higher velocity carry more sediment than the other zones. Similar observations have been made for the second and third available dredging options.

During lean flow period salinity in terms of chloride concentration in ppt along the study reach of river Gorai varies

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

from 0.179 ppt to 0.18 ppt. In response to dredging concentration decreases to a slight extent and varies from 0.179 ppt to 0.1795 ppt along the reach. During the wet period mostly in months of peak flow (September), both case of original and dredged bathymetry shows salinity concentration below 0.17 ppt and does not vary considerably along the reach. To compare the chloride concentration before and after dredging option 1, simulated values in both the cases at the previously set up monitoring points have been exported as time series data and averaged to obtain the mean concentration for the study area for the year 2010. Similar observations have been made for the dredging option 2 and option 3. The percentage variation of average monthly velocity, discharge, water level, sediment transport rate and chloride concentration (salinity) for the dredging option 1 comparing with the original bathymetry can be tabulated as shown in **TABLE I** for better visualization. Positive percentage indicates increase and negative percentage depicts the decrease of the corresponding parameter. Dredging option 2 and 3 have produced similar changing pattern of the hydrodynamic and morphologic parameters. The percentage variation of average monthly velocity, discharge, water level, sediment transport rate and chloride concentration (salinity) for the dredging option 1 comparing with the original bathymetry can be tabulated as follows in **TABLE II** and **TABLE III**.

TABLE I: Percentage Change of Hydrodynamic, Morphological and Salinity Parameters due to Dredging Option 1

Months	Velocity (%)	Discharge (%)	Water level (%)	Total sediment transport (%)	Cumulative Erosion (%)	Cumulative Sedimentation (%)	Cl ₂ Conc (%)
Jan	8.67	6.24	-11.37	5.13	2.961	-4.961	-2.308
Feb	11.03	6.04	-11.77	5.09	2.876	-4.876	-2.184
Mar	10.19	6.44	-13.30	4.97	2.453	-4.453	-2.361
Apr	9.17	6.89	-13.23	4.78	2.342	-4.342	-2.997
May	9.84	8.38	-14.98	4.92	2.321	-4.321	-3.021
Jun	9.59	8.61	-14.17	5.01	2.211	-4.211	-3.188
Jul	9.37	9.81	-14.76	5.16	2.01	-3.91	-3.219
Aug	9.17	10.73	-15.21	5.21	1.71	-3.716	-3.332
Sep	13.39	10.63	-15.78	5.9	1.333	-3.333	-3.765
Oct	7.56	6.55	-14.08	6.03	2.161	-3.361	-3.969
Nov	4.25	6.40	-13.68	5.87	2.11	-4.11	-2.81
Dec	6.56	6.25	-13.38	5.31	2.76	-4.76	-2.706

TABLE II: Percentage Change of Hydrodynamic, Morphological and Salinity Parameters due to Dredging Option 2

Months	Velocity (%)	Discharge (%)	Water level (%)	Total sediment transport (%)	Cumulative Erosion (%)	Cumulative Sedimentation (%)	Cl ₂ Conc. (%)
Jan	6.76	4.65	-9.07	3.67	2.091	-4.091	-1.828
Feb	9.39	4.48	-9.7	3.58	2.046	-4.046	-1.774
Mar	8.44	4.81	-10.77	3.51	1.523	-3.523	-1.901
Apr	7.26	5.13	-10.82	3.25	1.532	-3.532	-2.607
May	8.11	6.47	-12.89	3.47	1.361	-3.361	-2.551
Jun	7.88	6.97	-12.02	3.49	1.451	-3.451	-2.838
Jul	7.4	8.06	-12.28	3.71	1.14	-3.04	-2.829
Aug	7.52	9.02	-13.15	3.71	0.88	-2.886	-2.912
Sep	11.8	8.66	-13.06	4.47	0.403	-2.403	-3.295
Oct	6	4.9	-11.29	4.52	1.351	-2.551	-3.549
Nov	2.62	4.49	-11.38	4.48	1.15	-3.15	-2.32
Dec	4.8	4.52	-11.33	3.88	2.13	-4	-2.296

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

TABLE III:Percentage Change of Hydrodynamic, Morphological & Salinity Parameters due to Dredging Option 3

Months	Velocity (%)	Discharge (%)	Water level (%)	Total sediment transport (%)	Cumulative Erosion (%)	Cumulative Sedimentation (%)	Cl ₂ Conc (%)
Jan	5.17	3.06	-6.59	2.41	1.221	-3.221	-1.408
Feb	7.83	2.92	-6.98	2.3	1.216	-3.216	-1.304
Mar	6.81	3.18	-9	2.67	0.593	-2.593	-1.481
Apr	5.5	3.37	-9.18	2.73	0.722	-2.722	-2.117
May	6.2	4.56	-10.68	2.62	0.401	-2.401	-2.141
Jun	6.24	5.33	-10.01	2.94	0.691	-2.691	-2.358
Jul	5.65	6.31	-10.23	2.63	0.27	-2.17	-2.419
Aug	5.81	7.31	-10.8	2.8	0.05	-2.056	-2.452
Sep	9.83	6.69	-11.69	3.81	0.527	-1.473	-2.905
Oct	4.35	3.25	-9.93	3.88	0.541	-1.741	-3.079
Nov	0.71	2.58	-9.2	3.39	0.19	-2.19	-1.97
Dec	3.07	2.79	-9.32	3.25	1.37	-3.24	-1.906

Analysis on Efficiency of Dredging Strategies

A comparative analysis has been performed to identify the most efficient dredging strategy among the proposed three. For the attainment of the objective obtained percentage variation of river flow velocity, discharge, water level, total sediment transport, cumulative erosion, cumulative sedimentation and chloride concentration for the year 2010 have been averaged to obtain the percentage variation for both the dry and wet period. Percentage increase in flow velocity through the study reach of Gorai for the 3 proposed dredging option during dry period were obtained as 8.312%, 6.473% and 6.328% respectively, corresponding percentage increase during wet season are 9.816%, 7.068 and 6.647% respectively showing the fact that increase in velocity of flow is maximum in case of the dredging strategy-1 as the proposed section of the dredging strategy-1 is of greater depth and of steeper slope thus helps to divert more flow through the channel at the same time instant comparing with the other two. Percentage increase in flow discharge through the study reach of Gorai river for the 3 proposed dredging option during dry period were obtained as 6.403%, 4.768% and 3.418% respectively, corresponding percentage increase during wet season are 9.632%, 7.836 and 6.77% respectively highlighting the fact that increase in discharge is the highest in case of the dredging option 1 due to greater flow velocity throughout the reach. Figure 5 shows the seasonal variation of % increase for 3 dredging options in case of discharge and velocity

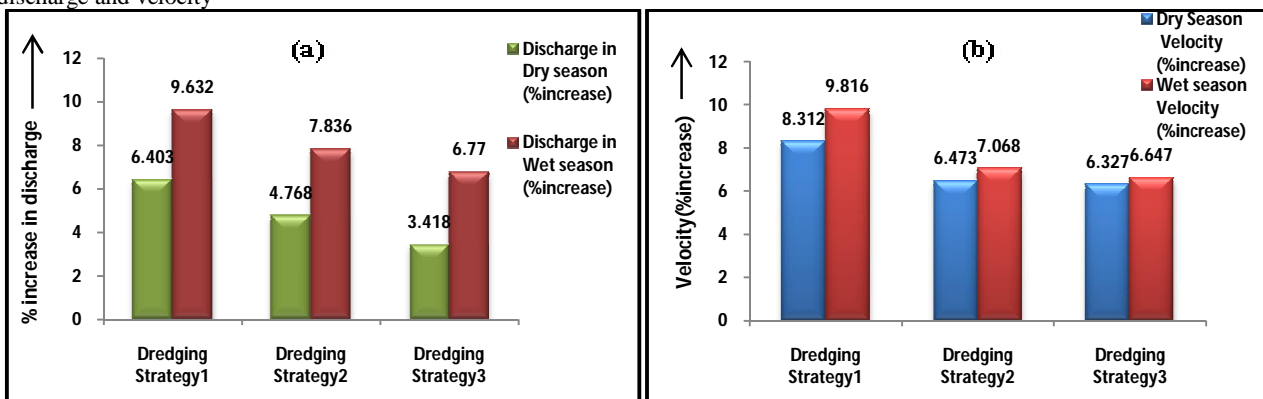


Figure 5: Seasonal variation of % increase for 3 dredging options (a) Discharge (b) Velocity

Percentage decrease in water surface elevation showed the similar result as obtained in case of velocity and discharge due to the fact that dredging results in narrowing and deepening of the river; the greater is the dredging, the lower will

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

be the water depth. Due to the effect of dredging river becomes more efficient in transporting sediments that is with same discharge more sediment can be transported as the deeper dredging induces more flow through a cross section sediment transport rate also increases in deeper dredged channel. Erosion in the main channel and side banks are increased in dredged bathymetry as the dredged river depth is less stable than the natural course. The steeper the side slope the more will be the erosion. That is why in case of dredging option 1, the cumulative erosion is maximum. Percentage increase in cumulative erosion through the study reach of Gorai river for the 3 proposed dredging strategies during dry period were obtained as 1.69%, 2.069% and 0.10% respectively, corresponding percentage during wet season are 2.591%, 2.069% and 0.938 % respectively. Percentage decrease in cumulative sedimentation through the study reach during dry period were obtained as 3.47%, 2.998% and 1.865% respectively, corresponding percentage during wet season are 4.527%, 3.798% and 2.938 % respectively. Salinity concentration decreases in dredged bathymetry due to greater flow discharge and velocity. The greater the dredged depth the higher the reduction in concentration with the values obtained as 2.463 and 3.416% during dry and wet season respectively.

V. CONCLUSION

In this study work, the hydrodynamic, morphological and salinity parameters of the river Gorai has been investigated in which Delft 3D module was used for development, calibration, validation, analyzing and comparing the simulated and the observed data sets using Manning's n and Morfac functioning as the calibration parameters. The simulated parameters were compared before and after dredging to assess the functionality of each dredged bathymetry. It was found that for the deeper dredging having 200 m base width, side slope is approximately 1:20 and depth of 13 m hydrodynamic performance, specifically, flow augmentation is maximum (9.632%) with a hint of increased instability and cost of dredging. Thus the deepest dredging strategy can be defined as the most efficient section for the augment of flow in upper reach of Gorai river.

REFERENCES

- [1] FAP24, 1994. Study report No. 3: "Morphological studies phase 1", Available data and characteristics. FAP24, Dhaka, Bangladesh
- [2] Horeet.al, "Study of the off-take dynamics for restoring the Gorai River", 4th International conference on Water and Flood Management, 2013.
- [3] Banglapedia, 2014; link: http://en.banglapedia.org/index.php?title=Gorai-Madhumati_River
- [4] BWDB, 2011. "Bangladesh er Nod-Nodi", Bangladesh Water Development Board (BWDB), Dhaka, Bangladesh
- [5] Islam S.N and Gnauck A, "Water Shortage in the Gorai River basin and Damage of Mangrove Forest Wetland Ecosystems in Sundarbans, Bangladesh, 3rd International Conference on Water & Flood Management (ICWFM-2011), 2011
- [6] BWDB (April, 2012), "Bathymetry survey for pre-work and post-work measurement of dredging for Gorai river restoration project (phase-II)", Progress report-23, pp.7-10
- [7] M.InamulHaque, The Daily Star: <http://www.thedailystar.net/gorai-river-can-it-flow-round-the-year-46910> (01:53 AM, March 08, 2015)
- [8] Andries J. Paarlberg, Massimo Guerrero, Fredrik Huthoff and Mariano Re, 2015 "Optimizing Dredge-and-Dump Activities for River Navigability Using a Hydro-Morphodynamic Model", Water 2015, 7, 3943-3962; doi:10.3390/w7073943, water ISSN 2073-444.
- [9] Judy England and Lydia Burgess-Gamble, August, 2013, "A report on-Evidence: Impacts of dredging", Environment Agency.
- [10] Islam G.M. Tarekul, Karim M.R (14 March 2005) " Predicting downstream hydraulic geometry of the Gorai river", Journal of Civil Engineering (IEB), 33 (2) 55-63.
- [11] A. Clijncke (2001), "Morphological response to dredging of the upper Gorai river", thesis main report, TU Delft.
- [12] Sarker M.H, Kamal M.M and Hassan K, "The Morphological Changes of a distributary of Ganges in response to the Declining Flow using Remote Sensing", Proceedings of the 20th Asian Conference on Remote Sensing, Vol.1, 1999.
- [13] Islam S.N and Gnauck A, 2011, "Water Shortage in the Gorai River basin and Damage of Mangrove Forest Wetland Ecosystems in Sundarbans, Bangladesh, 3rd International Conference on Water & Flood Management (ICWFM-2011)
- [14] Shamsad S.Z.K.M, Islam K.Z and Mahmud M.S, 2014, "Surface Water Quality of Gorai River of Bangladesh", Journal of Water Resources and Ocean Science, 3(1):10-16, published online on March 30, 2014
- [15] Biswas N.K, Ahammad M (Jan-Jun 2014), "Application of CCHE2D Mathematical Model in the Gorai Off-take for two-dimensional simulation, International Journal of Surface and Groundwater Management, Vol. 01, No. 01.
- [16] Kader M, "Effectiveness of Pilot Dredging in the Gorai River", MSc thesis, Department of Water Resources Engineering, BUET, 2000

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

BIOGRAPHY



Rahman A. has graduated from the department of Water Resources Engineering of Bangladesh University of Engineering and Technology. Currently she is working as a lecturer of the department of Water Resources Engineering, BUET. She was born in 1st August, 1992 in Khulna city of Bangladesh. She has pursued her S.S.C and H. S.C. Examination from Sirajganj District of Bangladesh. She was admitted into Water Resources Engineering discipline of BUET in 2010. In her varsity life she was engaged with different type of software and model related works like GIS, River2D, HEC-RAS, Delft3D, AutoCAD, MATLAB etc. Now she is pursuing her M.Sc. in Water Resources Engineering from BUET.

Afeefa Rahman is very interested in river engineering, software applications in water resources problems and impact of hydraulic structures on rivers. She has already published a paper on “A Study on Hydrodynamic and Morphological Behavior of Gorai River using Delft3D” in 3rd ICCESD’ 2016, KUET, Bangladesh. In future she has a plan to work with different type of hydraulic structures and climate change issues relating with water resources.



Yunus A. has been working as an Associate Professor in the Department of Water Resources Engineering of Bangladesh University of Engineering and Technology (BUET). She was born in 3rd September 1978 in Dhaka city of Bangladesh. She has graduated in Civil engineering from BUET and then accomplished her MSc in Water Resources Engineering. She has pursued her PhD in the University of Southampton, UK. She was a co-author with Afeefa Rahman in publishing a paper on “A Study on Hydrodynamic and Morphological Behavior of Gorai River using Delft3D” in 3rd ICCESD’ 2016, KUET, Bangladesh. Anika has been interested in river engineering, software applications in water resources problems and groundwater problems including fluid Mechanics, groundwater hydraulics and Irrigation and Drainage.