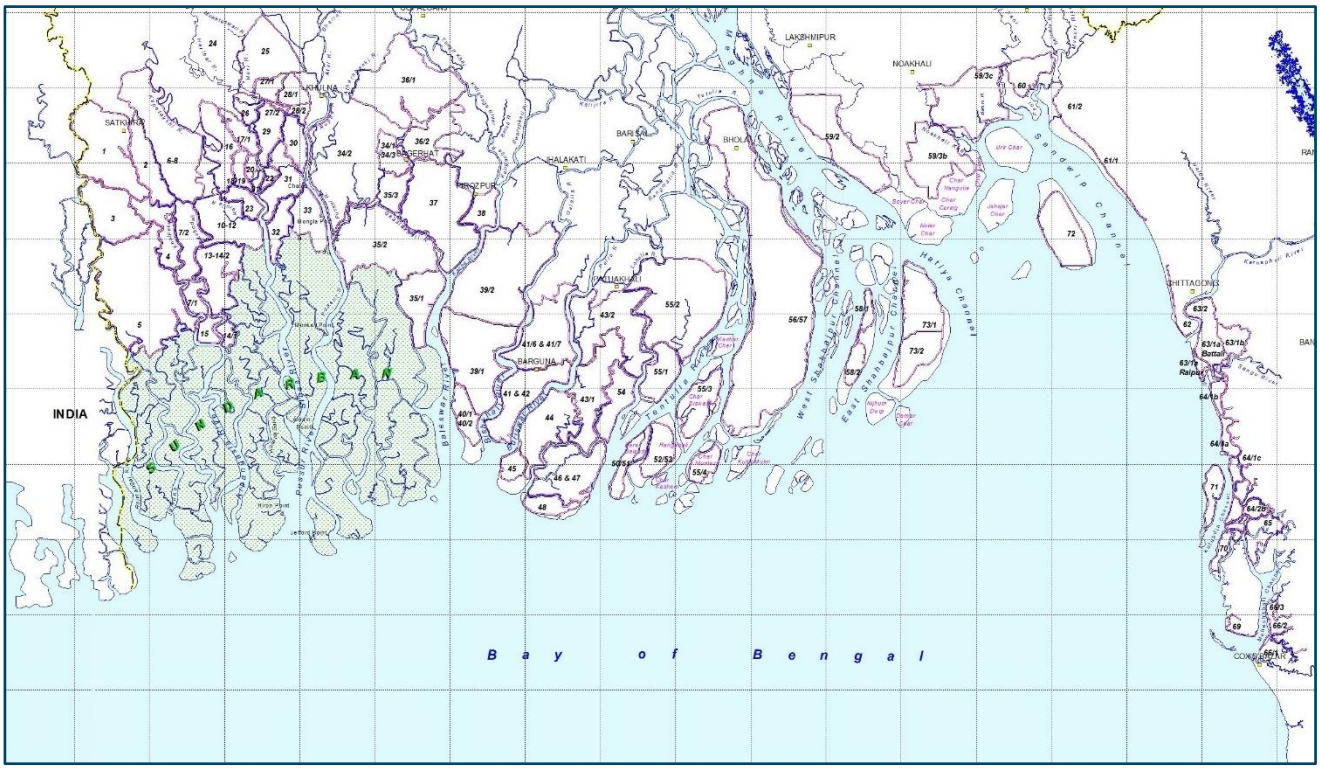
Ministry of Water Resources

Bangladesh Water Development Board

Coastal Embankment Improvement Project, Phase-I (CEIP-I)

Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics)



Monitoring Results on Sedimentation rate in Rivers and Floodplain (Revised)

December 2020

DHI · Deltares Enabling Delta Life · IWM Water Environment & Climate · Columbia University · UNESCO IHE Delft

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ACRONYMS AND ABBREVIATIONS

BoB	Bay of Bengal
BM	Benchmark
BWDB	Bangladesh Water Development Board
CEIP	Coastal Embankment Improvement Project
CEP	Coastal Embankment Project
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
FM	Flexible Mesh
GBM	Ganges, Brahmaputra and Meghna
GPS	Global Positioning System
HD	Hydrodynamic
IWM	Institute of Water Modelling
KJDRP	Khulna-Jessore Drainage Rehabilitation Project
RCC	Reinforced Cement Concrete
RTK	Real-Time Kinematic
SLR	Sea Level Rise
SOB	Survey of Bangaldesh
SSC	Suspended Sediment Concentration
SWRM	South West Region Model
ToR	Terms of reference
TRM	Tidal River Management
WL	Water Level

1 Introduction

1.1 Background

Coastal embankment construction has started in very early sixties under Coastal Embankment Project (CEP). The Coastal Embankment Project made possible the reclamation of large tracts of land for agriculture from 1960 onwards. Polder building proceeded continuously until today. We now have 1.2 million hectares of land reclaimed in 139 active polders in the coastal zone of Bangladesh.

However, by the time passed conditions of the embankment and sluices were deteriorated due to river erosion, siltation of rivers and canals, insufficient drainage etc. Also, due to the construction of many polders across the coastal belt, negative impacts have been created both inside and outside environment of the polders – inside canal silted up, navigability was lost, water logging created. Outside rivers got silted up and lost their conveyance. In addition, negative effects of climate change and sea level rise are being added. Hence, negative effect on entire coastal environment was ameliorating. In the face of such reality Bangladesh government felt necessity of improvement of polders through addressing those impacts and to cope up with the future challenges. The disasters resulting from two major cyclones Sidr (2007) and Aila (2009) and the unexpectedly high value of damages caused by these, provoked the World Bank and the Government of Bangladesh to initiate the Coastal Embankment Improvement Program (CEIP-1). Coastal Embankment Improvement Project -1 (CEIP-1) was initiated in 2010, and it included 17 polders in its scope of work. In subsequent time a research study was felt to be included as a component project to support the phased Coastal Embankment Improvement Program so that all improvement initiatives – planning, design and construction get effective momentum in order to build/improve a series of sustainable polders to create safer coastal environment - making polders more habitable and grow more food.

With this end in view Bangladesh Water Development Board undertook a research project titled ***Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics)*** under its CEIP-1 project. The study was initiated in October 2018 and is being carried out under a joint venture of Danish Hydraulic Institute (Denmark) and Stichting Deltares (The Netherlands) in association with sub consultants Institute of Water Modelling (Bangladesh), University of Colorado, Boulder (USA), Columbia University (USA), and Lousiana State University (USA). This research is sponsored by the World Bank.

The activities under the study is divided into 9 components as follows

1. Inception Report
2. Literature review
3. Development of input database for models
4. Modelling for long-term physical processes
5. Approach for reconstruction of the polder at different coastal zones
6. Updating design parameters and specifications for planning and design
7. Investment plan
8. Plan for capacity building of concerned professionals and relevant stakeholders
9. Outreach and communication strategy

The main objective of the Research Activities on Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders adapted to Coastal Dynamics) is to improve and manage the polders successfully in the coming decades and analysing any drawbacks of the existing polders and determining how the coastal polders can be managed in a more sustainable way for the long term.

To support this research activities, monitoring of the physical changes of the surrounding rivers of the polders is also important in addition to having detail investigations through mathematical

modelling. Accordingly, monitoring of sedimentation and erosion has been conducted for the selected 12 rivers including the flood plain by undertaking survey of river cross sections (two cross-sections for each river) four times during the period of two year. The monitoring survey results on sedimentation will help understanding of the morphological behaviour of the selected rivers around the coastal polders. According to ToR, this monitoring activities on sedimentation and erosion falls under component-3 and the report has been prepared to describe the methodology, results and findings of monitoring works.

1.2 Monitoring Survey Plan

For the purpose of monitoring changes in the selected rivers, surveys were carried out for 2 sample-cross-sections for each river. These rivers are located around the periphery of 41 coastal polders, and all are tidal in nature. Table 1-1 presents polder names (polders are named by numbers), surrounding river names, and position of rivers in relation to the respective polder the erosion and sedimentation processes in many of these rivers are influenced by the magnitude of tidal flow. However, in some of the coastal rivers like lower Meghna, Pussur, Baleswar and Sibsha, the erosion/ deposition processes are influenced by the upstream fresh-water flow during the monsoon as well as the tidal flow magnitude. The location of all monitoring sections has been shown in Figure 1-1.

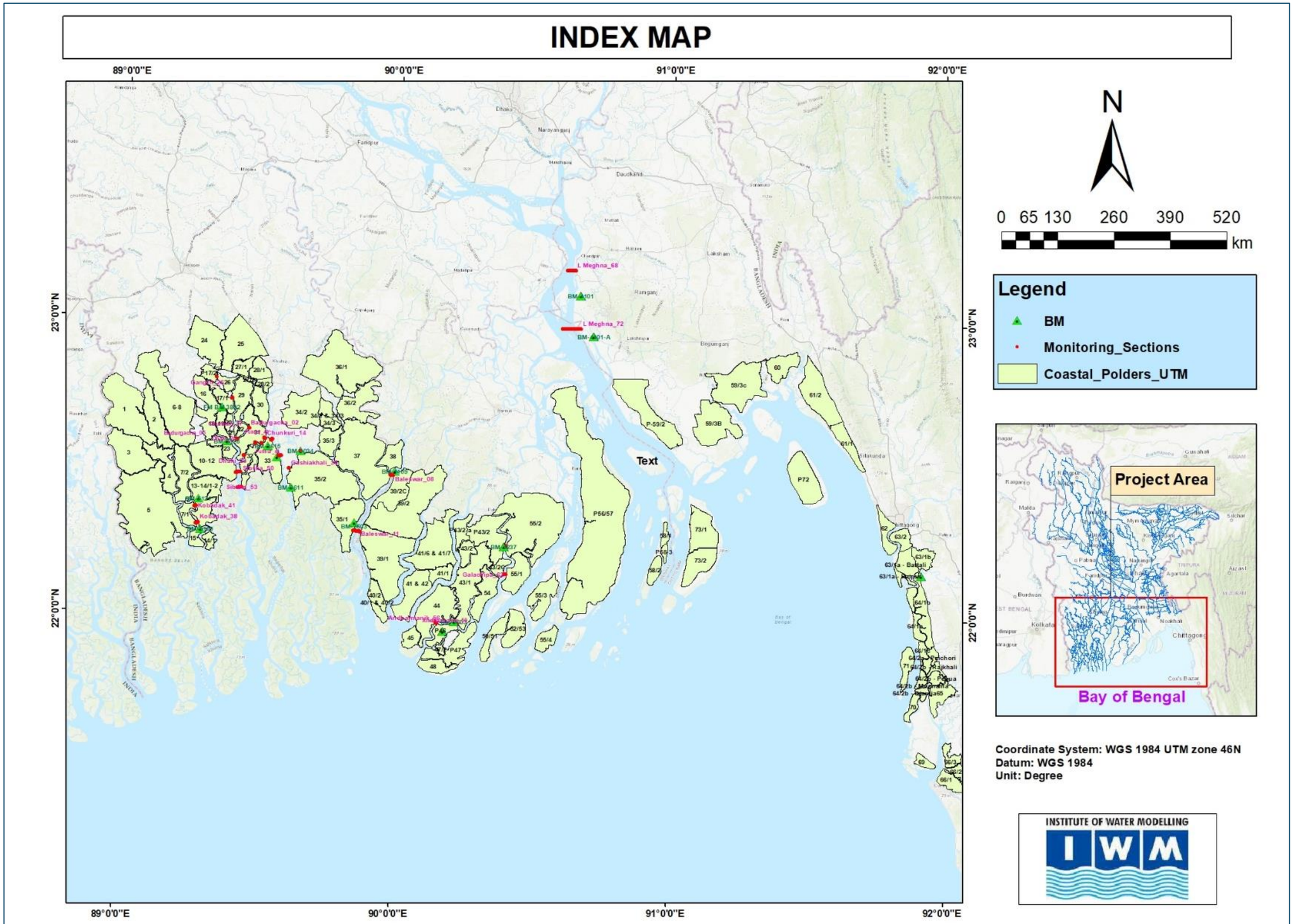

Figure 1-1: Index Map

Table 1-1: Names of selected rivers for monitoring, names of adjacent polders, and position of the rivers in relation to the polders

SL. Nos.	River Names	Polder Names	Position of Rivers
1	Badupgacha	22	East; South-East
		31	West
2	Gangril	17/1	South-East; North; North-East
		20; 17/2	East
		25	South-West
		29; 26	West
3	Gashiakhali	35/1	North-East
		35/2	East; North-West; West
		37	South-West
4	Andharmanik	43/1	South
		44	East
		46	North; West
5	Pussur	31; 33	East
		35/2	West
6	Sibsha	10-12	East
		18-19; 21	South
		23	North & East
		31	South-West
		32	West
7	Lower Meghna	56/57	North-East; East
		59/2	West
8	Dhaki	31	South
		32	North; North-West
		33	North-West
9	Kobadak	6-8	East; North-East; South
		7/1; 7/2; 15	East
		10-12; 13-14/1-2; 14/1; 16	West
10	Chunkuri	31	South-East
		32	North-East
		33	North
11	Baleswar	35/1; 36/1; 36/2; 37	East
		38; 39/1; 39/2; 39/2C; 40/1 & 40/2	West
12	Galachipa	43/2; 43/2C	North-East; East
		54	East
		55/1; 55/2	West

2 Methodology of Monitoring Field Survey

2.1 Establishment of Bench Marks

Control point arrangement is very essential to conduct any survey activities. Survey of Bangladesh (SOB) has established Bench Marks (BM) across the whole country for Horizontal Control (Latitude, Longitude) and Vertical Control (Reduce Level). In order for establishing bench marks for the purpose of the survey nearest available existing SOB bench marks were used. In order to get two fixed points on either side of each cross-section 2 RRC pillars were erected on banks of each river. BM Fly has been carried out by using optical level and RTK GPS to connect the RCC pillar which is used as Temporary BM (TBM) for the following consecutive measurements. The list of using Permanent Bench Mark from SOB is given in Table 2-1.

Figure 2-1: SOB Bench Mark at Dumuria, Khulna; used as reference to establish TBM for the Gangril and Badurgacha river sections

Table 2-1: A list of SOB Bench Mark used for monitoring river cross-sections survey

Sl. No.	SOB BM ID	Location Descriptions	Position of BM		Elevation (MSL)	Remarks
			Easting (m)	Northing (m)		
1	BM-5121	Near Union Health & Family Welfare Cente, Koyra, Khulna	734937	2477231	1.614	Kobadak River (MXS_41)
2	BM-5119	Near Gabur Purbapara Baitun-Nur Mosque, Shaymnagar, Satkhira	736183	2465696	1.531	Kobadak River (MXS_38)
3	FM BM 3822	Near Taltola kheya ghat,Magurkhali, Dumuria, Khulna	742354	2511722	4.149	Gangril River
4	GPS-122	Near Betbunia Primary School cum cyclone shelter, Paikgaccha, Khulna.	746245.4	2493218	1.631	Shibsa River & Dhaki (MXS_23)
5	BM-3614	Near Bajua Degree College's field,Bajua, Dacope, Khulna	763729	2493777	1.704	Pussur River (MXS_44)
6	BM-3615	Near Chunkuri Govt. Primary & High School, Dacope, Khulna.	760077	2497874	1.703	Pussur River (MXS_47) & Dhaki (MXS_20) & Chunkuri River
7	BM-5128	Situated at Soladana High School, Paikgaccha, Khulna	744807	2499069	1.782	Badurgacha River (MXS_5)
8	BM-1034	Near Amdabad Primary School,Fakirhat, Bagerhat.	772587	2496506	2.697	Gashiakhali River (MXS_32)
9	BM-3611	Near NUO Primary School, Purba Chila, Mongla, Bagerhat	769535	2482543	2.558	Gashiakhali River (MXS_35)
10	BM-1109	Near Char Khali Gol Chakkar Jame Mosque, Bhandaria, Pirojpur.	808281	2490118	2.582	Baleswar River (MXS_8)
11	BM-3603	Near Soaronkhola Police station, Sarankhola, Bagerhat.	793744	2470263	2.502	Baleswar River (MXS_11)
12	BM-4101	Near Haimchar Upazila Parishad, Aligi, Haimchar, Chandpur	260643	2555870	4.438	L.meghna U/S (MXS_68)
13	BM-4101-A	BM-4101-A, Near Hajimara WAPDA Rest House, Hajimara, Lakshmipur	265371	2540541	4.984	L.meghna D/S (MXS_71)
14	BM-5603	Near Khapupara Secondary school, Khapupara, Patuakhali	212963	2433829	2.644	Andhermanik River (MXS_59)
15	BM-5604	Pakhimara Secondary and Govt. Primary schoo, Kalapara, Patuakali	208703	2430093	2.078	Andhermanik River (MXS_56)

Sl. No.	SOB BM ID	Location Descriptions	Position of BM		Elevation (MSL)	Remarks
			Easting (m)	Northing (m)		
16	BM-5237	Amkhola Union Parishad office, Golachipa, Patuakhali	231591	2461882	2.568	Golachipa River
17	BM-1245	Near chandpur Nathmura junior high school, Banshkhali, Chittagong.	388329	2450706	17.681	Shangu River

2.2 Conducting Monitoring Survey

As per TOR, a total of 240 monitoring sections were planned to be carried out on 20 rivers. And, cross-sections would be undertaken at 2 locations for each river and twice a year for 3 years.

As per consultations with the expatriate consultants, it was agreed that monitoring cross section survey would be done for 12 rivers, frequency would be twice in a year (January and May), and duration would be for two years. The section survey has been done at two locations for each river. As such, a total of 24 numbers of cross sections have been surveyed for each campaign. So far a total of four campaign survey have been conducted during February-2019, May-2019, February-2020 and June-2020.

As mentioned earlier, monitoring sections are taken at a fixed location by installing two RCC pillars at the both bank of the river. Cross-section survey is carried out in combination of 2 methods. The water portion has been surveyed by using DGPS and Echo-sounder while the shore and shallow water part have been surveyed by using RTK-GPS or optical level and staff. Data obtained from land part and water part (bathymetry) are combined to form a complete cross-section at a particular transect.

Digital Echo-sounder supported by DGPS and notebook computer with Trimble Hydro Pro software have been used for the survey in the river part. The various components of equipment are fitted on a suitable boat (usually Engine driven wooden boat). The Hydro Pro Navigation software guides the survey boat along the desired transects. The survey data is stored in tabular format in MS Access database during survey. The Nav Edit module of the software compiles depth of water column and position of sounding with time. The depth and position data can be viewed both graphically and in tabular format in the software. The erroneous data is removed by checking the sections during processing. River bottom surface level is obtained by deducting water depth from the water level. The edited data is then exported into ASCII format from the Nav-edit module of Hydro-Pro software. Time-varying cross-sections (between two consecutive times), thus obtained, are superimposed in order to notice the change over the said time.

Figure 2-2: Monitoring cross section survey (water part) being carried out in at the Pussur River

The survey is conducted under a strict quality control process. With respect to equipment, the bar check is conducted for the echo sounder prior to starting the survey. The other equipment like GPS, Optical Level etc. are also checked from time to time during survey work. Moreover, a proper log sheet/field note is maintained for all kinds of field data collection.

The survey is conducted by the experienced and skilled surveyors who have gained long experience in handling various kinds of survey equipment and performed many similar nature of works. The field work is supervised by the Survey Specialist in the consultant team.

The standard methodology used in all IWM field surveys are recorded in the Field Procedures Manual of IWM. Any deviations from standard methodology are mentioned where applicable.

Post processing is being done immediately after the completion of field survey to check any kind of error or inconsistency. If found, they directly inform the field team of these for necessary correction.

3 Assessment of Erosion and Deposition

During the period of monitoring, survey in each section was carried out 4 times, as mentioned in Section 2.2. Figure 3-1 through Figure 3-24 show monitoring sections conducted from February 2019 to June 2020 for all 12 rivers. In each figure there are two panels – left panel shows line-graph of the cross-sections at four time points. Hence, a change can be visualized – be it either erosion or deposition. On the right panel, the location of the cross-section is shown in the respective river along with polder names and their positions on a piece of satellite image. Table 3-1 through Table 3-24 summarize the sectional data/properties of the rivers. In addition to the sectional data/properties, the tables provide information on the changes in flood plains over the monitoring period (i.e., from the first measurement). As compared to the first monitoring survey, the changes occurred between the subsequent surveys are assessed. Assessment of the sectional properties within the river portion have been carried out with respect to the bank full stage.

An account of cross-section data from survey, analysis thereof, changes in sections both in river portion and flood plain for each transect is provided, river by river, for all 12 rivers in following subsections:

3.1 Badurgacha River:

Monitoring Section-2

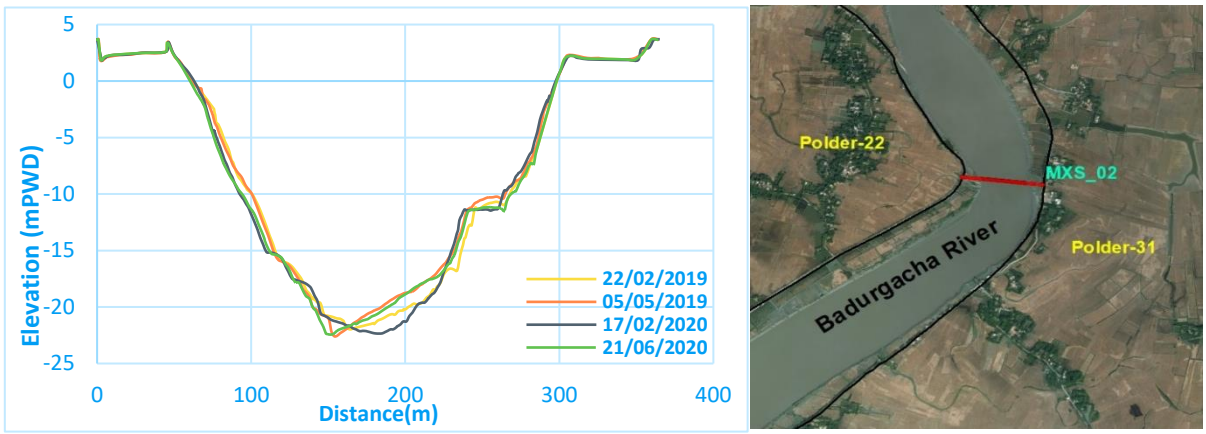

Figure 3-1: Superimposed monitoring Section-2 of Badurgacha River with its location

Cross section surveys at Section-2 in Badurgacha River were carried out on four occasions during the period from 20 February 2019 to 20 June 2020. Figure 3-1 shows the superimposed monitoring sections with the location in the river. Findings from the analysis of monitoring section-2 of Badurgacha River are summarized in Table 3-1. Top width at bank full stage in May 2019 as compared with that of in February 2019 is reduced by 0.45 m due to sediment deposition. However, bank erosion by June 2020 caused the top width to increase by 0.61 m. The overall monitoring survey in 16 months demonstrates an average increase in top width by 0.05 m. This change of 5 cm is insignificant and within the uncertainty limits of the survey, indicating that the river width at the section is stable/does not change. As compared to the sectional area in February 2019, the section of the river experienced sedimentation of 84 m^2 in May 2019 followed by erosions during February 2020 and June 2020 by 55 m^2 and 83 m^2 respectively. The average cross-sectional area during the monitoring period has been found to be enlarged by 17.79 m^2 indicating the scouring/ erosion. Badurgacha is a tidal river and the erosion and sedimentation processes in the river is mostly influenced by the magnitude of tidal flow. Compared to the cross-sectional area, erosion/sedimentation at the location during the monitoring period is not significant. The flood plain sedimentation according to the monitoring survey is also not

significant. The maximum erosion and deposition of the flood plain as assessed from the monitoring surveys are 0.11 m and 0.13 m respectively. The average changes in left and right flood plain elevations during the monitoring period are found to be eroded by 0.07 m and 0.01 m respectively. Thalweg shifting appears to be frequent and is within the range from 11m to 18 m with an average shifting of 2 m to the left as compared to the thalweg in 20 February 2019. This indicates dynamic characteristics of the river although the bank erosion was not significant.

Table 3-1: Badurgacha River Monitoring Section -2, Changes in the River and Flood plain

Survey date	Flood Plain Portion				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
20-02-2019	2.38		1.99		252.28	3747.26	14.85	260.73	14.37	-21.99				
May 2019	2.37	- 0.01	2.12	0.13	251.83	3662.82	14.54	260.15	14.08	-22.60	-0.45	-84.44	11 m to L	0.61
20-02-2020	2.27	-0.11	1.92	-0.07	252.28	3802.04	15.07	265.03	14.35	-22.36	0	54.78	18 m to R	0.37
20-06-2020	2.28	-0.10	1.90	-0.09	252.89	3830.28	15.15	263.62	14.53	-22.45	0.61	83.02	13 m to L	0.46
Average changes		-0.07		-0.01							0.05	17.79	2 m to L	0.48

Monitoring Section-5

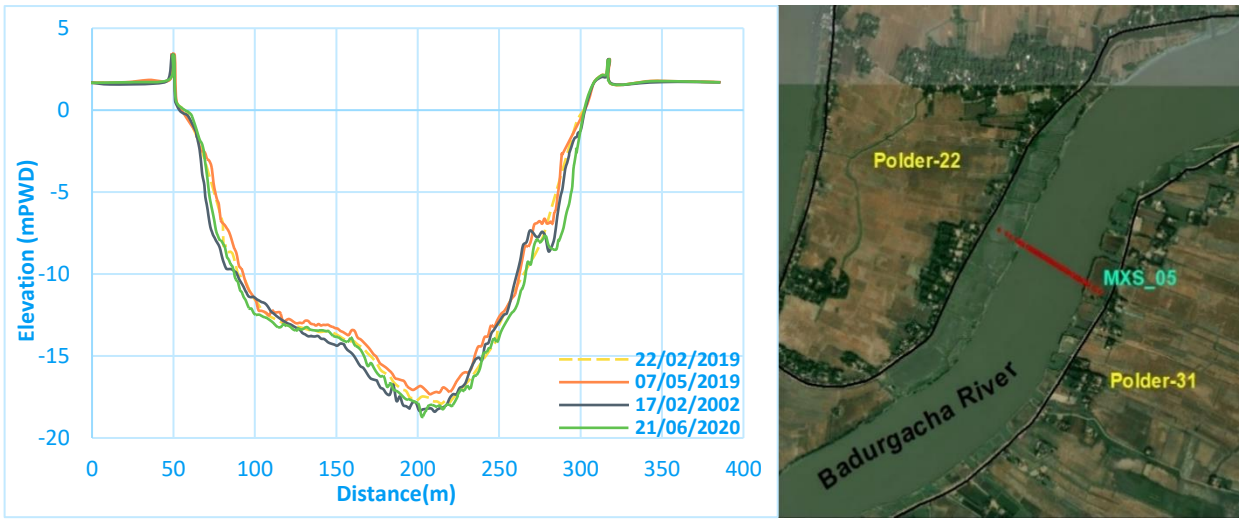

Figure 3-2: Superimposed monitoring section-5 of Badurgacha River with location

Monitoring section-5 in Badurgacha River was surveyed four time during the period from 22 February 2019 to 21 June 2020. The superimposed monitoring section with location is shown in Figure 3-2. Table 3-2 summarizes the findings of the analysis from monitoring section-5 of Badurgacha River.

The cross-sectional analyses of the river portion reveals that the top width at bankfull stage is increased due to erosion during May 2019 and June by 0.33 m and 2.82 m as compared to the top width in February 2019; however, a slight reduction in top width due to sedimentation is observed in February 2020. The overall monitoring survey in 16 months as compared to the top width in February 2019 demonstrates an average increase in top width by 1.03 m indicating tendency in bank erosion. Table 3-2 shows that the section of the river experienced sedimentation of 244 m^2 in May 2019 followed by erosions during February 2020 and June 2020 by 90 m^2 and 143 m^2 respectively. The average cross-sectional area during the monitoring period has been found to be decreased by 3.5 m^2 indicating the process of siltation. Badurgacha River is tidal in nature and the magnitude of the tidal flow governs erosion and sedimentation processes. Findings from the monitoring surveys show that the thalweg level is decreased by 1.33 m in May 2019 and increased by 0.39 m in February 2020 and 0.7 m in June 2020. An average change in the thalweg level over the period of monitoring survey as compared with the thalweg in 22 February 2019 has been found raising in level by 0.08 m. The thalweg shifting ranging from 3 m to 12 m to the left with an average of 7.17 m to the left of the thalweg in 22 February 2019 indicates the dynamic characteristics of the river. The maximum erosion and deposition of the flood plain as compared to the initial survey in Feb 2019 occurred in June 2020 are 0.39 m and 0.31 m respectively. The average changes in elevations in the left and right flood plain are accretion by 0.05 m and erosion by 0.2 m respectively.

Table 3-2: Badurgacha River Monitoring Section -5, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
22-02-2019	1.74		1.71		256.71	3305.86	12.88	262.81	12.58	-18.01				
07May 2019	1.75	0.01	2.00	-0.17	257.04	3061.84	11.91	263.52	11.62	-16.68	0.33	-244.02	6.46m to L	-1.33
17-02-2020	1.58	-0.16	1.65	-0.06	256.66	3396.09	13.23	265.22	12.80	-18.40	-0.05	90.23	3.14m to L	0.39
21-06-2020	2.05	0.31	1.32	-0.39	259.53	3449.13	13.29	267.86	12.88	-18.71	2.82	143.27	11.9 m to L	0.70
Average changes		0.05		-0.20							1.03	-3.50	7.17 m to L	-0.08

3.2 Gangril River:

Monitoring Section-26

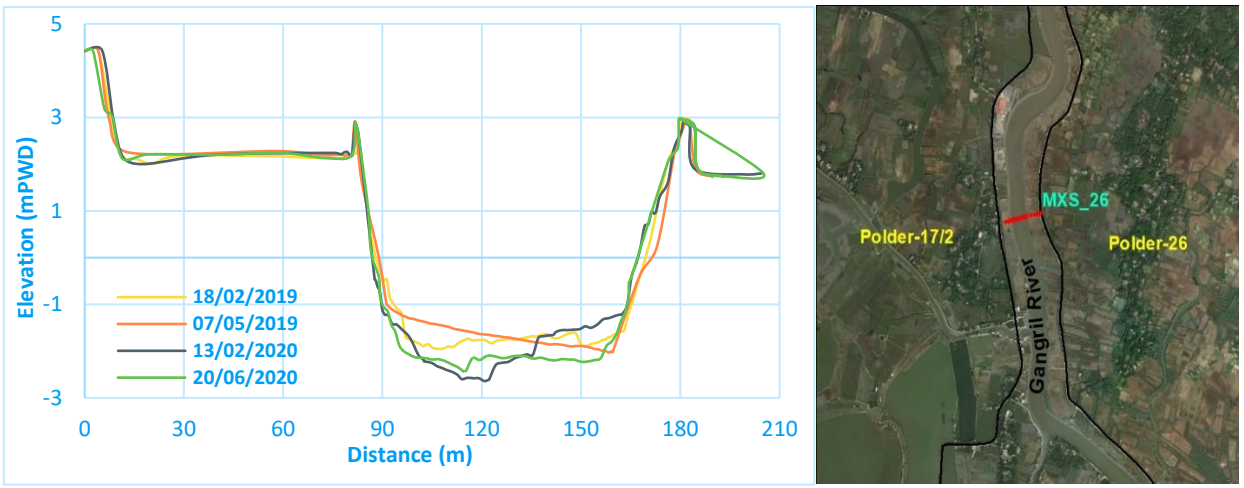

Figure 3-3: Superimposed monitoring section-26 of Gangril River with location

The monitoring section-26 in Gangril River was surveyed four time during the period from 18 February 2019 to 20 June 2020. The superimposed sections with location are sown in Figure 3-3. Table 3-3 summarizes the findings of the analysis from monitoring section-26 of Gangril River. The cross sectional analyses of the river portion shows that the top width at bankfull stage is increased by 2.08 m due to bank erosion during May 2019; later in February 2020 and June 2020, bank erosion caused the top width to increase by 1.57 m and 0.05 m respectively as compared to the top width in February 2019. The overall monitoring surveys in 16 months demonstrate an average increase in top width by 1.23 m indicating the tendency in bank erosion. As compared with the section in February 2019, the overall section of the river experienced sedimentation of 0.87 m^2 in May 2019 followed by erosions during February 2020 and June 2020 by 19.70 m^2 and 23.67 m^2 respectively. An average enlargement in cross-sectional area by 14.17 m^2 during the monitoring period indicates the process of scouring/ erosion. Gangril River is tidal in nature and the erosion and sedimentation process is governed mostly by the scale of tidal flow. Findings from the monitoring surveys show that the thalweg level as compared to February 2019 is increased in May 2019, February 2020 and June 2020 by 0.08 m, 1.04 m and 0.48 m respectively. The average change in the thalweg level during the monitoring period has been found to be elevated by 0.53 m. The thalweg is shifting frequently ranging from 1 m to the left to 50 m to the right with an average of 19.53 m to the right as compared to the thalweg in February 2019. Flood plain sedimentation with respect to the initial survey (Feb 2019) appears to be insignificant. However, the left flood plain experienced maximum sedimentation of 0.07 m in May 2019. The average changes in left and right flood plain elevations during the monitoring period are found to be accreted by 0.03 m and 0.01 m respectively.

Table 3-3: Gangril River Monitoring Section -26, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
18-02-2019	2.17		1.78		92.59	308.59	3.33	93.91	3.29	-1.95				
07May 2019	2.24	0.07	1.77	-0.01	94.67	307.72	3.25	95.80	3.21	-2.03	2.08	-0.87	50.23m to R	0.08
18-02-2020	2.17	0	1.82	0.04	94.16	328.29	3.49	95.71	3.43	-2.99	1.57	19.70	1 m to L	1.04
20-06-2020	2.18	0.01	1.79	0.01	92.64	332.27	3.59	94.38	3.52	-2.43	0.05	23.67	6.83m to R	0.48
Average changes		0.03		0.01							1.23	14.17	19.53m to R	0.53

Monitoring Section-29

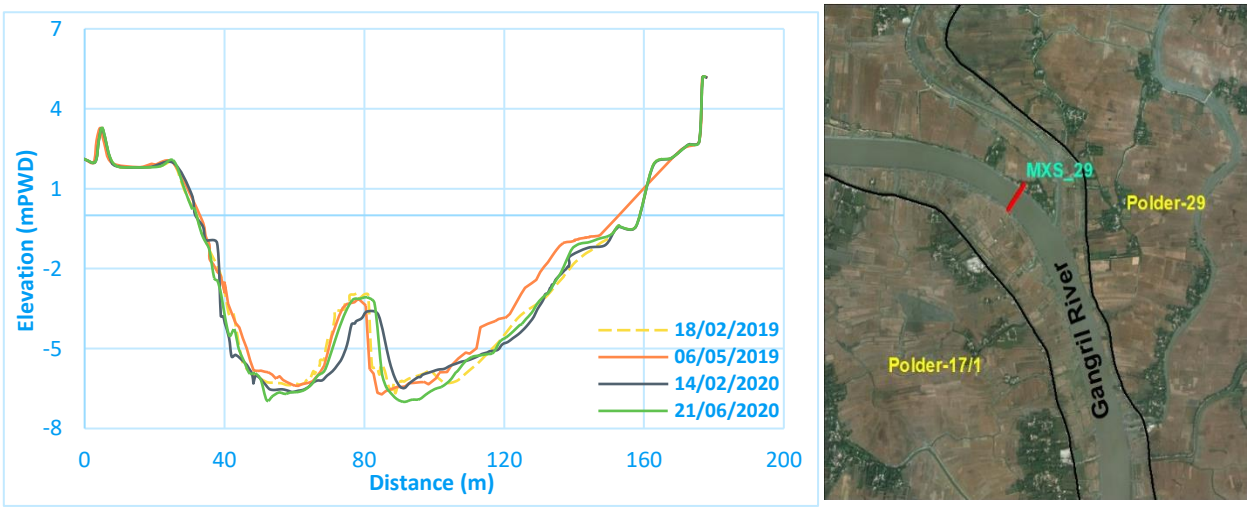

Figure 3-4: Superimposed monitoring section-29 of Gangril River with location

Cross section surveys at the monitoring section-29 in Gangril River were carried out four time during the period from 14 February 2019 to 21 June 2020. Figure 3-4 shows the superimposed section with location. Findings of the analysis from monitoring section-29 of Gangril River are summarized in Table 3-4. In this section, embankments are existed close to the riverbanks and survey was not extended beyond the embankments. As compared with the initial survey in February 2019, the top width at bankfull stage is increased due to bank erosions in May 2019 and February 2020 by 3.34 m and 0.22 m respectively. Later in June 2020, the section undergoes slight sedimentation that causes the top width to reduce by a 0.05 m. The overall monitoring surveys in 16 months demonstrate an average increase in top width by 1.17 m indicating the tendency in bank erosion. The overall section of the river experienced sedimentation in May 2019 and February 2020 by 53 m^2 and 13 m^2. In June 2020 erosion causes the section to slightly be enlarged by 2 m^2. On an average the cross-sectional area during the monitoring period has been found to be reduced by 21.34 m^2 indicating siltation. Gangril River is tidal in nature and the erosion and sedimentation process is governed mostly by the extent of tidal flow. Findings from the monitoring surveys show that the thalweg level as compared to

February 2019 is kept on increasing during May 2019, February 2020 and June 2020 by 0.09 m, 0.05 m and 0.37 m respectively with an average raise in the thalweg level of 0.17 m. The thalweg of the section continues to shift to the right during May 2019, February 2020 and June 2020 as compared to the initial survey in February 2019 by 26 m, 30 m and 32 m respectively with an average shifting of 29.1 m to the right. The average shifting of This indicates the dynamic characteristics of the river. Gangrail river at the section is embanked on both the sides having offset distances of around 15 m from the riverbanks. These stretches of land between river banks and the toe of embankments are considered as floodplains in the analysis. Outside the embankment surveys were not carried out. Changes in the left flood plain elevation have not been found significant which ranges from 0.01 m erosion in February 2020 to 0.05 m deposition in May 2019 as compared to the elevation in February 2019. In May 2019 the right flood plain experienced maximum erosion by 0.03 m. The average changes in left and right flood plain elevations during the monitoring period are found to be raised by 0.02 m and lowering by 0.01 m respectively.

Table 3-4: Gangril River Monitoring Section-29, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
14-02-2019	1.86		2.35		136.36	774.93	5.68	141.69	5.47	-6.63				
6-05-2019	1.91	0.05	2.32	-0.03	139.70	721.85	5.17	145.87	4.95	-6.72	3.34	-53.08	25.7 m to R	0.09
18-02-2020	1.85	-0.01	2.35	0	136.58	761.90	5.58	143.05	5.32	-6.68	0.22	-13.03	29.6 m to R	0.05
21-06-2020	1.88	0.02	2.35	0	136.31	777.02	5.70	141.26	5.50	-7.0	-0.05	2.09	32 m to R	0.37
Average changes		0.02		-0.01							1.17	-21.34	29.1 m to R	0.17

3.3 Gashiakhali River:

Monitoring Section-32

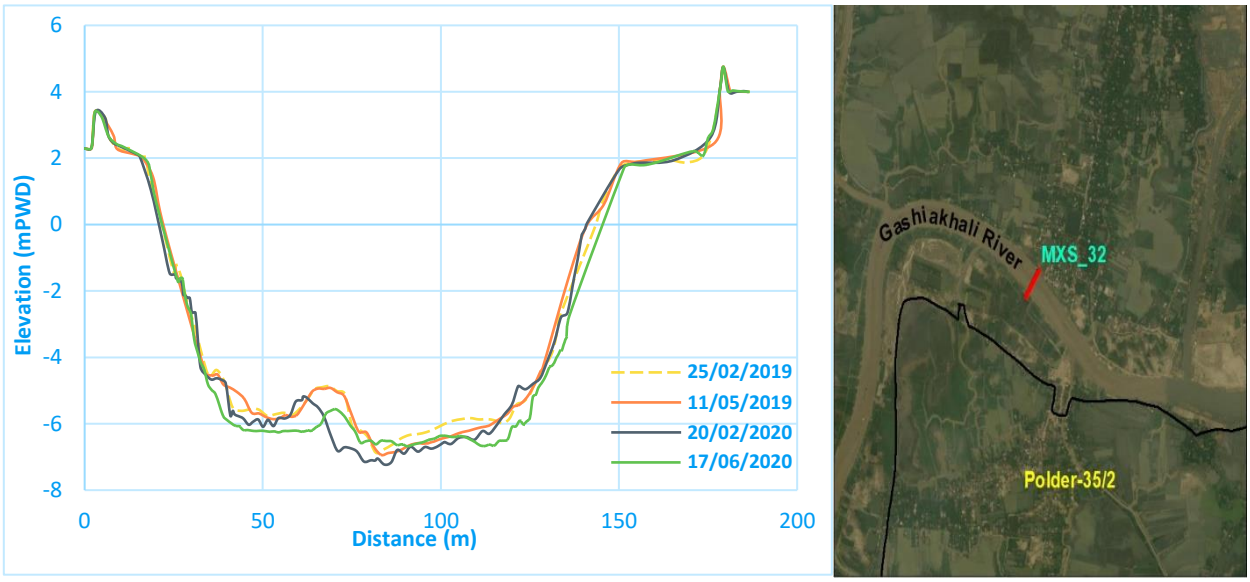

Figure 3- 5: Superimposed monitoring section-32 of Gashiakhali River with location

Cross section surveys at the monitoring section-32 in Gashiakhali River were carried out four time during the period from 25 February 2019 to 17 June 2020. Figure 3-5 shows the superimposed section with location. Findings of the analysis from monitoring section-32 of Gashiakhali River are summarized in Table 3-5. The cross-sectional analyses of the river portion shows that the top width at bankfull stage is slightly increased in May 2019 by 0.87 m due to erosion; later in February 2020 sedimentation causes the top width to reduce by 2 m as compared with the top width in February 2019. The section again experienced erosion in June 2020 thereby the top width enlarges by 1.36 m. The overall monitoring survey in 16 months demonstrates an average increase in top width by 0.06 m. This change of 6 cm is insignificant and within the uncertainty limits of the survey, indicating that the river width at the section is stable/does not change. As compared to the sectional area in February 2019, the overall section of the river experienced erosion of 108 m^2 in May 2019 followed by further erosions during February 2020 and June 2020 by 142 m^2 and 169 m^2 respectively. The average cross-sectional area during the monitoring period has been found to be enlarged by 139.86 m^2 indicating the scouring/ erosion. Findings from the monitoring surveys show that the thalweg level compared to February 2019 is reduced in May 2019 and June 2020 by 0.07 m, and 0.26 m respectively; but in February 2020 the level is increased by 0.29 m. The monitoring survey demonstrates an average raise in the thalweg level by 0.01 m as compared with the level in 25 February 2019. Flood plain sedimentation according to the Figure 3-5 is quite negligible. The left and right flood plains show deposition at all occasions of monitoring surveys with maximum magnitude of 0.03m in June 2020 on the left flood plain. The average changes in left and right flood plain elevations during the monitoring period are found to be raising by 0.02 m and 0.01 m respectively. Thalweg shifting of the river at this section is frequent with maximum magnitude of 7 m to the right in June 2020 as compared to the thalweg in February 2019. The overall monitoring survey demonstrates and average shifting of the thalweg by 2.24 m to the right.

Table 3-5: Gashiakhali River Monitoring Section -32, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
25-02-2019	2.28		4.00		160.68	788.94	4.91	163.35	4.83	-6.94				
11May 2019	2.30	0.02	4.01	0.01	161.55	897.07	5.55	164.6	5.45	-6.87	0.87	108.13	1.55 m to L	0.07
20-02-2020	2.30	0.02	4.00	0	158.63	931.25	5.87	162.57	5.72	-7.23	-2.05	142.31	0.86 m to R	-0.29
17-06-2020	2.31	0.03	4.01	0.01	162.04	958.07	5.91	165.32	5.80	-6.68	1.36	169.13	7.4 m to R	0.26
Average changes		0.02		0.01							0.06	139.86	2.24 m to R	0.01

Monitoring Station -35

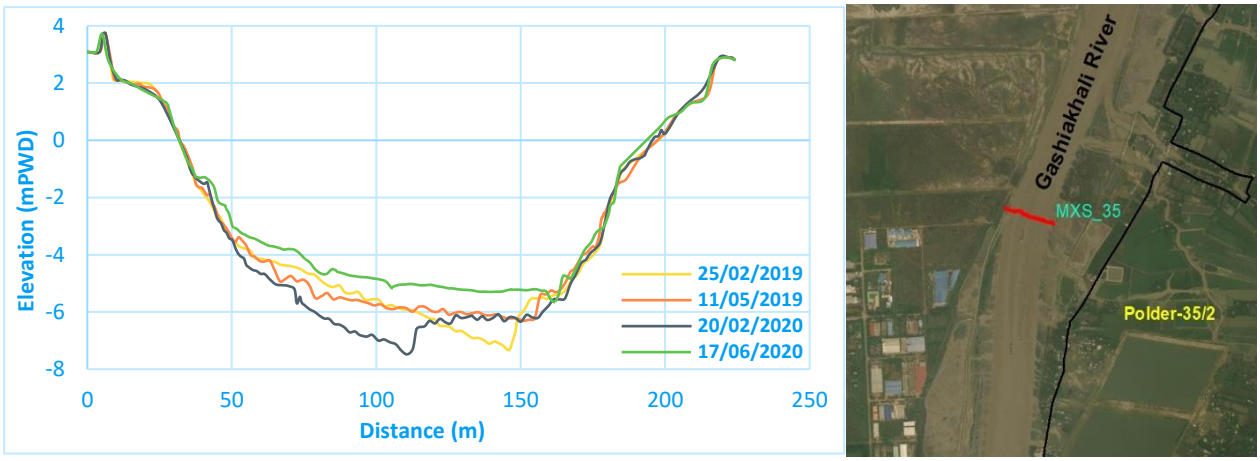

Figure 3-6: Superimposed monitoring section-35 of Gashiakhali River with location

The monitoring section-35 in Gashiakhali River was surveyed on four occasions during the period from 25 February 2019 to 17 June 2020. Figure 3-6 shows the superimposed section with location. Findings of the analysis from monitoring section-35 of Gashiakhali River are summarized in Table 3-6. The cross-sectional analysis of the river portion shows that the top width at bankfull stage is slightly increased in May 2019 due to bank erosion by 0.05 m; later in February 2020 and June 2020 sedimentation caused the top width to reduce by 2.39 m and 1.63 m respectively as compared with the initial survey in February 2019. The overall monitoring survey in 16 months demonstrates an average reduction in top width by 1.32 m indicating bank siltation. With respect to the survey in February 2019, the overall section of the river experienced sedimentation in May 2019 and June 2020 by 11.84 m^2 and 114 m^2 respectively. However, monitoring survey in February 2020 shows erosion of the overall section by 53.65 m^2. The average cross-sectional area during the monitoring period has

been found to be reduced by 24.18 m^2 indicating the process of siltation. Gashiakhali River is tidal in nature and erosion/ deposition is mainly governed by the extent of tidal flow. Findings from the monitoring surveys show that the thalweg level compared to February 2019 is reduced in May 2019 by 1.01 m but in February 2020 it is increased by 0.16 m and in June 2020 the level is again reduced by 1.65 m. The monitoring survey demonstrates an average raise in the thalweg level by 0.83 m in 16 months. Thalweg at the section as compared with the thalweg in February 2019, is found to be shifted on all occasions of survey. The maximum shifting of 35 m to the left occurs in February 2020. In May 2019 and June 2020, the thalweg shifted to the right by 5 m and 16 m respectively. The overall monitoring survey demonstrates and average shifting of the thalweg by 5.1 m to the left of the thalweg in 25 February 2019. The frequent shifting of the thalweg indicates the dynamic nature of the river. There exist embankments close to the banks on either side of the section. Beyond the embankment flood plains are not surveyed.

Table 3-6: Gashiakhali River Monitoring Section -35, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
25-02-2019					203.36	1122.65	5.53	205.19	5.47	-7.32				
11May 2019					203.41	1110.81	5.46	205.42	5.41	-6.31	0.05	-11.84	4.80 m to R	-1.01
20-02-2020					200.97	1176.3	5.85	203.20	5.79	-7.48	-2.39	53.65	35.45 m to L	0.16
17-06-2020					201.73	1008.3	5.00	203.48	4.96	-5.65	-1.63	-114.35	15.60 m to R	-1.65
Average changes											-1.32	-24.18	5.1 m to L	-0.83

3.4 Andharmanik River:

Monitoring Section-56

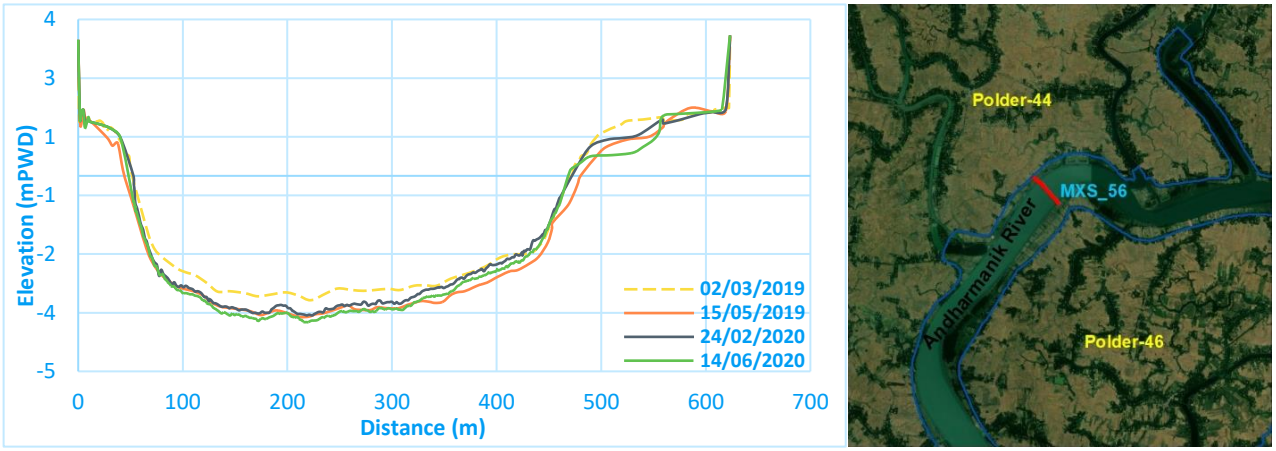

Figure 3-7: Superimposed monitoring section-56 of Andharmanik River with location

The monitoring section-56 in Andharmanik River was surveyed on four occasions during the period from 2 March 2019 to 14 June 2020. Figure 3-7 shows the superimposed section with location. Findings of the analysis from monitoring section-56 of Andharmanik River are summarized in Table 3-7. The cross-sectional analysis of the river portion shows that the top width at bankfull stage is increased in May 2019 due to bank erosion by 50 m; later in February 2020 and June 2020 bank erosion caused the top width to enlarge by 43 m and 44 m respectively as compared with the initial survey in March 2019. The overall monitoring survey in 16 months demonstrates an average increase in top width by 45.3 m indicating bank erosion. As compared with the survey in March 2019, the overall section of the river shows erosion on all occasions of survey in May 2019, February 2020 and June 2020 by 237 m^2 and 128 m^2 and 219 m^2 respectively. The average cross-sectional area during the monitoring period has been found to be enlarged by 194.9 m^2 indicating the trend towards erosion. Andharmanik River is tidal in nature and erosion/ deposition is mainly governed by the extent of tidal flow. Findings from the monitoring surveys show that the thalweg levels as compared to March 2019 are increased on all events of the surveys in May 2019, February 2020 and June 2020 by 0.4 m, 0.4 m and 0.6 m respectively. The monitoring survey demonstrates lowering in the thalweg level by 0.46 m in 16 months. Thalwegs at the section in comparison with the thalweg in March 2019 are found to be shifted to the left on all occasions of survey by 10 m in May 2019, 4 m in February 2020 and 6.5 m in June 2020. The overall monitoring survey demonstrates and average shifting of the thalweg by 6.8 m to the left of the thalweg in February 2019. The frequent shifting of the thalweg indicates the dynamic nature of the river. The table shows the changes of right flood plain with respect to the flood plain in March 2019. No significant changes in elevation of the right flood plain are observed. An average raise in the right flood plain elevation by 0.01 m is found during the monitoring period as compared to elevation in 02 March 2019. Survey on left flood plain is not done. There exists embankment close to left bank of the section. Beyond the embankment flood plain are not surveyed.

Table 3-7: Andharmanik River Monitoring Section-56, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
02-03-2019			1.55		502.70	1668.45	3.32	503	3.32	-3.18				
15May 2019			1.58	0.03	552.41	1905.88	3.45	552.69	3.44	-3.61	49.71	237.43	10 m to L	0.43
24-02-2020			1.50	-0.05	545.50	1796.2	3.29	545.93	3.29	-3.57	42.8	127.75	3.8 m to L	0.39
14-06-2020			1.59	0.04	546.22	1887.84	3.46	546.64	3.45	-3.74	43.52	219.39	6.5 m to L	0.56
Average changes				0.01							45.3	194.9	6.8 m to L	0.46

Monitoring Section-59

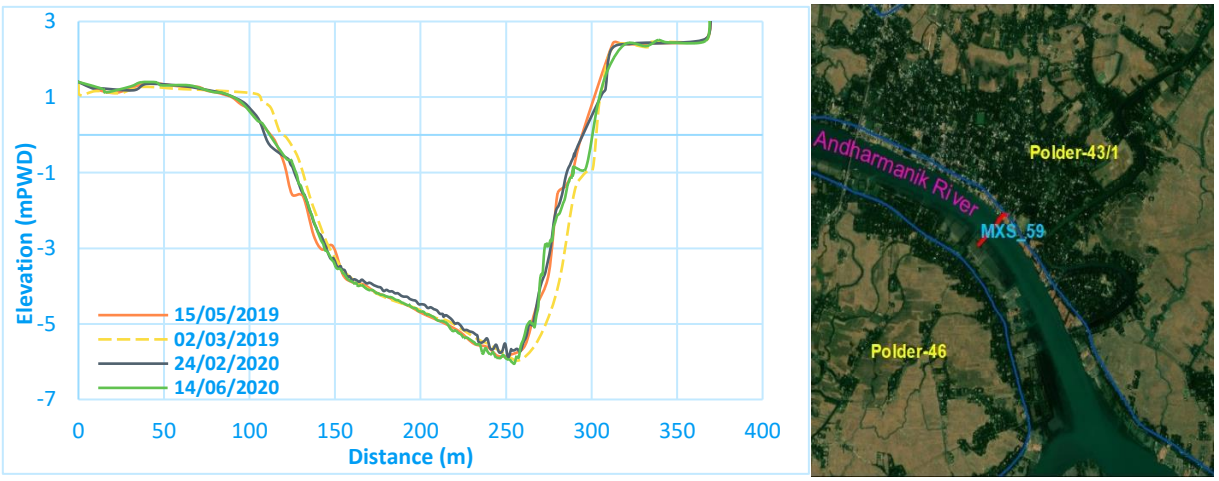

Figure 3- 8: Superimposed monitoring section-59 of Andharmanik River with location

Cross section surveys of the monitoring sectin-59 in Andharmanik River were carried out on four occasions during the period from 2 March 2019 to 14 June 2020. Figure 3-8 shows the superimposed section with location. Findings from the analysis of monitoring section-59 of Andharmanik River are summarized in Table 3-8. As compared with the survey in March 2019, the top widths at bank full stage on all occasions of the surveys in May 2019, February 2020 and June 2020 are enlarged due to bank erosions by 17 m, 19 m and 18 m respectively. The overall monitoring survey in 16 months demonstrates an average increase in top width by 18.15 m indicating bank erosion. The table shows that the section of the river compared to the section in March 2019 is reduced on all survey events due to sedimentation in May 2019, February 2020 and June 2020 by 16 m^2, 40 m^2 and 12 m^2 respectively. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 22.76 m^2 indicating trend of siltation. Andharmanik is a tidal river in nature and the erosion and sedimentation processes in the river is mostly influenced by the magnitude of tidal flow.

Thalwegs on all occasions of survey in May 2019, February 2020 and June 2020 are found to be shifted to the left from the thalweg in March 2019 by 12.5 m, 7 m and 3 m. This shifting indicates dynamic characteristics of the river. The monitoring survey demonstrates lowering in the thalweg level on an average by 0.03 m in 16 months. The flood plain sedimentation according to the monitoring survey is not that significant. The maximum erosion and deposition of the flood plains as assessed from the monitoring survey are 0.08 m and 0.10 m respectively. However, during the monitoring period the left flood plain undergoes an average increase in elevation by 0.09 m; whereas the right flood plain experiences average dropping in elevation by 0.02 m.

Table 3-8: Andharmanik River Monitoring Section -59, Changes in the River and Flood plain

Survey date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood plain (m, PWD)	Change in Ele. (m)	Right Flood plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic depth (m)	Wetted perimeter (m)	Hydraulic Radius (m)	Thalweg level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg shifting (m)	Thalweg level (m, PWD)
02-03-2019	1.16		2.40		201.17	923.09	4.59	202.30	4.56	-5.96				
15-05-2019	1.24	0.08	2.42	0.02	218.39	907.38	4.15	219.44	4.13	-5.85	17.22	-15.71	12.5 m to L	-0.11
24-02-2020	1.26	0.10	2.39	-0.01	220.06	882.71	4.01	221.11	3.99	-5.89	18.89	-40.38	6.6 m to L	-0.07
14-06-2020	1.25	0.09	2.32	-0.08	219.51	910.89	4.15	221.27	4.12	-6.05	18.34	-12.20	2.91 m to L	0.09
Average changes		0.09		-0.02							18.15	-22.76	7.34m to L	-0.03

3.5 Pussur River:

Monitoring Section-44

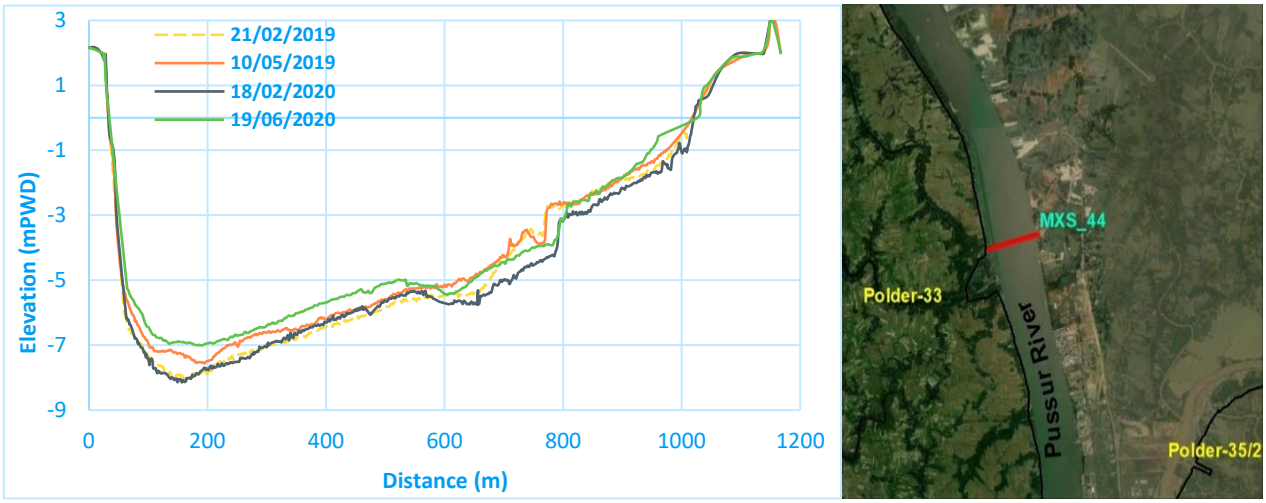

Figure 3-9: Superimposed monitoring section-44 of Pussur River with location

The monitoring section-44 in Pussur River has been surveyed four times during the period from 21 February 2019 to 19 June 2020. Figure 3-9 shows the superimposed section with location. Findings of the analysis from monitoring section-44 of Pussur River are summarized in Table 3-9. The cross-sectional analysis of the river portion shows that the top width at bankfull stage is increased in May 2019 due to bank erosion by 5 m; later in February 2020 and June 2020 sedimentation caused the top width to reduce by 11m and 10 m respectively as compared with the initial survey in February 2019. The overall monitoring survey in 16 months demonstrates an average reduction in top width by 5.32 m indicating the tendency in bank siltation. With respect to the survey in February 2019, the overall section of the river shows reduction in area due to sedimentation in May 2019 and June 2020 by 264 m^2 and 446 m^2 respectively. However, the section experiences enlargement in area due to erosion in February 2020 by 166 m^2. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 181.3 m^2 indicating siltation trend. Pussur is a dynamic river and tidal in nature and erosion/ deposition is mainly governed by the extent of tidal flow as well as the freshwater flow from the upstream during monsoon. Pussur river receives substantial freshwater discharges from upstream during monsoon. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 is increased by 0.07 m in February 2020; however, in May 2019 and June 2020 the levels are reduced by 0.5 m and 1 m respectively. The monitoring survey demonstrates decrease in the thalweg level on an average by 0.5 m in 16 months. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the right by 30 m and 24 m during May 2019 and June 2020 respectively. In February 2020, it is shifted to the left by 8 m. This frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 15.53 m to the right of the thalweg in February 2019. The table shows changes in flood plain elevations with respect to the flood plain in February 2019. No significant changes in elevation are observed. The maximum raise in elevation due to sedimentation of 0.05 m is occurred on the left flood plain in February 2020. However, during the monitoring period the left flood plain undergoes an average increase in elevation by 0.03 m; whereas the right flood plain experiences average dropping in elevation by 0.003 m. The stretch of land of around 25 m from the left bank at bankfull stage to the Sundarban forest is considered as the left flood plain. Similarly, the extent of land of around 40 m from the right bank to the toe of embankment has been considered as the right flood plain. Based on this consideration, analysis on the changes in elevation has been carried out.

Table 3-9: Pussur River Monitoring Section- 44, Changes in the River and Flood plain

Survey Date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
21/02/2019	2.07		1.94		1068.11	6858.70	6.42	1069.76	6.41	-8.07				
10/05/2019	2.08	0.01	1.93	0.00	1072.73	6594.40	6.15	1074.19	6.13	-7.56	4.62	-264.30	30.34m to R	-0.51
18/02/2020	2.12	0.05	1.93	0.00	1057.49	7024.66	6.64	1060.96	6.61	-8.14	-10.61	165.97	7.78m to L	0.07
19/06/2020	2.09	0.02	1.93	-0.01	1058.12	6413.12	6.06	1059.04	6.05	-7.01	-9.98	-445.58	24.04m to R	-1.06
Average changes		0.03		-0.003							-5.32	-181.30	15.53m to R	-0.50

Monitoring Section-47

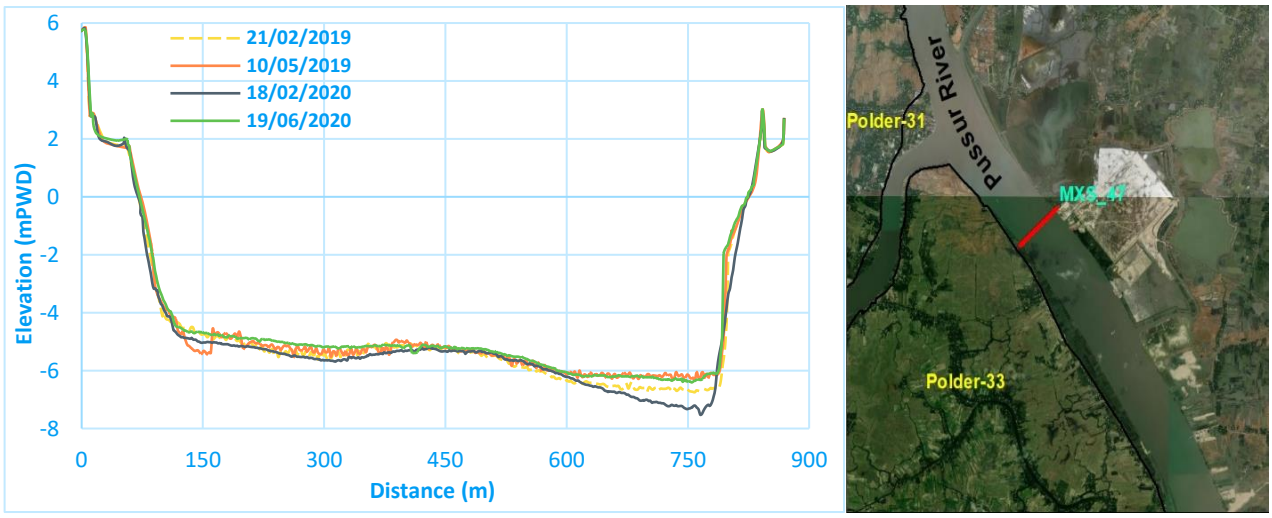

Figure 3-10: Superimposed monitoring section-47 of Pussur River with location

Monitoring section-47 in Pussur River has been surveyed four times during the period from 21 February 2019 to 19 June 2020. Figure 3-10 shows the superimposed section with location. Findings from the analysis of monitoring section-47 of Pussur River are summarized in Table 3-10. The cross-sectional analysis of the river portion shows that the top widths at bankfull stage as compared to the width in February 2019 are reduced on all the occasions of surveys in May 2019, February 2020 and June 2020 due to sedimentation by 2.68 m, 0.28 m and 2.47 m respectively. The overall monitoring survey in 16 months demonstrates an average reduction in top width by 1.81 m indicating tendency in bank siltation. With respect to the section in February 2019, the overall section of the river shows reduction in area due to sedimentation in May 2019 and June 2020 by 124 m^2 and 187 m^2 respectively. However, the section experiences enlargement due to erosion in February 2020 by 113 m^2. The

section during the monitoring period undergoes an average reduction in the cross-sectional area by 66 m^2 indicating the process of siltation. Pussur is a dynamic river and tidal in nature and erosion/ deposition is mainly governed by the extent of tidal flow as well as the freshwater flow from the upstream during monsoon. Findings from the monitoring surveys show that the thalweg levels as compared with February 2019 are reduced in May 2019 and June 2020 by 0.43 m and 0.34 m respectively; however, in February 2020 the level is lowered by 0.77 m. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the left by 27 m and 3 m during May 2019 and June 2020 respectively. In February 2020, it is shifted to the right by 7 m. This frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 7.95 m to the Left of the thalweg in February 2019. The table shows changes in left flood plain elevations with respect to the flood plain in February 2019. The maximum change in flood plain elevation is occurred in June 2020 due to sediment deposition by 0.07 m. During the monitoring period the left flood plain undergoes an average increase in elevation due by 0.03 m. The stretch of land of around 30 m from the left bank at bankfull stage to the embankment has been considered as the left flood plain. The right embankment being close to the right bank survey for the right flood plain was not carried out.

Table 3-10: Pussur River Monitoring Section- 47, Changes in the River and Flood plain

Survey Date	Flood plain Portion (EL in meter)				River Section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
21/02/2019	1.82		Not Surveyed		780.62	5306.50	6.80	783.20	6.78	-6.75				
10/05/2019	1.80	-0.02	Not Surveyed		777.94	5182.36	6.66	781.04	6.64	-6.32	-2.68	-124.14	27.27m to L	-0.43
18/02/2020	1.85	0.03	Not Surveyed		780.34	5420.09	6.95	781.84	6.93	-7.52	-0.28	113.59	6.89m to R	0.77
19/06/2020	1.89	0.07	Not Surveyed		778.15	5119.06	6.58	780.63	6.56	-6.41	-2.47	-187.44	3.46m to L	-0.34
Average changes		0.03									-1.81	-66	7.95 m to L	0

3.6 Sibsha River:

Monitoring Section-50

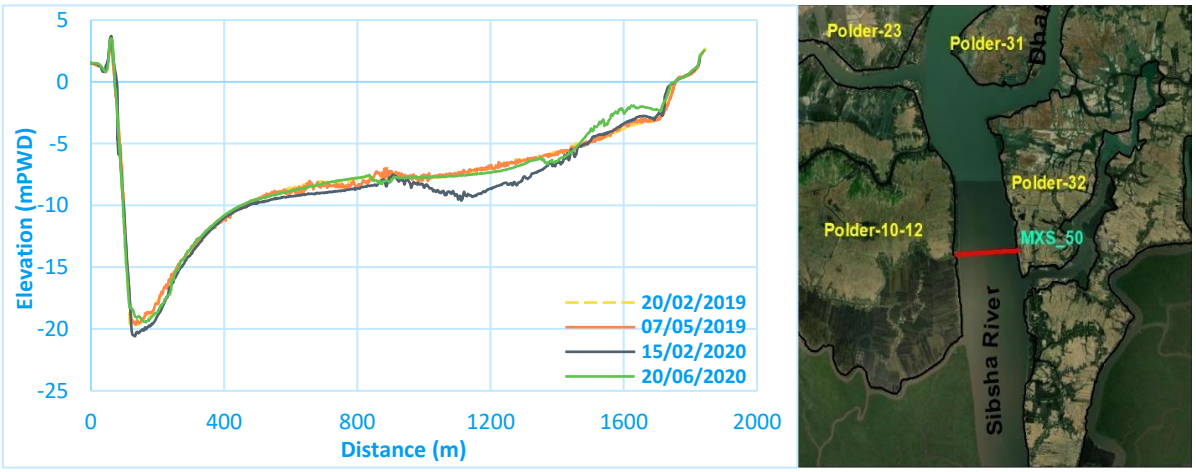

Figure 3-11: Superimposed monitoring section-50 of Sibsa River with location

On four occasions during the period from 20 February 2019 to 20 June 2020, the monitoring section-50 in Sibsa River was surveyed. Figure 3-11 shows the superimposed section with location. Findings of the analysis from monitoring section-50 of Sibsha River are summarized in Table 3-11. Monitoring surveys show that the top widths as compared to the width of 20 February 2019 are increased on all events of the surveys in May 2019, February 2020 and June 2020 by 13.05 m, 2.38 m and 1.86 m respectively due to bank erosion. The overall monitoring survey in 16 months demonstrates an average increase in top width by 5.76 m indicating tendency in bank erosion. As compared to the sectional area in February 2019, the overall section of the river is reduced due to sedimentation in May 2019 and June 2020 by 16 m^2 and 119 m^2 respectively. However, in February 2020, the section experienced enlargement in area due to erosion by 948 m^2. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 270.87m^2 indicating scouring/ erosion. Sibsha River is tidal in nature and erosion/deposition is mainly governed by the extent of tidal flow and the upstream fresh-water flow during monsoon. Findings from the monitoring surveys show that the thalweg level compared to February 2019 is reduced in May 2019 by 0.09 m; but in February 2020, it is increased by 0.86 m and in June 2020, the level is again reduced by 0.27 m. The monitoring survey demonstrates average rise in the thalweg level by 0.17 m in 16 months. Thalweg at the section as compared with the thalweg in February 2019, is found to be shifted to the right on all the occasions of monitoring survey. The maximum shifting of 34.24 m occurs in June 2020. In May 2019 and February 2020, the thalweg shifted by 3.69 m and 1.45 m respectively. The frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 13.13 m to the right of the thalweg in 20 February 2019. Changes in the flood plain elevations on the left and right of the monitoring section have not been found to be significant. The maximum change in elevation on the left flood plain has been occurred due to erosion in May 2019 0.07 m due to erosion. On the right flood plain, the maximum change of 0.1 m in elevation had taken place due erosion in February 2020. However, during the monitoring period, the left and right flood plain experience average decrease in elevations by 0.02 m and 0.07 m respectively.

Table 3-11: Sibsha River Monitoring Section- 50, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
20/02/2019	1.48		1.72		1728.72	15409.12	8.91	1734.26	8.89	-19.72				
07/05/2019	1.42	-0.07	1.70	-0.02	1741.77	15393.30	8.84	1751.55	8.79	-19.63	13.05	-15.82	3.69m to R	-0.09
15/02/2020	1.49	0.01	1.62	-0.10	1731.10	16357.01	9.45	1741.06	9.39	-20.58	2.38	947.89	1.45m to R	0.86
20/06/2020	1.47	-0.01	1.63	-0.09	1730.58	15289.65	8.83	1736.58	8.80	-19.45	1.86	-119.47	34.24m to R	-0.27
Average changes		-0.02		-0.07							5.76	270.87	13.13m to R	0.17

Monitoring Section-53

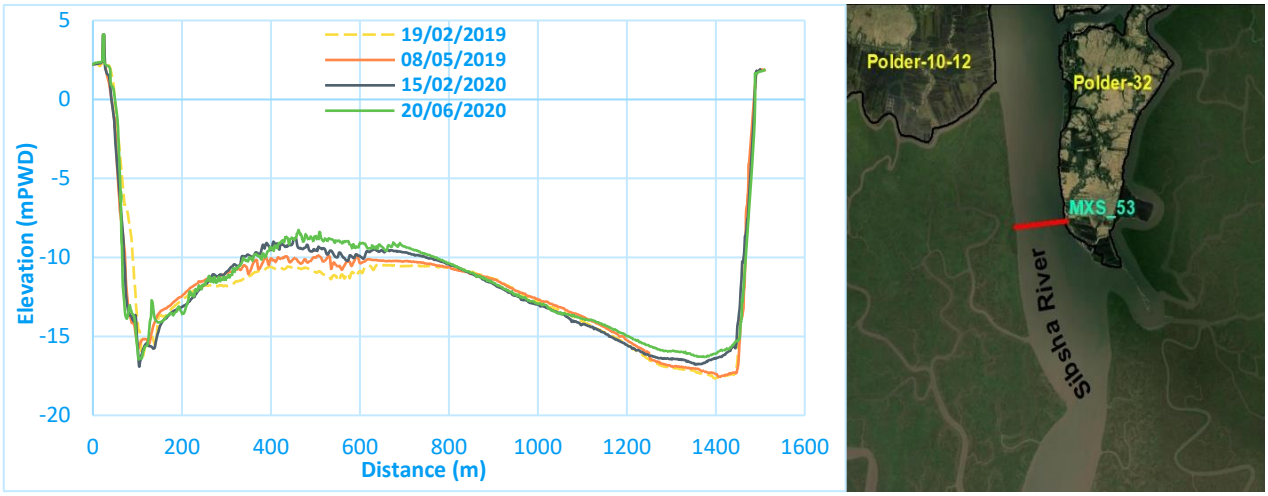

Figure 3-12: Superimposed monitoring section-53 of Sibsa River with location

On four occasions during the period from 19 February 2019 to 20 June 2020, the monitoring section-53 in Sibsa River was surveyed. Figure 3-12 shows the superimposed section with location. Findings of the analysis from monitoring section-53 of Sibsha River are summarized in Table 3-12. The monitoring surveys show that the top widths as compared to 19 February 2019 are increased on all events of the surveys in 08 May 2019, 15 February 2020 and 20 June 2020 by 8.88 m, 8.15 m and 10.44 m respectively due to bank erosion. The overall monitoring survey in 16 months demonstrates an average increase in top width by 9.16 m indicating bank erosion. As compared to the survey in

February 2019, the overall sectional areas of the river show decrease in area during May 2019, February 2020 and June 2020 by 237 m^2, 453 m^2 and 791m^2 respectively due to sedimentation. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 493.6 m^2 indicating siltation trend. Sibsha River is tidal in nature and erosion/deposition is mainly governed by the extent of the tidal flow and the upstream fresh waterflow during monsoon. Findings from the monitoring surveys show that the thalweg level as compared to 19 February 2019 is decreased in 08 May 2019, 15 February 2020 and 20 June 2020 by 0.10 m, 0.74 m and 1.21 m respectively. The average decrease in the thalweg level in 16 months as obtained from the monitoring survey is 0.68 m. As compared with the thalweg in 19 February 2019, thalwegs at the section are found to be shifted on all occasions of survey. The maximum shifting of 1296.55 m to the left occurs in 20 June 2020. In 08 May 2019 and 15 February 2020, the thalweg shifted by 11.05 m to the right and 1294.76 m to the left respectively. The frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 860.1 m to the left of the thalweg in February 2019. The changes in flood plain elevation during the monitoring period are negligible. The maximum change in elevation occurred on the left flood plain was increase in elevation by 0.05 m due to deposition of sediment in June 2020. On average in 16 months monitoring survey period, the left and right flood plain at the section experience increase in elevations by 0.017 m and 0.007 m respectively.

Table 3-12: Sibsha River Monitoring Section- 53, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
19/02/2019	2.25		1.85		1459.46	20718.21	14.20	1467.20	14.12	-17.66				
08/05/2019	2.25	0.00	1.86	0.01	1468.34	20481.40	13.95	1480.53	13.83	-17.56	8.88	-236.82	11.05m to R	-0.10
15/02/2020	2.26	0.00	1.86	0.01	1467.60	20265.16	13.81	1476.16	13.73	-16.92	8.15	-453.05	1294.76m to L	-0.74
20/06/2020	2.30	0.05	1.85	0.00	1469.90	19927.21	13.56	1484.85	13.42	-16.45	10.44	-791.00	1296.55m to L	-1.21
Average changes		0.017		0.007							9.16	-493.6	860.10m to L	-0.68

3.7 Lower Meghna River

Monitoring Section-68

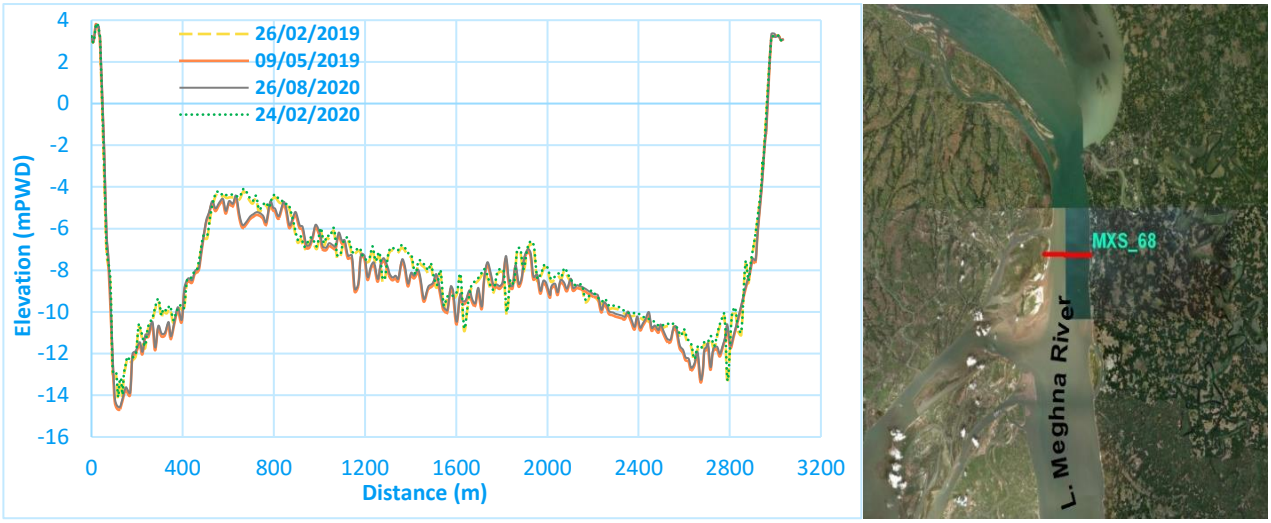

Figure 3-13: Superimposed monitoring section-68 of Lower Meghna River with location

The monitoring section-68 has been surveyed four times during the period from 26 February 2019 to 26 August 2020. Figure 3-13 shows the superimposed section with location. Findings from the analysis of Lower Meghna River monitoring section-68 are summarized in Table 3-13. The cross-sectional analysis of the river portion shows that the changes in top widths at bankfull stage as compared to the width in February 2019 are not that significant. In May 2019, the top width is slightly increased due to bank erosion by 0.04 m; later in February 2020 and August 2020 sedimentation caused the top width to reduce by 0.69 m and 1.57 m respectively as compared with the initial survey in February 2019. The overall monitoring survey in 18 months demonstrates an average reduction in top width by 0.74 m which is not that significant compared with the top width; although it is indicating the tendency in bank siltation. With respect to the survey in February 2019, the overall section of the river shows enlargement in area due to erosion in May 2019 and August 2020 by 1116 m^2 and 734 m^2 respectively. However, the section experiences reduction in area due to sedimentation in February 2020 by 379 m^2. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 490.37 m^2 indicating the development of erosion. Lower Meghna is a very dynamic river and tidal in nature and erosion/ deposition is mainly governed by the extent of tidal flow as well as the freshwater flow from the upstream during monsoon. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 is increased in May 2019 and August 2020 by 0.47 m and 0.34 m respectively; however, in February 2020 the level is reduced by 0.13 m. The average of the thalweg level in 18 months monitoring period is increased by 0.23 m as compared with the thalweg level in February 2019. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the right on all events of survey during May 2019, February 2020 and August 2020 by 8 m, 0.7 m and 9 m respectively. This frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 5.67 m to the right of the thalweg in February 2019. Figure 3-13 shows changes in flood plain elevations with respect to the flood plain in February 2019. No significant changes in elevations are observed. The maximum increase in elevations of the left flood plain by 0.05 m due to sedimentation are occurred in February 2020 and August 2020. On the average in 18 months monitoring survey period, the left and right flood plain at the section experience increase in elevations by 0.03 m and 0.01 m respectively.

Table 3-13: Lower Meghna River Monitoring Section- 68, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
26/02/2019	3.31		3.15		2944.58	33379.20	11.34	2951.45	11.31	-14.21				
09/05/2019	3.30	-0.01	3.16	0.01	2944.62	34495.25	11.71	2950.68	11.69	-14.68	0.04	1116.05	7.66m to R	0.47
24/02/2020	3.36	0.05	3.15	0.00	2943.89	33000.43	11.21	2950.81	11.18	-14.08	-0.69	-378.77	0.7m to R	-0.13
26/08/2020	3.36	0.05	3.19	0.03	2943.01	34113.04	11.59	2949.02	11.57	-14.55	-1.57	733.84	8.66m to R	0.34
Average changes		0.03		0.01							-0.74	490.37	5.67m to R	0.23

Monitoring Section-72

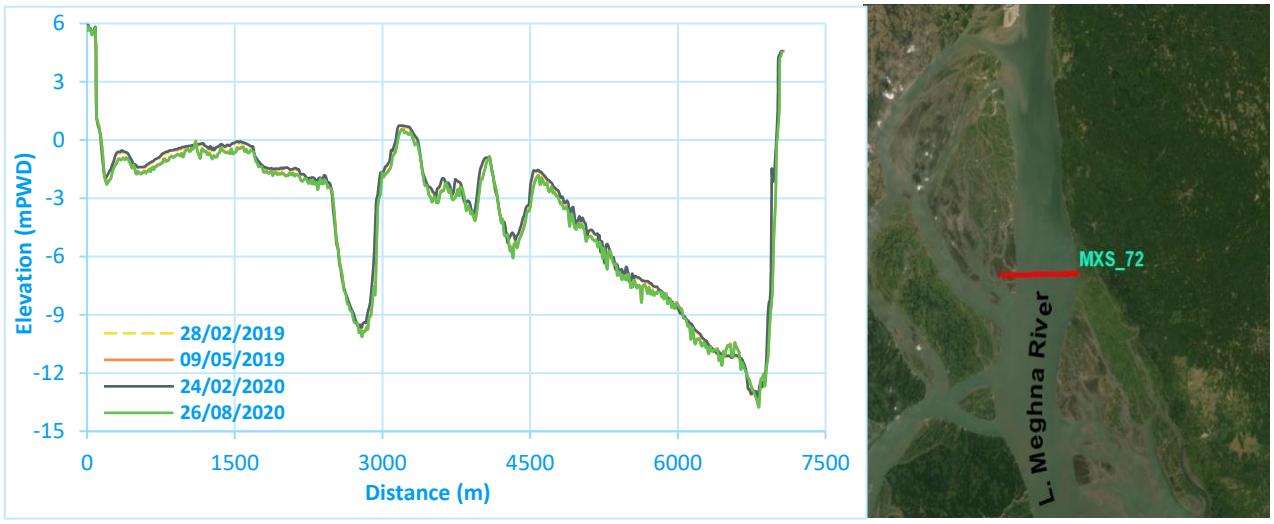

Figure 3-14: Superimposed monitoring section-72 of Lower Meghna River with location

The monitoring section-72 in Lower Meghna River has been surveyed four times during the period from 28 February 2019 to 26 August 2020. Figure 3-14 summarizes the superimposed section with location. Findings of the analysis from monitoring section-72 of Lower Meghna River are summarized in Table 3-14. The cross-sectional analysis of the river portion shows that the top widths at bankfull stage as compared to the width in February 2019 are increased in May 2019 and August 2020 due to bank erosion by 14.47 m and 14.76 m. In February 2020 sedimentation caused the top width to reduce

slightly by 0.5 m. The overall monitoring survey in 18 months demonstrates an average increase in top width by 9.58 m indicating the tendency in bank erosion. With respect to the survey in February 2019, the overall section of the river shows enlargement in area due to erosion in May 2019 and August 2020 by 1644 m^2 and 1922 m^2 respectively. However, the section experiences reduction in area due to sedimentation in February 2020 by 485 m^2. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 1026.71 m^2 indicating the development of erosion. Lower Meghna River is a very dynamic river and tidal in nature. Erosion/ deposition in the river is mainly governed by the extent of tidal flow as well as the freshwater flow from the upstream during monsoon. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 is increased in May 2019 and August 2020 by 0.41 m and 0.45 m respectively; however, in February 2020 the level is reduced by 0.07 m. The average of the thalweg level in 18 months monitoring period is increased by 0.26 m. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the right on all the occasions of survey in May 2019, February 2020 and August 2020 by 17.87 m, 0.8 m and 18 m respectively. This frequent shifting of the thalweg indicates the dynamic nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 12.25 m to the right of the thalweg in 28 February 2019. The table below shows changes in flood plain elevations with respect to the flood plain in February 2019. No significant changes in elevation are observed. The maximum raise in elevation of the left flood plain due to sedimentation of 0.07 m has occurred in February 2020. On the average in 18 months monitoring survey period, the left and right flood plain at the section experience increase in elevations by 0.05 m and 0.003 m respectively.

Table 3-14: Lower Meghna River Monitoring Section- 72, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
28/02/2019	5.63		4.42		6930.75	56853.97	8.20	6935.55	8.20	-13.31				
09/05/2019	5.69	0.06	4.44	0.03	6945.22	58497.69	8.42	6949.67	8.42	-13.72	14.47	1643.72	17.87m to R	0.41
24/02/2020	5.70	0.07	4.44	0.03	6930.25	56368.83	8.13	6935.03	8.13	-13.24	-0.50	-485.14	0.8m to R	-0.07
26/08/2020	5.65	0.02	4.37	-0.05	6945.51	58775.50	8.46	6949.97	8.46	-13.76	14.76	1921.54	18.07m to R	0.45
Average changes		0.05		0.003							9.58	1026.71	12.25m to R	0.26

3.8 Dhaki River:

Monitoring Section-20

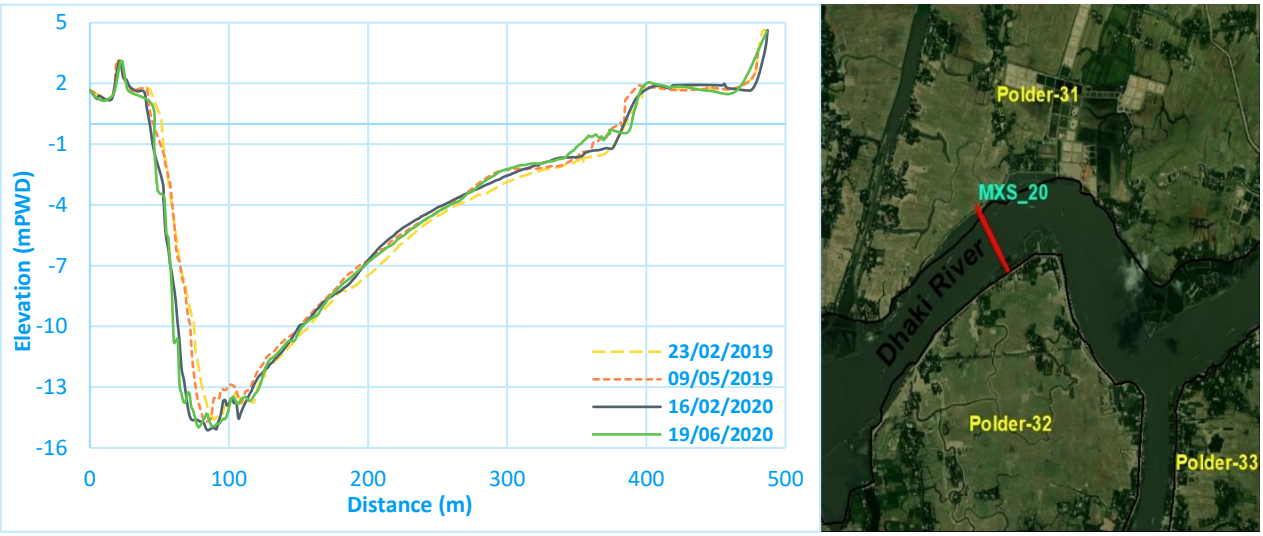

Figure 3-15: Superimposed monitoring section-20 of Dhaki River with location

Monitoring section-20 in Dhaki River has been surveyed four times during the period from 23 February 2019 to 19 June 2020. Figure 3-15 shows the superimposed section with location. Findings of the analysis from monitoring section-20 of Dhaki River are summarized in Table 3-15. The cross-sectional analysis of the river portion shows that the top width at bankfull stage as compared to the width in February 2019 is decreased by 3.58 m in May 2019 due to sedimentation on the riverbanks. However, in February 2020 and June 2020 bank erosion caused the top width to increase by 3.92 m and 2.13 m respectively. The overall monitoring survey in 16 months demonstrates an average increase in top width by 8.2 m indicating bank erosion. As compared to the survey in February 2019, the overall section of the river shows reduction in area due to sedimentation in May 2019 by 113 m^2. However, the section experiences increase in area due to erosion in February 2020 and June 2020 by 43 m^2 and 45 m^2 respectively. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 8.3 m^2 indicating the development of siltation. Dhaki River is tidal in nature and Erosion/ deposition in the river is mainly governed mostly by the extent of tidal flow. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 are increased on all the occasions of survey in May 2019, February 2020 and June2020 by 0.11 m, 0.54 m and 0.4 m respectively. The average of the thalweg level in 16 months monitoring period is increased by 0.35 m as compared with the thalweg level in 23 February 2019. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the left on all the occasions of survey in May 2019, February 2020 and June 2020 by 5 m, 4 m and 11 m respectively. This frequent shifting of the thalweg indicates the active characteristic of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 6.7 m to the right of the thalweg in 23 February 2019. The table below shows changes in flood plain elevations with respect to the flood plain in February 2019. No significant changes in elevation are observed. Embankments exist on both sides of the river section. 20 m survey extending to the left from Outside toe of the left embankment has been considered as the left flood plain. However, regarding right floodplain, the strip of land between the right bank at bankfull stage and the toe of the right r/s (riverside) embankment is considered as the right flood plain. Outside the right embankment no survey is carried out. The left flood plain experiences reduction in elevation due to erosion on all the occasions of monitoring surveys ranging from 0.01 m to 0.10 m. Changes in the right flood plain ranges from 0.04 m erosion in May 2019 to 0.02 m accretion in February 2020 and June 2020. On the average in 16 months monitoring survey period, the left flood plain at the section experiences decrease in elevation by 0.07 m; however, there has been no change in the average of right flood plain elevations as compared to the right flood plain in 23 February 2019.

Table 3-15: Dhaki River Monitoring Section- 20, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
23/02/2019	1.44		1.70		345.39	2486.46	7.20	349.87	7.11	-14.59				
09/05/2019	1.44	-0.01	1.66	-0.04	341.80	2373.10	6.94	346.97	6.84	-14.70	-3.58	-113.36	5.24m to L	0.11
16/02/2020	1.35	-0.09	1.72	0.02	349.30	2529.62	7.24	354.78	7.13	-15.13	3.92	43.16	4.27m to L	0.54
19/06/2020	1.34	-0.10	1.71	0.02	347.52	2531.76	7.29	355.92	7.11	-14.99	2.13	45.30	10.59m to L	0.40
Average changes		-0.07		0.0							8.2	-8.3	6.7m to L	0.35

Monitoring Section-23

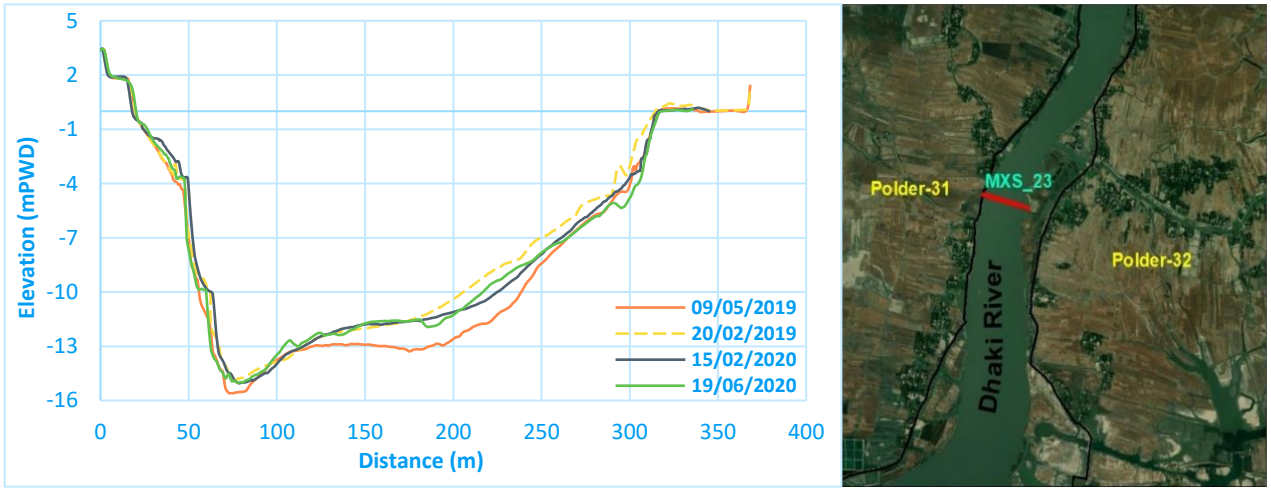

Figure 3-16: Superimposed monitoring section-23 of Dhaki River with location

The monitoring section-23 in Dhaki River has been surveyed four times during the period from 20 February 2019 to 19 June 2020. Figure 3-16 shows the superimposed section with location. Findings from the analysis of Dhaki River monitoring section-23 are summarized in Table 3-16. The cross-sectional analysis of the river portion shows that the changes in top widths at bankfull stage as compared to the width in February 2019 are increased in May 2019, February 2020 and June 2020 due to bank erosion by 3.08 m, 3.62 m and 3.7 m respectively. The overall monitoring survey in 16 months demonstrates an average increment in top width by 3.47 m indicating bank siltation. With respect to the survey in February 2019, the overall section of the river shows enlargement in area due to erosion in May 2019, February 2020 and June 2020 by 320 m^2, 89 m^2 and 136 m^2 respectively. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 181.67 m^2 indicating the development of scouring/ erosion. Dhaki River river is tidal in nature

and erosion/ deposition is mainly governed by the magnitude of the tidal flow. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 are increased during May 2019, February 2020 and June 2020 by 0.67 m, 0.11 m and 0.08 m respectively. The average increase in the thalweg level in 16 months monitoring period has been 0.29 m. Thalwegs at the section as compared with the thalweg in February 2019 are found to be shifted in all survey events. In May 2019, it is shifted to the left by 1.72 m; Later in Februay 2020 and June 2020 the thalweg has been shifted to the right by 2.53 m and 1.75 m respectively. This frequent shifting of the thalweg although the extents are not that significant indicates the active nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 0.85 m to the right of the thalweg in 20 February 2019. Figure 3-16 shows changes in flood plain elevations with respect to the flood plain in February 2019. The maximum change in elevation of the left flood plain occurred due to erosion in June 2020 by 0.2 m. On the right flood plain erosions have been found on all the occasions of monitoring survey ranging from 0.11 m to 0.15 m. On the average in 16 months monitoring survey period, the left and right flood plain at the section experience decrease in elevations by 0.03 m and 0.14 m respectively.

Table 3-16: Dhaki River Monitoring Section- 23, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
20/02/2019	1.38		0.19		294.90	2639.75	8.95	301.25	8.76	-14.93				
09/05/2019	1.46	0.09	0.04	-0.15	297.98	2959.85	9.93	302.97	9.77	-15.60	3.08	320.10	1.72m to L	0.67
15/02/2020	1.40	0.02	0.08	-0.11	298.52	2728.34	9.14	304.07	8.97	-15.04	3.62	88.59	2.53m to R	0.11
19/06/2020	1.18	-0.20	0.04	-0.15	298.59	2776.08	9.30	304.92	9.10	-15.01	3.70	136.33	1.75m to R	0.08
Average changes		-0.03		-0.14							3.47	181.67	0.85m to R	0.29

3.9 Kobadak River:

Monitoring Section-38

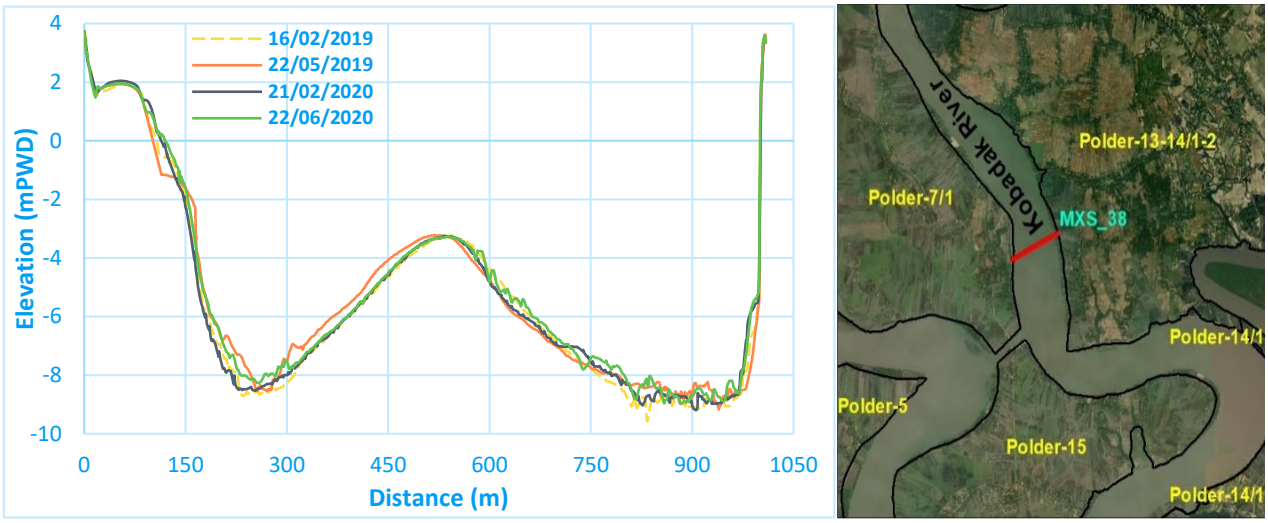

Figure 3-17: Superimposed monitoring section-38 of Kobadak River with location

The monitoring section-38 in Kobadak River has been surveyed four times during the period from 16 February 2019 to 22 June 2020. Figure 3-17 shows the superimposed section with location. Findings of the analysis from monitoring section-38 of Kobadak River area summarized in Table 3-17. The cross-sectional analysis of the river portion shows that the top width at bankfull stage as compared to the width in February 2019 is increased on all the occasions of monitoring survey in May 2019, February 2020 and June 2020 by 2.26 m, 1.92 m and 1.52 m due to riverbank erosions. The overall monitoring survey in 16 months demonstrates an average increase in top width by 1.9 m indicating the tendency in bank erosion. As compared to the survey in February 2019, the overall section of the river shows reduction in area due to sedimentation in May 2019 by 178 m^2, in February 2020 by 54 m^2 and in June 2020 by 235 m^2. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 155.5 m^2 indicating the development of siltation. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 are decreased on all the occasions of survey in May 2019, February 2020 and June 2020 by 0.38 m, 0.36 m and 0.58 m respectively. The average of the thalweg level in 16 months monitoring period has been reduced by 0.44 m as compared with the thalweg level in 16 February 2019. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the right on all the occasions of survey in May 2019, February 2020 and June 2020 by 106 m, 73 m and 49 m respectively. This frequent shifting of the thalweg indicates the active characteristic of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 76.14 m to the right of the thalweg in 16 February 2019. The table below shows changes in elevations of the left flood plain with respect to the flood plain in February 2019. Kobadak River is embanked on both sides of this section. The strip of land of around 65 m between the left bank at bank full stage and the toe of the left embankment is considered left flood plain where monitoring surveys are conducted. The changes in left flood plain elevations are insignificant and the maximum increase in the level due to sedimentation is occurred in February 2020 by 0.09 m. On the average in 16 months monitoring survey period, the left flood plain at the section experiences increase in elevations by 0.063 m.

Table 3-17: Kobadak River Monitoring Section- 38, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
16/02/2019	1.69		Not Surveyed		915.27	7046.81	7.70	921.82	7.64	-9.55				
22/05/2019	1.73	0.05	Not Surveyed		917.53	6868.83	7.49	924.46	7.43	-9.17	2.26	-177.98	106.13m to R	-0.38
21/02/2020	1.78	0.09	Not Surveyed		917.19	6992.84	7.62	924.87	7.56	-9.19	1.92	-53.98	73.23m to R	-0.36
22/06/2020	1.74	0.05	Not Surveyed		916.79	6812.23	7.43	923.39	7.38	-8.97	1.52	-234.59	49.05m to R	-0.58
Average changes		0.063									1.9	-155.5	76.14m to R	-0.44

Monitoring Section-41

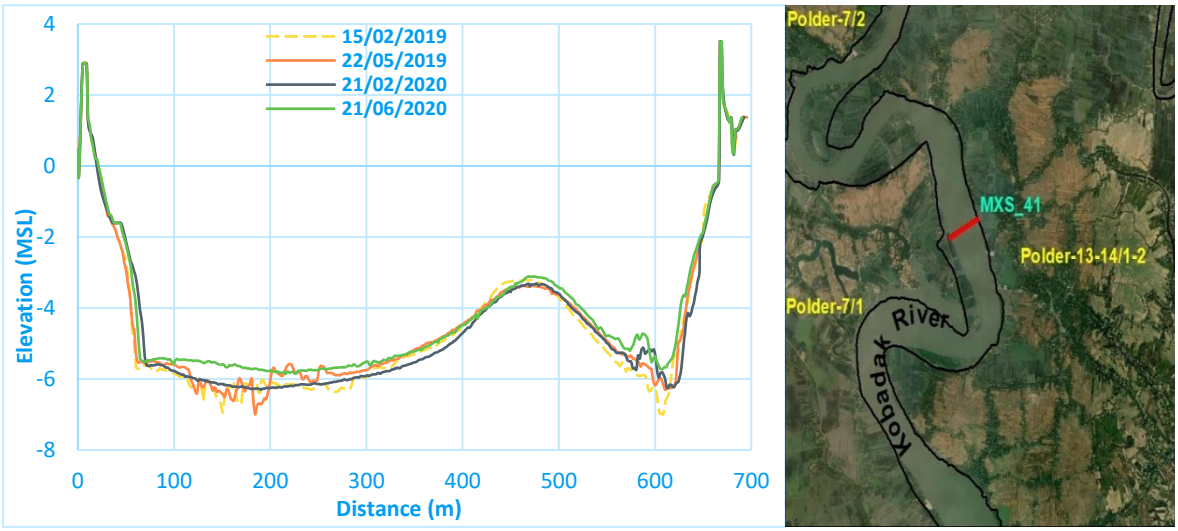

Figure 3-18: Superimposed` monitoring section-41of Kobadak River with location

This monitoring section-41 in Kobadak River has been surveyed four times during the period from 15 February 2019 to 21 June 2020. Figure 3-18 shows the superimposed section with location. Findings of the analysis from monitoring section-41 of Kobadak River are summarized in Table 3-18. The cross-sectional analysis of the river portion shows that the top width at bankfull stage as compared to the width in February 2019 is reduced in May 2019 and June 2020 by 0.15 m and 1.18 m due to riverbank sedimentation. However, erosion caused the top width to be increased in February 2020 by 0.28 m only. The overall monitoring survey in 16 months demonstrates an average reduction in top width by

0.35 m which is insignificant compared with the top width of the river. As compared to the survey in February 2019, the overall section of the river shows reduction in area on all the occasions of monitoring surveys due to sedimentation in May 2019 by 72 m^2, in February 2020 by 37 m^2 and in June 2020 by 240 m^2. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 116.45 m^2 indicating the process of siltation. Findings from the monitoring surveys show that the thalweg level as compared to February 2019 is increased to a very negligible amount in May 2019 by 0.01 m. In February 2020 and June 2020 the thalweg levels are decreased by 0.69 m and 1.13 m respectively. The average of the thalweg level in 16 months monitoring period has been decreased by 0.6 m. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the left on all the occasions of survey in May 2019, February 2020 and June 2020 by 424 m, 418 m and 392 m respectively. This frequent shifting of the thalweg indicates the active characteristic of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 411.58 m to the right of the thalweg in 15 February 2019. No flood plain surveys are carried out at this section of Kobadak river. The river is embanked on both sides of the section and no offset distances between the banks and the dyke exist.

Table 3-18: Kobadak River Monitoring Section- 41, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
15/02/2019	Not Surveyed		Not Surveyed		655.54	3957.89	6.04	658.57	6.01	-6.53				
22/05/2019	Not Surveyed		Not Surveyed		655.39	3885.45	5.93	686.59	5.66	-6.54	-0.15	-72.44	424.21m to L	0.01
21/02/2020	Not Surveyed		Not Surveyed		655.82	3921.25	5.98	676.30	5.80	-5.84	0.28	-36.63	418.11m to L	-0.69
21/06/2020	Not Surveyed		Not Surveyed		654.37	3717.60	5.68	672.96	5.52	-5.40	-1.18	-240.29	392.43m to L	-1.13
Average changes											-0.35	-116.45	411.58m to L	-0.6

3.10 Chunkuri River

Monitoring Section-14

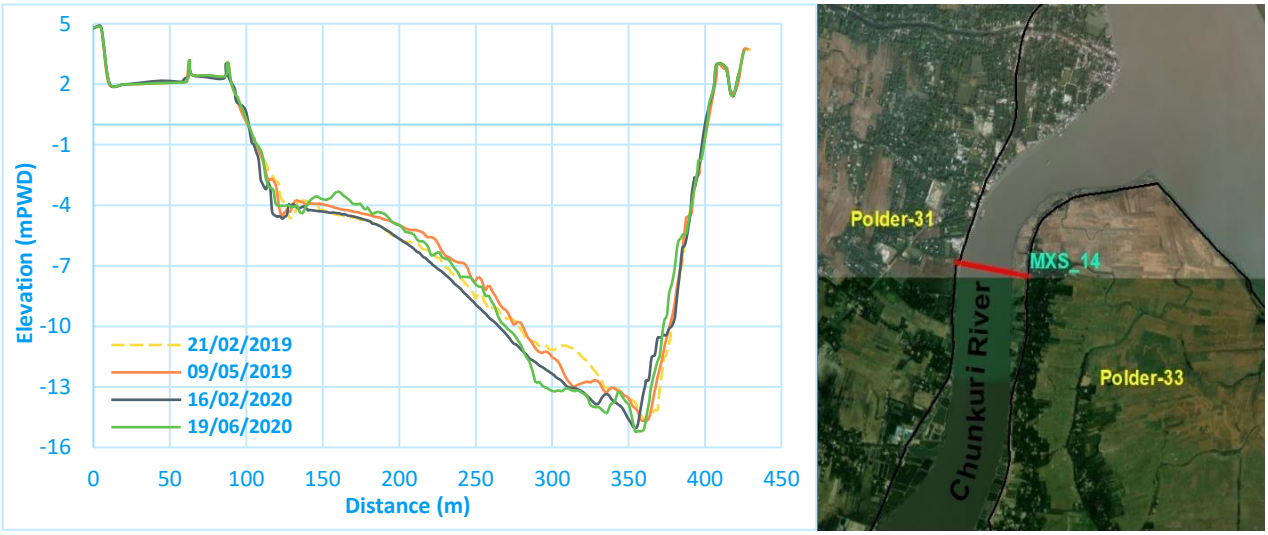

Figure 3-19: Superimposed monitoring section-14 of Chunkuri River with location

The monitoring section-14 in Chunkuri River has been surveyed four times during the period from 21 February 2019 to 19 June 2020. Figure 3-19 shows the superimposed section with location. Findings from the analysis of Chunkuri River monitoring section-14 are summarized in Table 3-19. The cross-sectional analysis of the river portion shows that the top width at bankfull stage as compared to the width in February 2019 is slightly increased in May 2019 by 0.69 m due to bank erosion. Later in February 2020, top width is reduced by 0.39 m due to sedimentation. However, in June 2020, there has been no change in top width as compared with the width in February 2019. The overall monitoring survey in 16 months demonstrates an average increase in top width by 0.10 m which is not that significant compared with the top width of the river; although it is indicating the tendency in bank erosion. With respect to the survey in February 2019, the overall section of the river shows reduction in area due to sedimentation in May 2019 by 32 m^2; but in February 2020 and June 2020, the river experiences increase in area due to erosion by 123 m^2 and 29 m^2 respectively. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 39.86 m^2 indicating the process of scouring/ erosion. Chunkuri River is tidal in nature and erosion/ deposition is mainly governed by the magnitude of the tidal flow. Findings from the monitoring surveys show that the thalweg levels as compared to February 2019 are increased during May 2019, February 2020 and June 2020 by 0.11 m, 0.45 m and 0.64 m respectively. The average of the thalweg level in 16 months monitoring period has been increased by 0.4 m. Thalwegs at the section as compared with the thalweg in February 2019 are found to be shifted to the Left on all the events of monitoring survey ranging from 1 m in May 2019 to 7 m in February 2020. This frequent shifting of the thalweg although the extents are not that significant indicates the active nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 4.77 m to the left of the thalweg in 21 February 2019. The table below shows no significant changes in left flood plain elevations. On the average in 16 months monitoring survey period, the left flood plain at the section experiences negligible decrease in elevations due to siltation by 0.003 m. Regarding right flood plain elevation, no offset distance exists between the right bank and the right embankment and beyond the right embankment survey was not carried out.

Table 3-19: Chunkuri River Monitoring Section-14, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
21/02/2019	2.22		Not Surveyed		315.39	2922.75	9.27	321.31	9.10	-14.57				
09/05/2019	2.22	0.00	Not Surveyed		316.09	2890.40	9.14	321.57	8.99	-14.68	0.69	-32.35	1.12m to L	0.11
16/02/2020	2.21	-0.01	Not Surveyed		315.00	3045.49	9.67	321.52	9.47	-15.02	-0.39	122.74	7.04m to L	0.45
19/06/2020	2.22	0.00	Not Surveyed		315.39	2951.95	9.36	321.33	9.19	-15.21	0.00	29.20	6.16m to L	0.64
Average changes		-0.003									0.10	39.86	4.77m to L	0.40

Monitoring Section-17

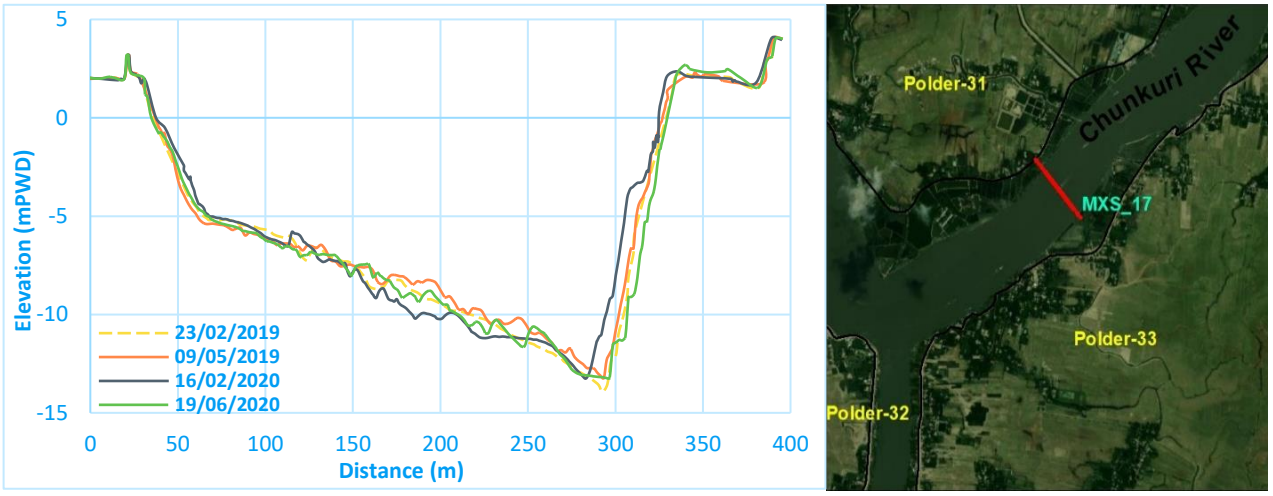

Figure 3-20: Superimposed monitoring section-17 of Chunkuri River with location

The monitoring section-17 in Chunkuri River has been surveyed four times during the period from 23 February 2019 to 19 June 2020. Figure 3-20 shows the superimposed section with location. Findings of the analysis from monitoring section-17 of Chunkuri River are summarized in Table 3-20. The cross-sectional analysis of the river portion shows that the top width at bankfull stage as compared to the width in February 2019 is increased in May 2019 due to riverbank erosion. Later in February 2020, riverbank sedimentation caused the top width to reduce by 6.5 m. However, in June 2020 slight

reduction in top width occurred with respect to the width in February 2019. The overall monitoring survey in 16 months demonstrates an average reduction in top width by 1.33 m indicating the tendency in bank siltation. As compared to the survey in February 2019, the overall section of the river shows reduction in area during May 2019 and February 2020 by 81 m^2 and 82 m^2 respectively due to sedimentation. In June 2020, the sectional area is increased due to the cause of erosion by 39 m^2. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 41 m^2 indicating the development of siltation. Findings from the monitoring surveys show that the thalweg level as compared to the thalweg in February 2019 is decreased during all the events of survey in May 2019, February 2020 and June 2020 by 0.7 m, 0.67 m and 0.7 m respectively. The average of the thalweg level at the section in 16 months monitoring period has been reduced by 0.69 m. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted on all the occasions of monitoring surveys. In May 2019 and June 2020 thalwegs have been found to be shifted to the right of the thalweg in February 2020 by 0.83 m and 2.27m respectively. However, In February 2020, maximum shifting of the thalweg to the left is occurred by 9.5 m. This frequent shifting of the thalweg indicates the active nature of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 2.15 m to the left of the thalweg in 23 February 2019. The river is embanked on both sides of the section. On the left side, survey is carried out beyond the embankment into the countryside by to around 15 m. This portion is considered as the left flood plain in the analysis which shows insignificant changes in elevations. Regarding right flood plain, the strip of land between the right bank and the toe of right embankment has been surveyed and considered as the right flood plain. The changes in elevations of the right flood plain as obtained from the monitoring survey shows sedimentation ranging from 0.03 m in February 2020 to 0.29 in June 2020. On the average in 16 months monitoring survey period, the left flood plain at the section experiences decrease in elevation by 0.01 m; however, the right flood plain undergoes an average increase in elevation by 0.14m.

Table 3-20: Chunkuri River Monitoring Section- 17, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
23/02/2019	2.01		1.96		303.30	2865.03	9.45	308.12	9.30	-13.93				
09/05/2019	2.00	-0.01	2.06	0.11	305.86	2784.63	9.10	311.14	8.95	-13.23	2.56	-80.40	0.83m to R	-0.70
16/02/2020	1.98	-0.03	1.98	0.03	296.76	2783.21	9.38	303.14	9.18	-13.26	-6.53	-81.82	9.54m to L	-0.67
19/06/2020	2.02	0.01	2.25	0.29	303.26	2904.24	9.58	309.48	9.38	-13.23	-0.03	39.21	2.27m to R	-0.70
Average changes		-0.01		0.14							-1.33	-41.0	2.15m to L	-0.69

3.11 Baleswar River:

Monitoring Section-08

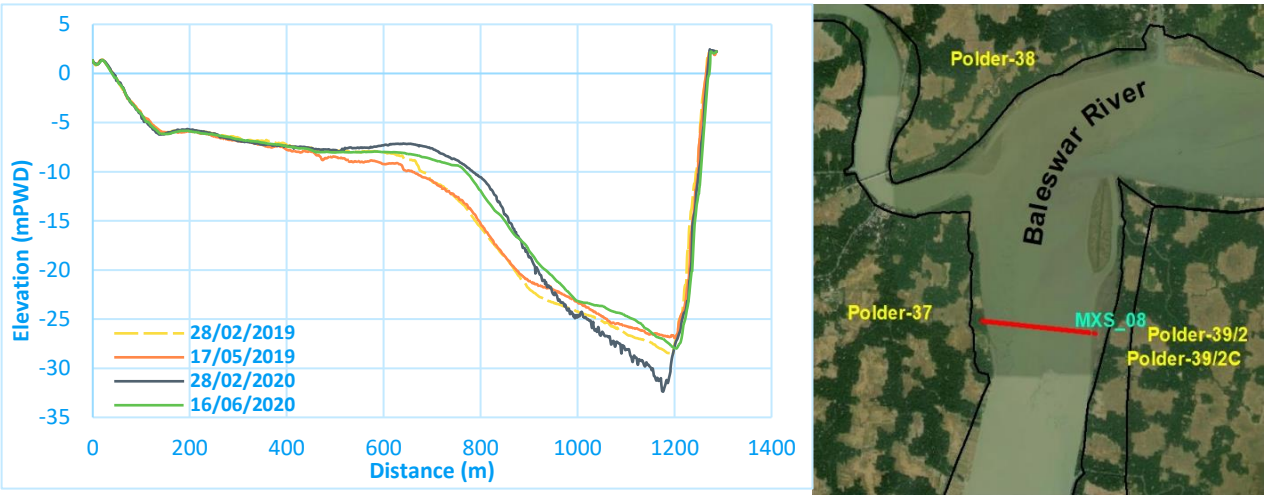

Figure 3-21: Superimposed monitoring section-08 of Baleswar River with location

Cross sections surveys in the monitoring section-08 of Baleswar River were carried out on four occasions during the period from 28 February 2019 to 16 June 2020. Figure 3-21 shows the superimposed section with location. Findings from the analysis of monitoring section-08 of Baleswar River are summarized in Table 3-21. As compared with the survey in February 2019, the top widths at bank full stage on all occasions of the surveys in May 2019, February 2020 and June 2020 are enlarged due to bank erosions by 0.95 m, 0.92 m and 6.82 m respectively. The overall monitoring survey in 16 months demonstrates an average increase in top width by 2.9 m indicating the tendency in bank erosion. The table shows that the sectional area of the river in May 2019 compared to the area in February 2019 is enlarged by 44 m^2 due to erosion. However, the section experienced reduction in areas due to sedimentation in February 2020 and June 2020 by 587 m^2 and 947 m^2 respectively. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 496.66 m^2 indicating the development of siltation. Baleswar River is a tidal in nature and the erosion and sedimentation processes in the river is mostly influenced by the magnitude of tidal flow as well as by the upstream freshwater flow during monsoon. Findings from the monitoring surveys show that the thalweg level as compared to 28 February 2019 is decreased in 17 May 2019 and 16 June 2020 by 1.74 m and 0.64 m respectively. However, the thalweg has been found to be increased by 3.73 m in February 2020. The average of the thalweg level in 16 months monitoring period has been increased by 0.45 m. Thalwegs at the section in May 2019 and June 2020 are found to be shifted to the right from the thalweg in February 2019 by 8.69 m and 8.34 m respectively. However, the maximum shifting of the thalweg was occurred in February 2020 by 15.84 m to the left. The overall monitoring survey demonstrates an average shifting of the thalweg by only 0.4 m to the right of the thalweg in 28 February 2019. Considering the dynamic behaviour of the river the extent of thalweg shifting as obtained from the monitoring surveys are minor. Sedimentation on the left flood plain according to the monitoring survey has not been found significant. The maximum change of 0.08 m in elevation of the left flood plain has occurred in February 2019 due to sedimentation. On the average in 16 months monitoring survey period, the left flood plain at the section experiences increase in elevation by 0.04 m. Monitoring survey has not been carried out on the right flood plain due to the existence of Sundarban forest.

Table 3-21: Baleswar River Monitoring Section- 08, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
28/02/2019	1.07		Forest		1237.78	17215.83	13.91	1247.59	13.80	-28.65				
17/05/2019	1.10	0.03	Forest		1238.74	17259.84	13.93	1247.67	13.83	-26.91	0.95	44.01	8.69m to R	-1.74
28/02/2020	1.14	0.08	Forest		1238.70	16629.18	13.42	1253.27	13.27	-32.38	0.92	-586.65	15.84m to L	3.73
16/06/2020	1.07	0.00	Forest		1244.60	16268.50	13.07	1252.86	12.99	-28.01	6.82	-947.33	8.34m to R	-0.64
Average changes		0.04									2.9	-496.66	0.4m to R	0.45

Monitoring Section-11

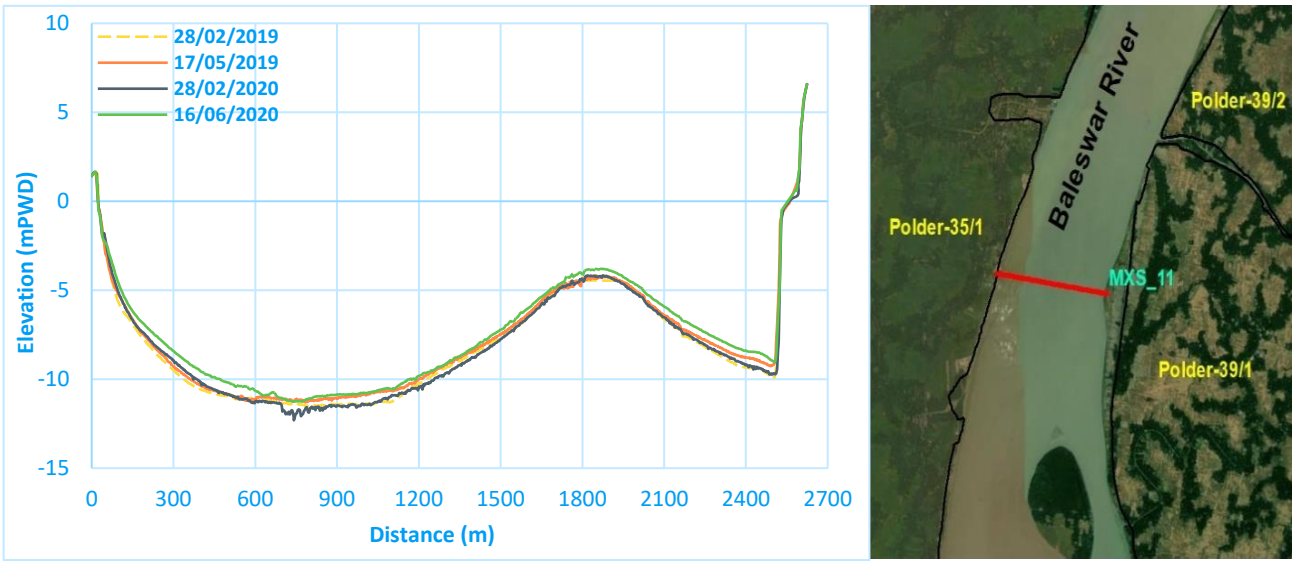

Figure 3-22: Superimposed monitoring section-11 of Baleswar River with location

Cross sections surveys for the monitoring section-11 in Baleswar River were carried out on four occasions during the period from 28 February 2019 to 16 June 2020. Figure 3-22 shows the superimposed section with location. Findings of the analysis from monitoring section-11 of Baleswar River are summarized in Table 3-22. As compared with the survey in February 2019, the top widths at bank full stage on all occasions of the surveys in May 2019, February 2020 and June 2020 are reduced due to river bank sedimentations by 16.28 m, 4.5 m and 20 m respectively. The overall monitoring survey in 16 months demonstrates an average reduction in top width by 13.6 m indicating bank siltation. The table shows that the sectional areas of the river compared to the area in February 2019 are reduced on all events of monitoring survey in May 2019, February 2020 and June 2020 by

638 m^2, 68 m^2 and 1520 m^2 respectively due to river sedimentation. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 742.25 m^2 indicating the development of siltation. Baleswar River is a tidal in nature and the erosion and sedimentation processes in the river is mostly influenced by the magnitude of tidal flow and also on the upstream freshwater flow during monsoon. Findings from the monitoring surveys show that the changes in thalweg levels as compared to 28 February 2019 are negligible. In 17 May 2019 and in 16 June 2020 the thalweg levels are decreased by only 0.24 m and 0.28 m respectively. However, the thalweg level has been found to the increased by 0.77 m in February 2020. The average of the thalweg level in 16 months monitoring period is increased by 0.08 m as compared with the thalweg level in 28 February 2019. Thalwegs at the section on all the events of monitoring surveys in May 2019, February 2020 and June 2020 are found to be shifted to the left from the thalweg in February 2019 by 13 m, 54 m and 23 m respectively. The shifting of the thalweg indicates the dynamic characteristic of the river. The overall monitoring survey demonstrates an average shifting of the thalweg by 29.79 m to the left of the thalweg in 28 February 2019. Monitoring surveys on the flood plains are not carried out.

Table 3-22: Baleswar River Monitoring Section- 11, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
28/02/2019	Not Surveyed		Not Surveyed		2562.53	22002.13	8.59	2565.72	8.58	-11.54				
17/05/2019	Not Surveyed		Not Surveyed		2546.25	21363.94	8.39	2549.55	8.38	-11.30	-16.28	-638.19	12.52m to L	-0.24
28/02/2020	Not Surveyed		Not Surveyed		2558.04	21933.79	8.57	2561.65	8.56	-12.31	-4.50	-68.33	53.65m to L	0.77
16/06/2020	Not Surveyed		Not Surveyed		2542.52	20481.89	8.06	2545.02	8.05	-11.26	-20.01	-1520.24	23.20m to L	-0.28
Average changes											-13.60	-742.25	29.79m to L	0.08

3.12 Galachipa River:

Monitoring Section-62

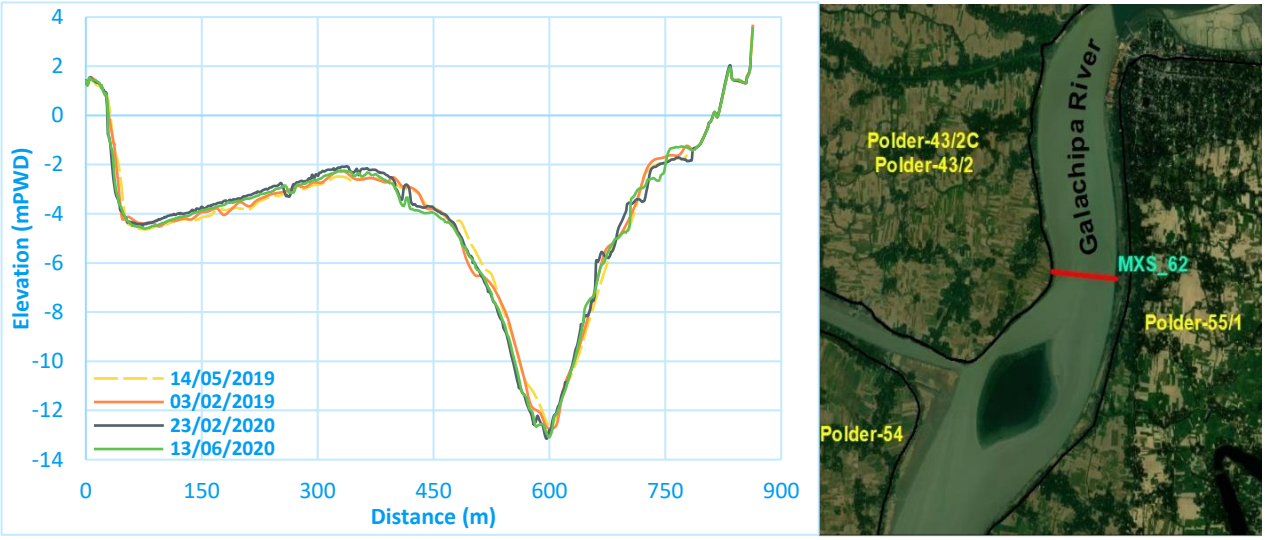

Figure 3-23: Superimposed monitoring section-62 of Galachipa River with location

The monitoring section-62 in Galachipa River has been surveyed four times during the period from 02 March 2019 to 13 June 2020. Figure 3-23 shows the superimposed section with location. Findings of the analysis from monitoring section-62 of Galachipa River are summarized in Table 3-23. The cross-sectional analysis of the river portion shows that the top width at bank full stage as compared to the width in 02 March 2019 is increased by 2.34 m in May 2019 due to riverbank erosion. Later in February 2020 and June 2020, riverbank sedimentation caused the top width to reduce by 0.12 m and 0.87 m respectively. The overall monitoring survey in 16 months demonstrates an average increase in top width by 0.45 m which is not significant compared with the top width. As compared to the survey in February 2019, the overall section of the river shows enlargement in area during May 2019 and June 2020 by 17 m^2 and 58 m^2 respectively due to erosion. In February 2020, the sectional area is reduced slightly due to the cause of sedimentation by 2.3 m^2. The section during the monitoring period undergoes an average enlargement in the cross-sectional area by 24.27 m^2 indicating the development of scouring/ erosion. Findings from the monitoring surveys show that the thalweg level as compared to the thalweg in February 2019 is decreased in May 2019. However, increases in thalweg levels have occurred in February 2020 and June 2020 by 0.44 m and 0.38 m respectively. The average of the thalweg level in 16 months monitoring period is increased by 0.24 m as compared with the thalweg level in 2 March 2019. Thalwegs at the section with respect to the thalweg in February 2019 are found to be shifted to the right in May 2019 and June 2020 by 1.91 m and 2.51 m whereas in February 2020 it was shifted to the left by 0.83 m. The overall monitoring survey demonstrates an average shifting of the thalweg by 1.2 m to the right of the thalweg in 2 March 2019. Monitoring survey for the flood plain elevations are carried out to about 20 m on either side of the section from the river banks. The changes in elevation of the left and right flood plains compared to the initial survey on 2 March 2019 are minor and not significant. On the average in 16 months monitoring survey period, the left flood plain at the section experiences decrease in elevation due to erosion by 0.01 m; however, the right flood plain undergoes an average increase elevation by 0.003 m as compared to the right flood plain in 2 March 2019.

Table 3-23: Galachipa River Monitoring Section- 62, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
02/03/2019	1.36		1.46		807.73	4538.73	5.62	809.57	5.61	-12.71				
14/05/2019	1.34	-0.02	1.46	0.00	810.07	4555.97	5.62	811.65	5.61	-12.61	2.34	17.24	1.91m to R	-0.10
23/02/2020	1.36	0.01	1.47	0.01	807.61	4536.43	5.62	811.10	5.59	-13.15	-0.12	-2.30	0.83m to L	0.44
13/06/2020	1.33	-0.02	1.46	0.00	806.86	4596.60	5.70	809.41	5.68	-13.09	-0.87	57.87	2.51m to R	0.38
Average changes		-0.01		0.003							0.45	24.27	1.20m to R	0.24

Monitoring Section-65

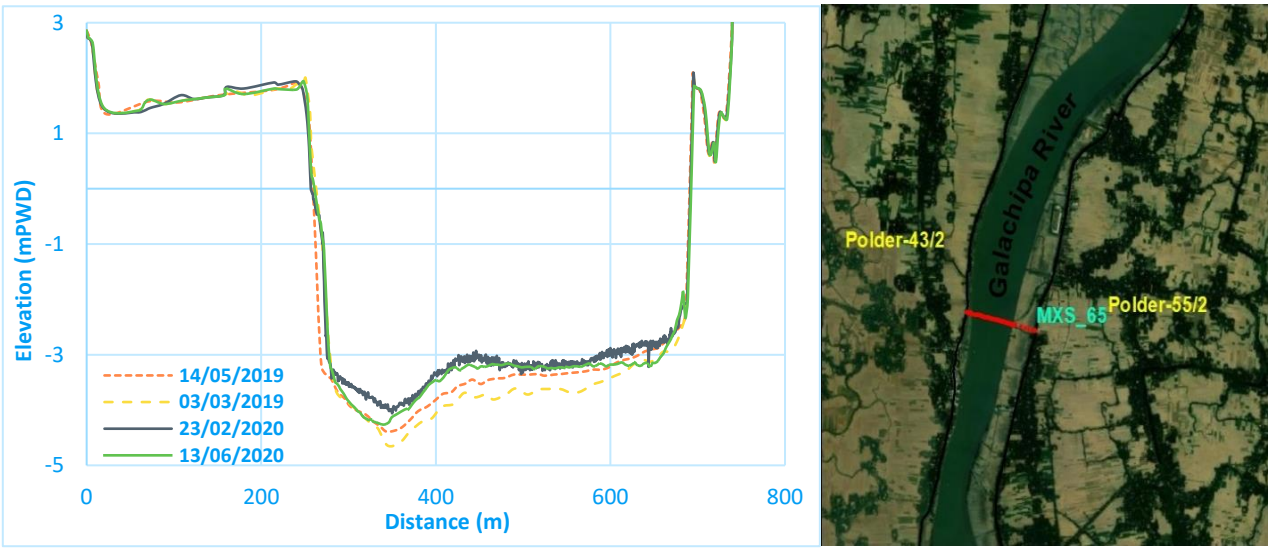

Figure 3-24: Superimposed monitoring section-65 of Galachipa River with location

Cross sections surveys of the monitoring section-65 in Galachipa River were carried out on four occasions during the period from 03 March 2019 to 13 June 2020. Figure 3-24 shows the superimposed section with location. Findings from analysis on the monitoring section-65 of Galachipa River are summarized in Table 3-24. As compared with the survey in 03 March 2019, the top widths at bank full stage on all occasions of the surveys in May 2019, February 2020 and June 2020 are enlarged due to bank erosions by 1.24 m, 4.01 m and 3.17 m respectively. The overall monitoring

survey in 16 months demonstrates an average increase in top width by 2.81m indicating the tendency in bank erosion. The table shows that the sectional areas of the river compared to the area in March 2019 are enlarged on all the events of monitoring surveys in May 2019, February 2020 and June 2020 by 60 m^2, 184 m^2 and 129 m^2 respectively due to sedimentation. The section during the monitoring period undergoes an average reduction in the cross-sectional area by 124.19 m^2 indicating siltation. Galachipa River is tidal in nature and the erosion and sedimentation processes in the river is mostly influenced by the magnitude of tidal flow. Findings from the monitoring surveys show that the thalweg levels as compared to 03 March 2019 are decreased in 14 May 2019, 23 February 2020 and 13 June 2020 by 0.25 m, 0.58 m and 0.38 m respectively. The monitoring survey demonstrates decrease in the thalweg level on an average by 0.4 m in 16 months as compared with the thalweg level in 03 March 2019. Thalwegs at the section in May 2019 and June 2020 are found to be shifted slightly to the Left from the thalweg in 03 March 2019 by 1.19 m and 2.7 m respectively. However, the maximum shifting of the thalweg was occurred to the right by 5.39 m in February 2020. The overall monitoring survey demonstrates an average shifting of the thalweg by 0.5 m to the right of the thalweg in 03 March 2019. Changes in elevations of the left flood plain according to the monitoring survey are not found significant. Decrease in elevations from 0.01 m to 0.02 m have been found in all the survey events on May 2019, February 2020 and June 2020. However, during the monitoring period the left flood plain undergoes an average decrease in elevation by 0.017 m. Monitoring survey has not been carried out on the right flood plain.

Table 3-24: Galachipa River Monitoring Section- 65, Changes in the River and Flood plain

Survey Date	Flood plain portion (EL in meter)				River section portion at bank full stage									
					Sectional properties						Change in sectional properties			
	Left Flood Plain (m, PWD)	Change in Ele. (m)	Right Flood Plain (m, PWD)	Change in Ele. (m)	Top Width (m)	Area (m^2)	Hydraulic Depth (m)	Wetted Perimeter (m)	Hydraulic Radius (m)	Thalweg Level (m, PWD)	Top Width (m)	Area (m^2)	Thalweg Shifting (m)	Thalweg Level (m)
03/03/2019	1.68				437.97	2124.04	4.85	439.36	4.83	-4.64				
14/05/2019	1.66	-0.02			439.21	2064.42	4.70	440.79	4.68	-4.39	1.24	-59.62	1.19m to L	-0.25
23/02/2020	1.66	-0.02			441.98	1940.28	4.39	446.88	4.34	-4.06	4.01	-183.76	5.39m to R	-0.58
13/06/2020	1.67	-0.01			441.14	1994.84	4.52	442.66	4.51	-4.26	3.17	-129.20	2.70m to L	-0.38
Average changes		-0.017									2.81	-124.19	0.5m to R	-0.40

4 Observation

Monitoring surveys in the selected sections of 12 coastal rivers have been conducted during the period from February 2019 to August 2020. These rivers are all dynamic and tidal in nature and surrounded by around 41 coastal polders. Each of the rivers had two sections where surveys were conducted on four occasions to monitor sedimentation in the rivers and flood plain at the sections. The erosion and sedimentation processes in most of these rivers are influenced by the extent of tidal flow. However, some big rivers like Lower Meghna, Pussur, Sibsa and Baleswar, the sedimentation process are influenced by both the extent of tidal flow and upstream fresh-water flow during monsoon.

Based on average changes in 24 sections of 12 rivers it can be concluded that riverbank erosions have been dominating during the monitoring period of 16 to 18 months. During the period, top widths of 17 sections in 11 rivers have been enlarged due to erosion. Among the rivers, Andharmanik at the monitoring section-56 experiences maximum bank erosion and thus increases in top width by 45.3 m which is 9.01% of the top width in 02 March 2019 during the initial monitoring survey. On the contrary, Baleswar river at section-11 undergoes maximum reduction in average top width by 13.6 m due to siltation which equivalents to 0.53% of the top width at the initial survey in 28 February 2019.

Analysis from the findings of monitoring survey reveals that the monitoring sections at bankfull stages have been predominated by siltation. During the monitoring period 14 sections in 12 rivers suffer average reduction in cross sectional area due to siltation. The maximum average reduction in area at bankfull stage occurs in Baleswar River at section-11 is 742.25 m^2 which is 3.37% of the sectional area during initial survey in 28 February 2019. On the other hand, lower Meghna river at section-72 experiences maximum average enlargement in area by 1026.71 m^2 that is equivalent to 1.8% of the sectional area in 28 February 2019.

Analyses of the monitoring sections reveal that there has been dominance in the rise in average thalweg levels due to siltation though only 9 sections in 8 rivers demonstrate average reductions in the thalweg level. Gashiakhali River at section-35 experienced maximum average reduction by 0.83 m during the monitoring period which is 11.34% of the thalweg level during initial survey in 25 February 2019. However, Gangril River at section-26 undergoes maximum increase in the thalweg level by 0.53 m that corresponds to 27.2% of the thalweg level during initial survey in 18 February 2019.

The survey reveals frequent shifting of the thalweg at the 24 section in 12 rivers. As compared with the thalweg at initial survey, maximum average shifting occurs in the Sibsa river at section-53 by 860.1 m to the left. However, Baleswar River at Section-08 experiences minimum average thalweg shifting by 0.4 m to the right.

Regarding flood plain elevations, the average changes in elevations as obtained from the monitoring survey are mostly minor and insignificant. The maximum of the average changes occurred in the left flood plain is accretion by 0.09 m in Andharmanik River at section-59, that equivalents to 7.76% of the left flood plain elevation during initial survey in 25 February 2019. In the right flood plain, it is erosion by 0.14 m in Dhaki River at section-23 which corresponds to 73.68% of the right flood plain in 20 February 2019. In Chunkuri River, the right flood plain at section-17 also experienced maximum average accretion by 0.14 m during the period of monitoring which is 7.14% of the right flood plain during the first monitoring survey in 23 February 2019.

Findings from 16 to 18 months monitoring survey at river sections are not enough time to make conclusions on sedimentation rate in the rivers and flood plain. It requires at least 10 to 15 years to arrive to a precise conclusion on the trend including the rate of sedimentation in the rivers and flood plain. However, from this little period of monitoring survey at 24 sections in 12 rivers, the modelers/ researcher can enrich their understanding on the short-term morphological behavior of the selected rives around the coastal polders.