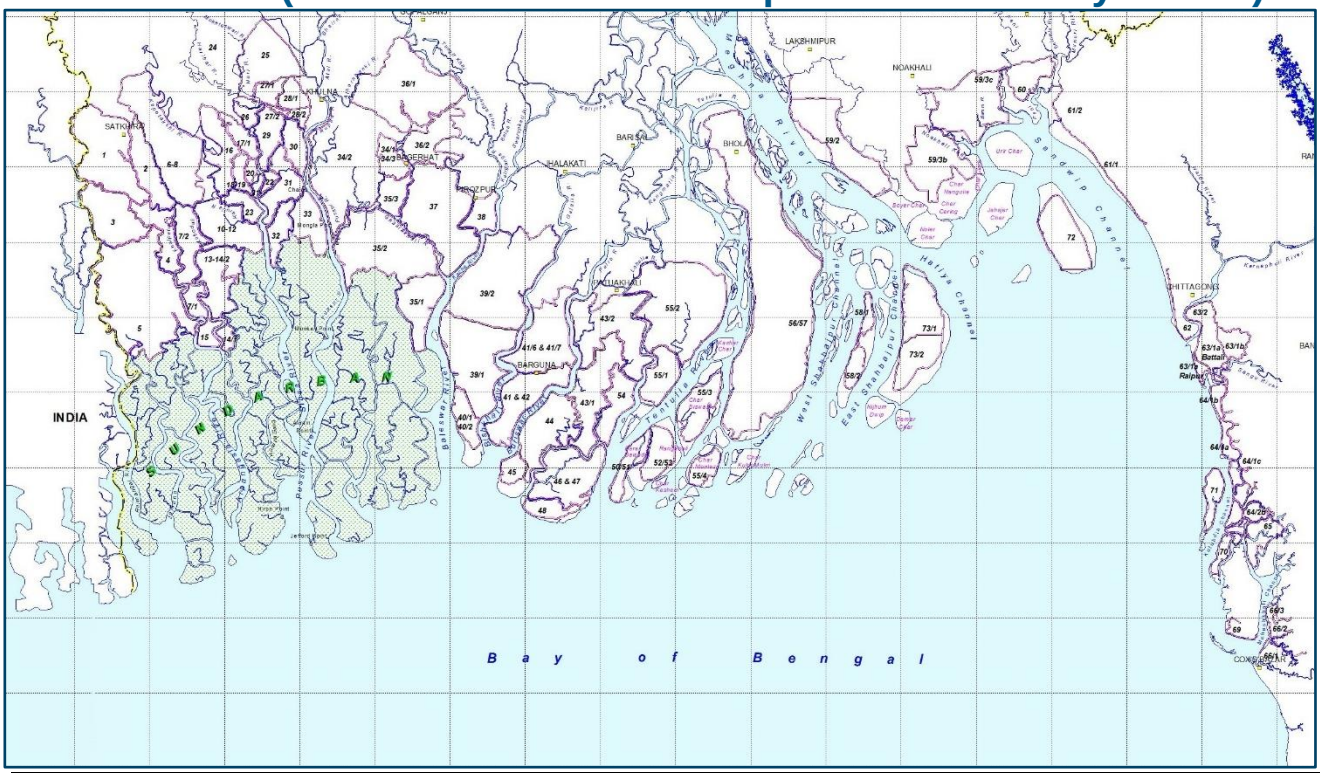
Ministry of Water Resources

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)



QUARTERLY PROGRESS REPORT-13

January 2022

DHI Deltares Enabling Delta Life IWM Water Environment & Climate Columbia University

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January 2022

Bangladesh Water Development Board
Coastal Embankment Improvement Project, Phase-I (CEIP-I)
Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone
Office: Flat #3/B, House #4, Road #23/A, Banani, Dhaka 1213, BANGLADESH Phone +880 1307 693299

Memo No: CEIP/LTMRA/0222/147 06 February 2022

Project Management Unit
Coastal Embankment Improvement Project, Phase-I (CEIP-I)
House No.15, 4tn Floor, Road
No.24(CNW) Gulshan, Dhaka-1212

Attn: Mr. Syed Hasan Imam, Project Director

Dear Mr Imam,

Subject: Submission of Quarterly Progress Report-13

It is our pleasure to submit herewith three copies of the Quarterly Progress Report-13. This is the 13th Quarterly Progress Report describing the progress made between 1st October 2021 and 31 December 2021.

The amount of progress made during this quarter has been less than optimal on all fronts because of restrictions on staff travel for COVID-19 lockdowns which have been accommodated within the extended schedule and other adjustments re-negotiated with you in recent months, which is expected to result in an extension of the project duration until the end of June 2022. The 13th Quarter has seen the beginning of the post-COVID acceleration of the work with the restarting of field inputs from International Staff on the team

This report comprises 7 chapters, including the first three chapters that, as usual, describe progress in development of input datasets for modelling including coastal database. Chapter 4 which usually deals with a variety of modelling work, deals in this report, with Salinity Modelling, and Storm surge Modelling. Chapter 5 describes the work done to lay the groundwork for completion on the Polder Development Plan and the Investment Plan.

Chapter 6 deals with Capacity Building and Chapter 7 deals with the Outreach Programme which is an important aspect of introducing the outputs of this project to stakeholders as the work approaches its conclusion.

Thanking you,

Yours sincerely,

Dr Ranjit Galappatti
Team Leader

Copies: Engineer Mr. Fazlur Rashid, Director General, BWDB
Engr. Md. Mizanur Rahman, ADG (Planning), BWDB
Dr Kim Wium Olesen, Project Manager, DHI
Ms Sonja Pans, Deltares Project Manager
Mr Zahirul Haque Khan, Deputy Team Leader
Mr AKM Bodruddoza, Procurement Specialist
Ms Swarna Kazi, Sr. Disaster Risk Management Specialist, World Bank

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ACRONYMS AND ABBREVIATIONS

ADCP- Acoustic Doppler Current Profiler

AGU- American Geophysical Union

BDP2100- Bangladesh Delta Plan 2100

BIWTA- Bangladesh Inland Water Transport Authority

BMD- Bangladesh Meteorological Department

BoB - Bay of Bengal

BWDB- Bangladesh Water Development Board

CBA- Coast Benefit Analysis

CCP- Chittagong Coastal Plain

CDMP-Comprehensive Disaster Management Program

CDSP- Char Development Settlement Project

CEA- Cost Effectiveness Analysis

CEGIS- Centre for Environmental and Geographic Information Services

CEIP- Coastal Embankment Improvement Project

CEP- Coastal Embankment Project

CERP-Coastal Embankment Rehabilitation Project

CPA- Chittagong Port Authority

CPP-Cyclone Protection Project

CSPS-Cyclone Shelter Preparatory Study

DDM- Department of Disaster Management

DEM- Digital Elevation Model

DOE- Department of Environment

EDP- Estuary Development Program

FAP- Flood Action Plan

FM- Flexible Mesh

GBM- Ganges Brahmaputra Meghna

GCM- General Circulation Model

GIS- Geographical Information System

GNSS- Global Navigation Satellite System

GNSS-IR- GNSS interferometric reflectometry

GPS- Global Positioning System

GTPE- Ganges Tidal Plain East

GTPW- Ganges Tidal Plain West

HD- Hydrodynamic

IGDCZ- Interactive Geo-Database for Coastal Zone

InSAR- Interferometric Synthetic Aperture Radar

IPCC- Intergovernmental Panel for Climate Change

IPSWAM- Integrated Planning for Sustainable Water Management

IWM- Institute of Water Modelling

LCC- Life Cycle Costs

LGED- Local Government Engineering Department

LGI- local Government Institute

LRP- Land Reclamation Project

MCA- Multi Criteria Analysis

MES- Meghna Estuary Study

MoWR- Ministry of Water Resources

MPA- Mongla Port Authority

MSL- Mean Sea Level

NAM - Nedbor Afstromnings Model

PPMM- Participatory Polder Management Model

RCP- Representative Concentration Pathways

RSET-MH- Rod surface elevation table – marker horizon

RTK- Real-Time Kinematic

SET-MH- Surface Elevation Tables – Marker Horizons

SLR- Sea Level Rise

SOB- Survey of Bangladesh

SSC- Suspended Sediment Concentration

SWRM- South West Region Model

TBM- Temporary Bench Mark

ToR- Terms of Reference

WARPO- Water Resources Planning Organization L - Water Level

1 INTRODUCTION

The coastal zone of Bangladesh spans over 710 km of coastline and is subject to multiple threats. Sixty- two percent of the coastal land has an elevation less than 3 meters above mean see level. The coastal lands, being subject to regular flooding by saline water during high tides, could not be used for normal agricultural production in a country with a very high demand for land.

The damage caused by Cyclones Sidr and Aila in 2007 and 2009 led to a major new investment of World Bank funds called the Coastal Embankment Improvement Project through which the coastal embankment system was to be improved and made much more climate resilient, over several phases of construction. After the feasibility study of the first phase CEIP-1, it was recommended that certain gaps in our knowledge of the delta should be addressed by the research study which was to be known as the **Long-Term Monitoring, Research and Analysis of Bangladesh Coastal Zone.**

After a very long gestation period, the study was initiated on 15 October 2018 and the Inception Phase was completed in January 2019. The Inception Report was treated as the first Quarterly Progress Report (QPR-1). The Second Quarterly Progress Report which was submitted in April 2019 covered the period 1 January 2019 to 31 March 2019. The Third Quarterly Progress Report (QPR-3) covers the period 1 April 2019 to 30 June 2019. QPR-4 covered the period from 1 July 2019 to 30 September 2019. QPR-5 covering the period 1 October 2019 to 31 December 2019 was submitted in February 2020. This present report is QPR-13 covering the period 1 October 2021 to 31 December 2021

The advent of the COVID-19 crisis in early 2020 signalled the beginnings of a global pandemic. QPR-6 covered period 1 January to 31 March 2020. The work of the project during the 6th Quarter was not seriously affected because the international experts working in Dhaka were not recalled by their home offices until the 15th of March 2020. The Seventh and Eighth Quarterly Progress Reports (QPR-7 & QPR-8) describing the progress made between 1st April 2020 to 30th June 2020 and 1st July 2020 to 30th September 2020 respectively, covered the two periods where the original work schedule was badly affected by the travel bans imposed by Denmark, the Netherlands and the United States. The 8th, 9th, 10th, 11th and 12th Quarters had to be completed without a single International Consultant being permitted to travel to Bangladesh. We were fortunate that 13th Quarter saw the return of International Consultant staff.

The constraints imposed by the travel bans which prevented the field inputs (in Bangladesh) by International Staff was the subject of several rounds of protracted negotiations between the Consultant and the Client – has made some progress in the face of growing global uncertainty. Progress made in 12th quarter which paved the way for rapid progress provided the incentive for the return of International Staff to Bangladesh in the 13th Quarter.

1.1 The New Work Plan

The Inception Report (DHI, 2019) gave a detailed description of the work to be carried out by this project. This programme was disrupted from March 2020 onwards by the advent of the COVID pandemic especially because of the travel restrictions placed on international staff by their respective governments. The work plan and the staff deployment plan has been under continuous negotiation throughout the last three quarters while the international COVID situation continued to evolve. Eventually agreement was reached on a new work schedule with sufficient built-in flexibility to cope with future contingencies. This new schedule allowed the project duration to be extended by 12 months and the deliverables and the related man-power inputs to be re-arranged and re-scheduled as necessary.

Table 1.1 shows the schedule of activities based on Contract Modificaiton-2. On 13 December 2021 (Letter No DHI/CEIP-12-13-2021), the Consultants submitted 2nd revised contract (Contract Modification-2) to the Project Director, PMU, CEIP-1 requesting the project duration to be extended up to the end of June 2022. The second variation proposal is under evaluation by the PMU.

The original workplan (not shown here) was published in the Inception Report published in December 2018. Later a revised work plan was published in QPR-10 showing an extension of the project duration until January 2022. That revised work plan was planned based on signing of the 1st revised contract on 26 April 2021.

The work programme has been modified to accommodate the rapidly evolving travel restrictions imposed by the COVID-19 crisis. This programme involves some staffing and budget changes currently under discussion. Section 1.2 and section 1.3 describe the current adjusted work schedules and the corresponding lists of deliverables, as Table 1.2 for non-modelling deliverables and Table 1.3 for modelling deliverables.

It is apparent that some deliveries have not been made according to even the modified deadlines suggested in previous progress reports. This has been not only due to unpredictable travel restrictions being imposed on our team by their home countries and due to difficulties in remotely coordinating an international team spread over three continents. Nevertheless, we are on track to complete the assigned tasks within the extended time granted to us.

Table 1. 1: New Activity Schedule Page 1

Overview of Deliverables (Effective Date of commencement is 15 October 2018)																																															
No	TOR Reference/ Deliverables Code	TOR Deliverables	15-Oct-18	15-Nov-18	15-Dec-18	15-Jan-19	15-Feb-19	15-Mar-19	15-Apr-19	15-May-19	15-Jun-19	15-Jul-19	15-Aug-19	15-Sep-19	15-Oct-19	15-Nov-19	15-Dec-19	15-Jan-20	15-Feb-20	15-Mar-20	15-Apr-20	15-May-20	15-Jun-20	15-Jul-20	15-Aug-20	15-Sep-20	15-Oct-20	15-Nov-20	15-Dec-20	15-Jan-21	15-Feb-21	15-Mar-21	15-Apr-21	15-May-21	15-Jun-21	15-Jul-21	15-Aug-21	15-Sep-21	15-Oct-21	15-Nov-21	15-Dec-21	15-Jan-22	15-Feb-22	15-Mar-22	15-Apr-22	15-May-22	15-Jun-22
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
D-1	D-1	Inception Workshop																																													
		Inception Report (Workplan etc																																													
D-2	D-2	**Literature Review & Lessons Learnt**																																													
		Literature Inventory & Interim Review 1																																													
		Literature Inventory & Interim Review 2																																													
		Literature Review & Lessons Learnt																																													
D-3		**Development of Input datasets for modelling the physical processes**																																													
	D-3:1,2	1) Soft and hard copies of map of the location of all the current field measurement stations, by tape, stored in Database of BWDB, Map showing the location of primary BM with values																																													
	D-3:1,2	2) Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB																																													
	D-3.3	Completed and validated dataset including meta-data, stored in Database of BWDB (Database design report)																																													
	D-3:4	GIS based National Coastal Polder Database/ Management Information System/ Database (GIS based map)																																													
	D-3:4	GIS based National Coastal Polder Database/ Management Information System/ Database																																													
	D-3:5	Boundary conditions and data for calibration and validation of models																																													
	D-3:6	Monitoring results on sedimentation rate in rivers and floodplain																																													
	D-3:7	Annual and seasonal sediment load of major rivers and to Bay of Bengal																																													
	D-3:8	Technical memorandum describing the validation and completion procedures that have been udes by the consultant for all type of data; for reproducibility purposes and to be stored in Database of BWDB																																													
	D-3:9	Memorandum with recommendations to improve the data collection, processing, validation and dissemination within the GoB																																													
D-4		**Modelling of the long-term physical processes**																																													
D-4A-1		**Morphology on a macro scale**																																													
	D-4A-1:1	The software newly developed under this project with all source code and accompanying technical document with detailed explanation of the methodology and assumptions																																													
	D-4A-1:2																																														
	D-4A-1:2,3	Geospatial datasets of main sources and deposits of sediment at present, including full meta-data a restored and archived in Database of BWDB;																																													
		Geospatial datasets of main sources and deposits of sediment for 100 years from present, including full meta-data are published and archived in Database of BWDB.																																													
	D-4A-1:4																																														
		Technical reports (one report for 4A-1 Final Report on Morphological Trend)																																													

Table 1.1 (contd) : New Activity Schedule Page 2

No	TOR Reference/ Deliverables Code	TOR Deliverables
D-4A-2		**Morphology on a meso scale**
	D-4A-2:1	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions. Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB
	D-4A-2:2,3	Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB; Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should incldue full meta-data and be stored and archived in Database of BWDB
	D-4A-2:4	Technical report (one report for 4A-2 - FINAL REPORT ON ESTUARINE MORPHOLOGY)
D-4A-2		**Bank Erosion on Meso scale**
	D-4A-2:1,2	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions. Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB
	D-4A-2:3	Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should incldue full meta-data and be stored and archived in Database of BWDB
	D-4A-2:4	Technical report (one report for 4A-1 and 4A-2)
D-4D-3		**Other special purpose models**
	D-4D-3:1,2,3,4	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now. Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges

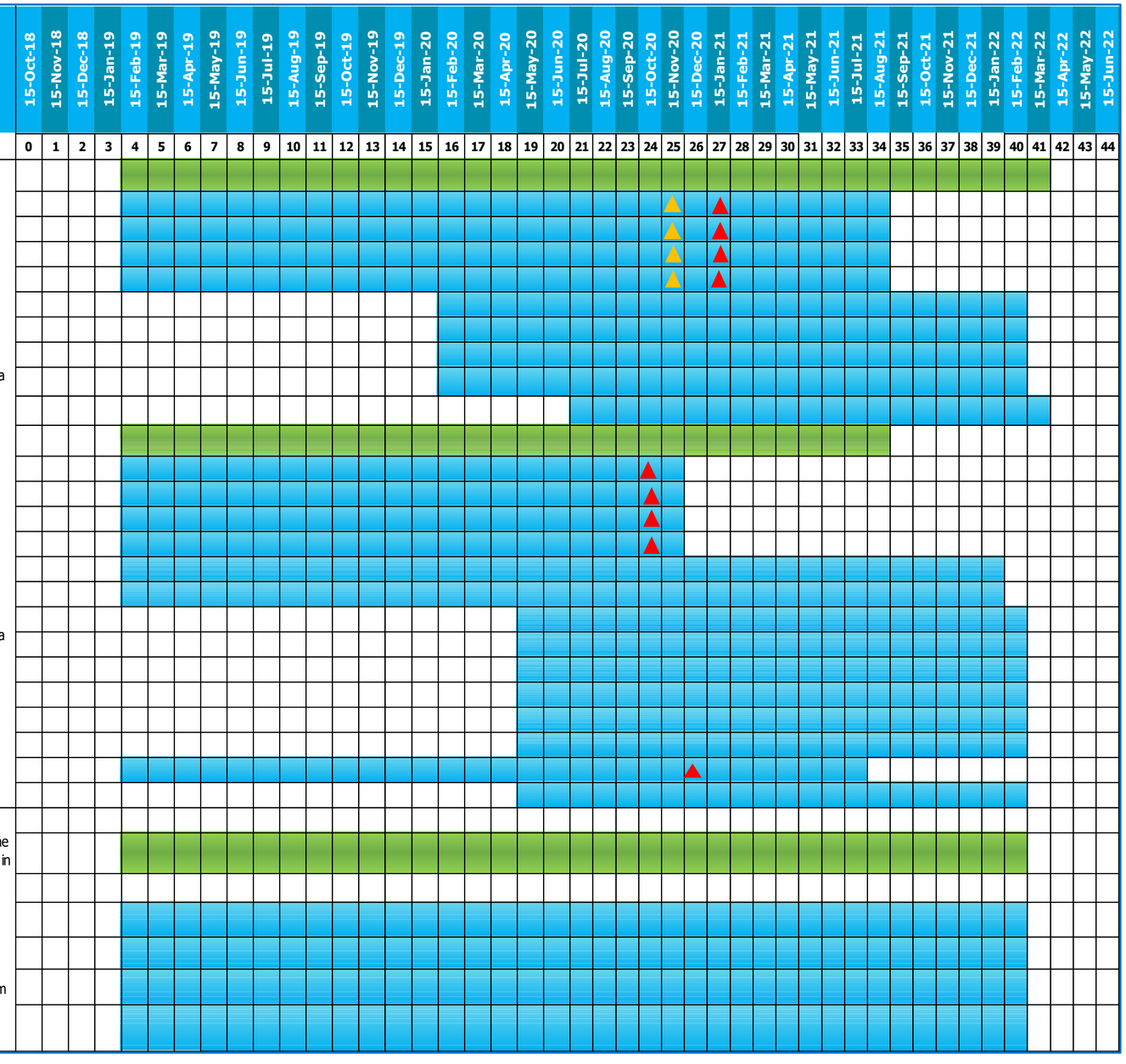


Table 1. 1 (contd) : New Activity Schedule Page 3

No	TOR Reference/ Deliverables Code	TOR Deliverables
D-4A-3	D-4A-3:1,2,3	The model setup developed will be updated under this project with all accompanying technical document with detailed explanation of the methodology and assumptions. A report that describes the pros and cons of the different methodologies to prevent water-logging within the polder and sedimentation of tidal river system including polder-subsidence. The report will include meta-data on the models used and measurements, recommendations for polder design including drainage and long term management plan, and recommendations for pilot area/ polder to implement the ideas, such as but not limited to location, methods and measurements. Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder.
D-4B	D-4B:1,2,3	**Subsidence** Geospatial datasets of total subsidence at present and for 25, 50 and 100 years from now, including full metadata and stored in Database of BWDB and Estimate the annual rate of subsidence. Detailed Technical Report with description and explanation of geospatial analysis of the total subsidence in the four regions of the polder area of the coastal zone at present and for 25, 50 and 100 years from present, including description of the causes of subsidence, full metadata and stored in Databse of BWDB. Report on the total subsidence in specific polders (designated by BWDB) in 25, 50 and 100 years from now when no sediment is supplied to the polder, including the amount of sediment needed to counteract this subsidence.
D-4C	D-4C:1,2	**Meteorology** Technical Report describing current trends and future scenarios in rainfall in the polder area of coastal zone for four coastal regions (including estimation of rainfall distribution over the year) and cyclone frequency and intensity for the next 25, 50 amd 100 years from now, including meta-data of the datasets used for the trend analyses and store and archived in Database of BWDB. The Research Team shall include a description of the statistical and downscaling methods used for reproducibility reasons. Geospatial Dataset and archived in Database of BWDB.
D-4D	D-4D:1,2,3	**Climate Change Effects** Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now.
	D-4D:4,5	Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges.
	D-4D:6	Technical Report with description and explanation of the geospatial datasets of surface and ground water salinity, and the tidal salinity and water level curves, including description of relevant seasonal variations, used models, indication of more and less likely scenarios and full metadata. The Research Team shall also discuss the effect of at least two relevant options of redistribution of river water in the South West delta on salt intrusion.

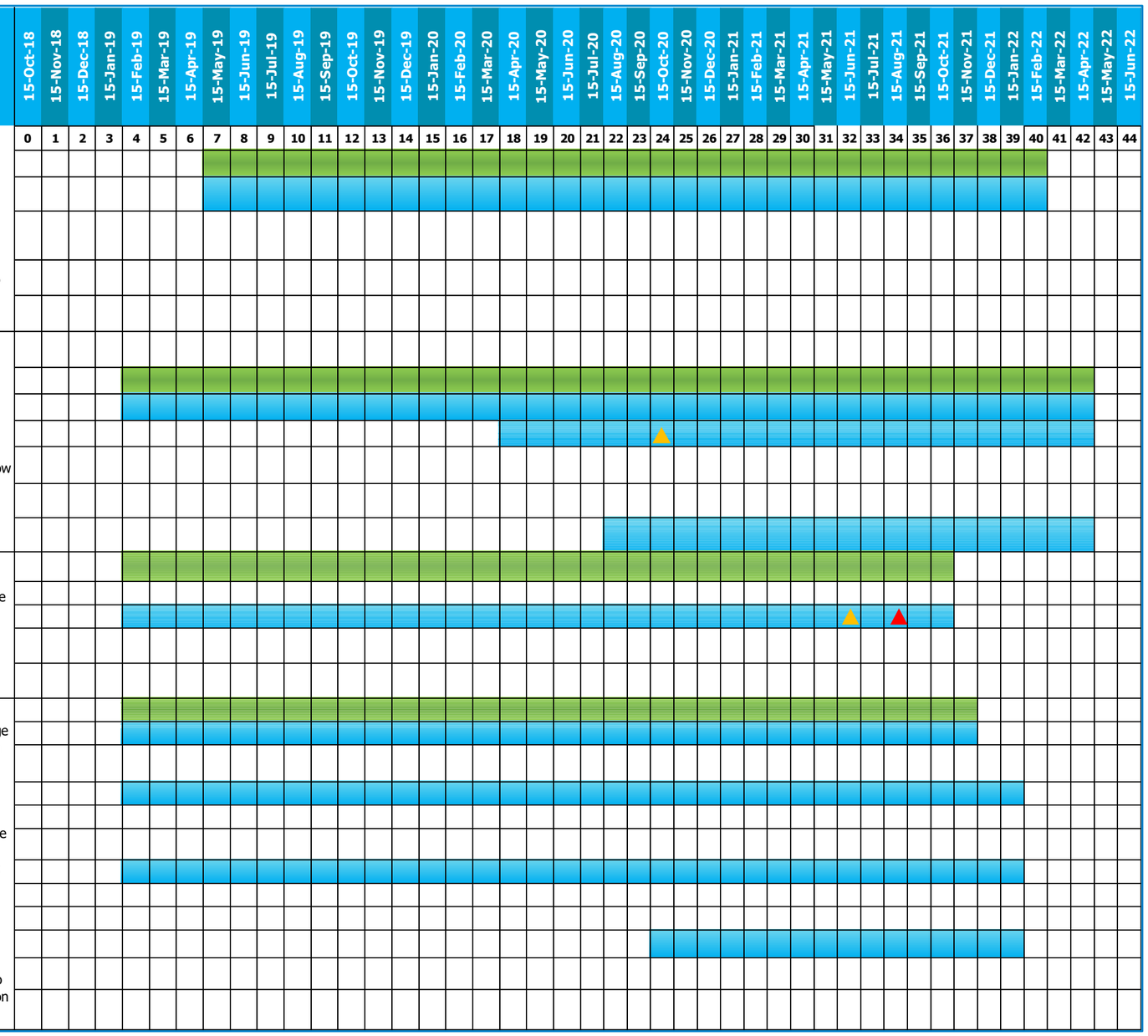


Table 1. 1 (contd) : New Activity Schedule Page 4

No	TOR Reference/ Deliverables Code	TOR Deliverables	15-Oct-18	15-Nov-18	15-Dec-18	15-Jan-19	15-Feb-19	15-Mar-19	15-Apr-19	15-May-19	15-Jun-19	15-Jul-19	15-Aug-19	15-Sep-19	15-Oct-19	15-Nov-19	15-Dec-19	15-Jan-20	15-Feb-20	15-Mar-20	15-Apr-20	15-May-20	15-Jun-20	15-Jul-20	15-Aug-20	15-Sep-20	15-Oct-20	15-Nov-20	15-Dec-20	15-Jan-21	15-Feb-21	15-Mar-21	15-Apr-21	15-May-21	15-Jun-21	15-Jul-21	15-Aug-21	15-Sep-21	15-Oct-21	15-Nov-21	15-Dec-21	15-Jan-22	15-Feb-22	15-Mar-22	15-Apr-22	15-May-22	15-Jun-22
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
D-5																																														
D-5A																																														
	D-5A:1																																													
	D-5A:1	Technical Report on Long Term Polder Improvement measures and Polder Development Plan																																												
	D-5A:1																																													
	D-5A:2	Design of polder improvement measures of 17 polders under CEIP-I with consideration of existing improvements. Draft report focusing on initial 4 Polders to be optimised. Final report, 17 polders																																												
	D-5A:3	Report for each of the 3-5 polders with a description of ; Present situation, boundary conditions (scenarios), Matching with polder options, Including management plan, Costs and benefits. Draft report focusing on initial 4 Polders to be optimised. Final Report, 17 Polders.																																											
D-5B		Report describing the Interdependencies and relations between the processes and parameters, consequences for the boundary conditions and recommendations for future action plan/ research																																												
D-6		**Updating of design paramerters and specificaitons for construction works and management paractices**																																												
	D-6.1	Report with updated set of design parameters and specifications for construction/ reconstruction of the polders as well as associated appurtenant structures. Detailed delivery plan to be developed druing the inception phase.																																												
D-6.2 & D-6.3	**D-6.2 & D-6.3**																																												
		Report on Management plans for the polders including review approaches of polder management and performance monitoirng mechanism																																												
		Detailed delivery plan to be developed during the inception phase																																												
D-7		**Investment Plan for Entire CEIP**																																												
	D-7:1	An investment plan describing a phaased polder improvement roadmap and required budget																																											
	D-7:2	An investment plan for long term management of the polders, including the expansion of monitoring																																											
	D-7:3	An execution plan including financing and fundraising strategies and plan and technical collaboration plan																																											
D-8		**Action Plan for Capacity Building**																																												
		On the job technical training in country																																												
		Report on: results of the on the job training, list of participants																																												
		International Workshop																																												
		Teach the teacher, Teaching at the universities																																												
		Overseas Study tour																																												
D-9.1		**Outreach Program**																																												
	D-9.1:1	Workshops																																												
	D-9.1:2	Workshop Report (Stakeholder's workshop at Barisal and Khulna & Mid-term workshop at Dhaka)																																												
D-9.2		**Communication Strategy**																																												
		Storage of all datasets of BWDB and Communication materials																																												
QPR																																													

▲ Draft submission of report ▲ Submission of revised report

1.2 Revised List of Non-Modelling Milestones and Deliverables)

Table 1.2 a: List of non-modelling milestones and deliverables (Part 1)

Overview of Deliverables		As per Consultant				
No	**ToR Deliverables**	**Program Item**	**Status**	**Deadline as per Signed Contract**	**Date of Submission to PIU**	**Proposed Deadline (2nd Contract Amendment to June)**
D-1	**Inception**					
	Inception Workshop	Inception Workshop	Accepted	4-Jan-19	9-Jan-19	
	Inception Report (Workplan etc)	Inception Report (Workplan etc)	Accepted	4-Jan-19	30-Jan-19	
D-2	**Detailed Literature Review and its Summary and Lessons Learnt**					
	Literature Inventory & Interim Review 1	Literature Inventory & Interim Review 1	Submitted	4-Feb-19	24-Jun-19	Revised report 31 aug-21
	Literature Inventory & Interim Review 2	Literature Inventory & Interim Review 2	Submitted	4-Oct-20	15-Jan-20	
	Literature Review & Lessons Learnt	Literature Review & Lessons Learnt	Pending	4-Oct-20		28-Feb-22
D-3	**Development of Input Datasets for Modelling the physical processes**					
	Soft and hard copies of map of the location of all the current field measurement stations, by tape, stored in Database of BWDB, Map showing the location of primary BM with values	Data Report, Inventory & Quality Checks (Includes field Data collection and monitoring programmes)	Submitted	4-Jul-19	29-Sep-19	
	Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB					
	Completed and validated dataset including meta-data, stored in Database of BWDB	Database Design Report	Submitted	4-Jul-19	11-Sep-19	
	GIS based National Coastal Polder Database/ Management Information System/ Database	GIS Based Maps	Submitted	4-Jul-19	25-Sep-19	
		GIS Based Database/ MIS system/ Sharepoint	Pending	4-Jul-19		31-Mar-22
	Boundary conditions and data for calibration and validation of models	Supply of Model Boundary Data	Submitted	4-Jul-19	25-Sep-19	
	Monitoring results on sedimentation rate in rivers and floodplain	Monitoring Results on Sedimentation rate in rivers	Submitted	4-Jul-19	Draft version submitted on Dec 7, 2020	
	Annual and seasonal sediment load of major rivers and to Bay of Bengal	Annual & Seasonal Sediment load of Major rivers & to Bay of Bengal	Pending	4-Aug-19		31-Mar-22
	Technical memorandum describing the validation and completion procedures that have been udes by the consultant for all type of data; for reproducibility purposes and to be stored in Database of BWDB	Technical Report of Data analysis & Validation	Submitted	4-Aug-19	24-Feb-21	
	Memorandum with recommendations to improve the data collection, processing, validation and dissemination within the GoB	Technical Report on improving Data collection	Pending	4-Aug-19		28-Feb-22
D-5A	**Finalization of approach for reconstruction of the Polder at different coastal zones including their phasing and construction program**					
	Technical Report on Long Term Polder Improvement measures and Polder Development Plan	Draft	Pending	4-Apr-21		31-Jan-22
		Final	Pending			28-Feb-22
	Design of polder improvement measures of 17 polders under CEIP-I with consideration of existing improvements with a description of ; opportunities for livelihood, spatial planning, water management and operation, subsidence, raising of low lying area and future climate change scenarios.	Draft	Submitted	4-Apr-21	18-Jan-21	
		Final	Pending			Submitted 1-11-2021
	Report for each of the 3-5 polders with a description of; · Present situation · Boundary conditions (scenarios) · Establish design, including management plan · Costs and benefits · Matching with polder options	Draft	Pending	4-Jul-20		31-Jan-22
		Final	Pending			28-Feb-22
D-5B	**Coherence and Overall picture of Delta**					
	Report describing the Interdependencies and relations between the processes and parameters, consequences for the boundary conditions and recommendations for future action plan/ research	Coherence with respect to Overall Delta	Pending	4-Apr-21		28-Feb-22
		~~Environmental Assessment of Proposed Interventions~~	Pending			
D-6.1	**Updating of design parameters and specifications for construction works**					
	Report with updated set of design parameters and specifications for construction/ reconstruction of the polders as well as associated appurtenant structures	Updated Design Parameters & Specifications	Pending	4-Apr-21		31-Mar-22
	Detailed delivery plan to be developed during the inception phase for D-6.1	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.2	**Review of approaches for management of polders with emphasis on active participat**					
	Report on Management plans for the polders	Polder Management Plan	Pending	4-Apr-21		31-Jan-21
	Detailed delivery plan to be developed during the inception phase for D-6.2	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.3	**Setting up a performance monitoring Mechanism**					
	Report on participatory monitoring mechanism with goals and targets	Performance Monitoring Mechanisms	Pending	4-Apr-21		31-Jan-22
	Detailed delivery plan to be developed during the inception phase for D-6.3	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	

Table 1.2 b: List of non-modelling milestones and deliverables (Part 2)

Overview of Deliverables		As per Consultant				
No	**ToR Deliverables**	**Program Item**	**Status**	**Deadline as per Signed Contract**	**Date of Submission to PIU**	**Proposed Deadline (2nd Contract Amendment to June)**
D-7	**Investment plan for the Entire CEIP**					
	An investment plan describing a phaased polder improvement roadmap and required budget	An investment plan describing a phaased polder improvement roadmap and required budget	Pending	4-Apr-21		30-Apr-22
	An investment plan for long term management of the polders, including the expansion of monitoring	An investment plan for long term management of the polders, including the expansion of monitoring	Pending	4-Apr-21		
	An execution plan including financing and fundraising strategies and plan and technical collaboration plan	An execution plan including financing and fundraising strategies and plan and technical collaboration plan	Pending	4-Apr-21		
D-8	**Action Plan for Capacity Building**					
	On the job technical training in country	In-country on-the- job Training	Pending	Continuous		ongoing
	Report on: results of the on the job training, list of participants	Training Report with list of trainees	Pending	Bi Annually		31-Mar-22
	International Workshop	International Workshop	Pending	4-Jul-20		31-May-22
	Teach the teacher, Teaching at the universities	Curriculum Development	Pending	4-Apr-21		30-Apr-22
D-9.1	**Outreach Program**					
	Workshops	Workshop 1 - Barishal	Accepted		30-Mar-19	
	Workshops	Workshop 2 - Khulna	Accepted		27-Apr-19	
	Workshops	Workshop 3 - Mid Term Progress Workshop	Accepted		6-Feb-20	
	Workshops	Workshop 4	Pending			
	Workshops	Workshop 5	Pending			
	Workshops	Workshop 6	Pending			
	Workshops	Workshop 7	Pending			
	Workshop Report	Workshop 1 Report - Barishal	Submitted		20-Feb-20	
	Workshop Report	Workshop 2 Report - Khulna	Submitted		20-Feb-20	
	Workshop Report	Workshop 3 Report - Mid Term Progress Workshop	Submitted		8-Jun-20	
	Workshop Report	Workshop 4 Report	Pending			
	Workshop Report	Workshop 5 Report	Pending			
	Workshop Report	Workshop 6 Report	Pending			
	Workshop Report	Workshop 7 Report	Pending			
D-9.2	**Communication Strategy**					
	Storage of all datasets BWDB	Storage of all datasets BWDB	Pending	4-Apr-21		31-Dec-21
	Communication materials such as brochures, animations etc.	Communication materials such as brochures, animations etc.	Pending	4-Oct-20		30-May-22
Q	**QPR**					
	QPR-1	QPR-1	Submitted		30-Jan-19	
	QPR-2	QPR-2	Submitted		20-Aug-19	
	QPR-3	QPR-3	Submitted		20-Aug-19	
	QPR-4	QPR-4	Submitted		7-Nov-19	
	QPR-5	QPR-5	Submitted		2-Mar-20	
	QPR-6	QPR-6	Submitted		10-Jun-20	
	QPR-7	QPR-7	Submitted		6-Sep-20	
	QPR-8	QPR-8	Submitted		20-Jan-21	
	QPR-9	QPR-9	Submitted		21-Mar-21	
	QPR-10	QPR-10	Submitted		23-May-21	
	QPR-11	QPR-11	Submitted		18-Aug-21	
	QPR-12	QPR-12	Submitted		30-Nov-21	
	QPR-13	QPR-13				

1.3 Revised List of Modelling Milestones and Deliverables

Table 1.3 a: List of Modelling Deliverables & Milestones (Part 1)

DELIVERABLES RELATED TO MODELLING ACTIVITIES							
TOR Reference	**TOR Deliverables**	**Scale**	**Model**	**Status**	**Delivery Dates as per signed Contract**	**Date of Submission**	**Proposed Deadline (2nd Contract Amendment to June)**
Macro-scale modelling							
D-4A-1: 1	The software newly developed under this project with all source code and accompanying technical document with detailed explanation of the methodology and assumptions			Pending	4-Apr-21		
D-4A-1: 2, 3	Geospatial datasets of main sources and deposits of sediment at present, including full meta-data a restored and archived in Database of BWDB Geospatial datasets of main sources and deposits of sediment for 100 years from present, including full meta-data are published and archived in Database of BWDB.	**Macro**	GBM Basin Model	Submitted	D-4A-1: 2 (Jan 20) D-4A-1: 3 (Oct 20)	Interim report submitted on Nov 19, 2020	16-Jan-22
		Macro	Macro scale River Model	Submitted		Interim report submitted on Nov 19, 2020	
		Macro	Macro scale River Model	Submitted		Interim report submitted on Nov 19, 2020	
		Macro	GBM Basin Model Applications	Pending			
		Macro	Macro scale River Model Applications	Pending			
		Macro	Macro scale River Model Applications	Pending			
		Macro	Sediment Budget Analyses	Pending			
D-4A-1:-4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Jan 21)		31-Jan-22
Long Term Morphology Modelling							
D-4A-2: 1	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions.	**Meso**	Pussur Sibsa	Submitted	4-Oct-19	December 30, 2020	
		Meso	Baleswar-Bishkhali Model	Submitted		December 30, 2020	
		Meso	Lower Meghna	Submitted		December 2, 2020	
		Meso	Sangu	Submitted		December 30, 2020	
D-4A-2: 2, 3	Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB. Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should incldue full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur Sibsa	Pending	D-4A-2: 2 (Apr 20) D-4A-2: 3 (Jul 20)		31-Jan-22
		Meso	Baleswar-Bishkhali Model	Pending			
		Meso	Lower Meghna	Pending			
		Meso	Sangu	Pending			
D-4A-2: 4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Oct 20)		28-Feb-22
Bank Erosion on Meso Scale							
D-4A-2: 1, 2	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions. Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Submitted	4-Oct-19	October 30, 2020	Interim Report: October 2020 Updated Report: 16-1-2022
		Meso	Sibsa	Submitted		October 30, 2020	
		Meso	Baleswar	Submitted		October 30, 2020	
		Meso	Bishkali	Submitted		October 9, 2020	
		Meso	Lower Meghna	Pending			
		Meso	Sangu	Pending			
D-4A-2: 3	Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should incldue full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Pending	D-4A-2: 2 (Apr 20) D-4A-2: 3 (Jul 20)		28-Feb-22
		Meso	Sibsa	Pending			
		Meso	Baleswar	Pending			
		Meso	Bishkali	Pending			
		Meso	Lower Meghna	Pending			
		Meso	Sangu	Pending			
		Meso	Pussur-Sibsa fine sediment model- ext	Submitted		October 9, 2020	
D-4A-2: 4	Technical report (one report for 4A-1 and 4A-2)	**Meso**	**FINAL REPORT ON BANK EROSION**	Pending	Draft (Jul 20) Final (Oct 20)		28-Feb-22
Micro-scale modelling							
D-4A-3: 1, 2, 3	The model setup developed will be updated under this project with all accompanying technical document with detailed explanation of the methodology and assumptions. A report that describes the pros and cons of the different methodologies to prevent water-logging within the polder and sedimentation of tidal river system including polder-subsidence. The report will include meta-data on the models used and measurements, recommendations for polder design including drainage and long term management plan, and recommendations for pilot area/ polder to implement the ideas, such as but not limited to location, methods and measurements. Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder.	**Micro**	Pilot TRM Model for Polders 24 etc	Pending	4-Oct-20		Interim (15-07-2021) & Final (31-1-2022)
		Micro	5 or more polder models	Pending			Current situations/Interim: Polder modelling report 15-08-2021 Final Version: 31-12-2021
D-4A-3: 4	Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder						

Table 1.3 b: List of Modelling Milestones and Deliverables (Part 2)

DELIVERABLES RELATED TO MODELLING ACTIVITIES							
TOR Reference	**TOR Deliverables**	**Scale**	**Model**	**Status**	**Delivery Dates as per signed Contract**	**Date of Submission**	**Proposed Deadline (2nd Contract Amendment to June)**
SUBSIDENCE							
D-4B: 1, 2,3	Geospatial datasets of total subsidence at present and for 25, 50 and 100 years from now, including full metadata and stored in Database of BWDB and Estimate the annual rate of subsidence. Detailed Technical Report with description and explanation of geospatial analysis of the total subsidence in the four regions of the polder area of the coastal zone at present and for 25, 50 and 100 years from present, including description of the causes of subsidence, full metadata and stored in Databse of BWDB. Report on the total subsidence in specific polders (designated by BWDB) in 25, 50 and 100 years from now when no sediment is supplied to the polder, including the amount of sediment needed to counteract this subsidence.		Field Campaigns (several)	Pending	D-4B: 1, 2 (Oct 20) D-4B: 3 (Report: Draft - July 20, Final - Oct 20)		30-Apr-22
			Subsidence Geospatial Datasets	Submitted		Interim report submitted on Oct 30, 2020	
				Pending			
METEOROLOGY (these are covered under other modelling and data topics)							
D-4C: 1, 2	Technical Report describing current trends and future scenarios in rainfall in the polder area of coastal zone for four coastal regions (including estimation of rainfall distribution over the year) and cyclone frequency and intensity for the next 25, 50 amd 100 years from now, including meta-data of the datasets used for the trend analyses and store and archived in Database of BWDB. The Research Team shall include a description of the statistical and downscaling methods used for reproducibility reasons. Geospatial Dataset and archived in Database of BWDB.		Technical reports & Database	Submitted	D-4C: 1 (Apr 20) D-4C: 2 (Jul 20)	6/26/2021	
CLIMATE CHANGE EFFECTS							
			Climate Change & Preciptation,	Submitted		6/26/2021	This item is fully covered by D-4C
D-4D: 1, 2, 3	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now.		Salinity intrusion & Groundwater Salinity	Pending			31-Jan-22
D-4D: 4, 5	Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges.		Extreme Storm Surges	Pending			31-Jan-22
D-4D: 6	Technical Report with description and explanation of the geospatial datasets of surface and ground water salinity, and the tidal salinity and water level curves, including description of relevant seasonal variations, used models, indication of more and less likely scenarios and full metadata. The Research Team shall also discuss the effect of at least two relevant options of redistribution of river water in the South West delta on salt intrusion.			Pending			Current situations/Interim: Storm surge and wave modelling 30-09-2021 Salinity Modelling 30-09-2021 Final (Report on CC Effects) 30-11-02021
Other special purpose models							
D-4D: 1, 2, 3, 4, 5	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now. Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges	**Bay of Bengal**	Storm Surge Model	CANCELLED			The use of synthetic cyclone events has been abandoned. It has been deemed that use of historical events (and amplified to represent climate change effects) will yield more realistic results.
		Bay of Bengal	Storm Surge Model	Pending			Current situation: 15-09-2021 Future situation: 10-2-2022
		Bay of Bengal	Wave Propagation Model	Pending			
		Bay of Bengal	Salinity Model	Pending			

1.4 List of Deliverables Submitted

Table 1.4: Total List of Deliverables including revised reports submitted to PD

SL No.	Name of the Report	Date of Submission (m/d/y)	Reference as per Tracker	Program Item/Description as per Tracker	Reports under component
1	Final Inception Report	1/30/2019	D-1: 2	Inception Report (Workplan etc)	Component-1
2	QPR-2	04/07/2019	Q 2	QPR-2	QPR
3	1st interim Literature Review Report	6/24/2019	D-2: 1	Literature Inventory & Interim Review 1	Component-2
4	Report on Selection of Polders for Conceptual Design as Pilot Program	8/6/2019	D-5A:1	Polder Development Plan	Component-5
5	QPR-3	08/06/2019	Q 3	QPR-3	QPR
6	Database Design Report (1st submission)	9/11/2019	D-3: 3	Database Design Report	Component-3
7	Report on Regional Stakeholder's Consultation Workshop, Barisal (Both English and Bengali versions),	9/24/2019	D-9.1: 2	Workshop 1 Report - Barishal	Component-9
8	Report on Regional Stakeholder's Consultation Workshop, Khulna (Both English and Bengali versions),	9/24/2019	D-9.1: 2	Workshop 2 Report - Khulna	Component-9
9	Supply of GIS Based Maps	9/25/2019	D-3: 4	GIS Based Maps	Component-3
10	Supply of Boundary Data for Models at Various Scales	9/25/2019	D-3: 5	Supply of Model Boundary Data	Component-3
11	Data Reports, Inventory, Quality Checks	9/29/2019	D-3: 1, 2	Data Report, Inventory & Quality Checks (Includes field Data collection and monitoring programmes)	Component-3
12	QPR-4	11/7/2019	Q 4	QPR-4	QPR
13	Interim Literature Review Report 2	1/15/2020	D-2: 2	Literature Inventory & Interim Review 2	Component-2
14	QPR-5	3/2/2020	Q 5	QPR-5	QPR
15	Database Design Report (Revised)	5/21/2020	D-3: 3	Database Design Report	Component-3
16	Revised Interim Literature Review Report 1	5/31/2020	D-2: 1	Literature Inventory & Interim Review 1	Component-2
17	Mid-term Progress Workshop Report	6/8/2020	D-9.1: 2	Workshop 3 Report - Mid Term Progress Workshop	Component-9
18	QPR-6	6/10/2020	Q 6	QPR-6	QPR
19	Boundary conditions and data for calibration and validation of models (Revised Submission)	6/11/2020	D-3: 5	Supply of Model Boundary Data	Component-3

SL No.	Name of the Report	Date of Submission (m/d/y)	Reference as per Tracker	Program Item/Description as per Tracker	Reports under component
20	GBM Basin Model and Macro Scale river and coastal model -current scenario (1st submission)	8/12/2020; 8/16/2020;	D-4A-1: 2, 3	Model Set up Calibration & Validation	Component-4
21	Meso-scale Interim Report: Effect of human interventions on tidal and sediment dynamics in the Pussur-Sibsa basin (1st submission)	Sep 2020	D-4A-2: 3	Pussur Sibsa Fine Sediment Model	Component-4
22	QPR-7	9/6/2020	Q 7	QPR-7	QPR
23	MIKE 21C Bishkhali Meso-scale Bank Erosion Morphological Modelling Study: Model Development Report	10/08/2020	D-4A-2: 1, 2	Bishkhali: Model Set up Calibration & Validation	Component-4
24	Interim Subsidence Report	10/30/2020	D-4B: 1, 2,3	Report	Component-4
25	MIKE 21C Pussur meso-scale bank erosion morphological modelling study: Model development report	10/30/2020	D-4A-2: 1, 2	Pussur: Model Set up Calibration & Validation	Component-4
26	MIKE 21C Sibsa meso-scale bank erosion morphological modelling study: Model development report	10/30/2020	D-4A-2: 1, 2	Sibsa: Model Set up Calibration & Validation	Component-4
27	GBM Basin Model and Macro Scale river and coastal model -current scenario (Revised)	11/19/2020	D-4A-1: 2, 3	Model Set up Calibration & Validation	Component-4
28	Lower Meghna-Tetulia river system morphological modelling study-Current situation	12/02/2020	D-4A-2: 1	Lower Meghna: Model Set up Calibration & Validation	Component-4
29	Meso-scale Interim Report: Effect of human interventions on tidal and sediment dynamics in the Pussur-Sibsa basin (revised)	12/04/2020	D-4A-2: 3	Pussur Sibsa Fine Sediment Model	Component-4
30	Monitoring Results on Sedimentation rate in Rivers and Floodplain	12/12/2020	D-3:6	Monitoring Results on Sedimentation rate in rivers	Component-3
31	Baleswar-Bishkhali morphological modelling study-Current situation-Interim Report	01/06/2021	D-4A-2: 1	Baleswar-Bishkhali: Model Set up Calibration & Validation	Component-4
32	Pussur-Sibsa morphological modelling study-Current situation - Interim Report	01/06/2021	D-4A-2: 1	Pussur Sibsa: Model Set up Calibration & Validation	Component-4
33	Sangu River morphological modelling study- Interim Report	01/06/2021	D-4A-2: 1	Sangu: Model Set up Calibration & Validation	Component-4
34	Review/Improvements on-going work (CEIP-I)	01/17/2021	D-5A:2	Improvement to 17 Polders	Component-5

SL No.	Name of the Report	Date of Submission (m/d/y)	Reference as per Tracker	Program Item/Description as per Tracker	Reports under component
		June 2021 (online)			
35	QPR-8	01/20/2021	Q 8	QPR-8	QPR
36	Data Validation and Compilation Report	02/16/2021	D-3:8	Technical Report of Data Analysis and validation	Component-3
37	Report on Selection of Polders for Conceptual Design as Pilot Program (revised submission)	Online 03/20/2021	D-5A:1	Polder Development Plan	Component-5
38	Boundary conditions and data for calibration and validation of models (2nd Revised Submission)	Online 03/20/2021	D-3: 5	Supply of Model Boundary Data	Component-3
39	QPR-9	03/21/2021	Q 9	QPR-9	QPR
40	Baleswar-Bishkhali morphological modelling study- Meso-scale Interim Report-revised	5/19/2021	D-4A-2: 1	Baleswar-Bishkhali: Model Set up Calibration & Validation	Component-4
41	Sangu River morphological modelling study Meso-scale Interim Report-revised	5/19/2021	D-4A-2: 1	Sangu: Model Set up Calibration & Validation	Component-4
42	QPR-10	05/23/2021	Q 10	QPR-10	QPR
43	Monitoring Results on Sedimentation rate in Rivers and Floodplain-revised report submitted online	06/16/2021 (online) 06/21/2021 (hardcopy)	D-3:6	Monitoring Results on Sedimentation rate in rivers	Component-3
44	Climate Change Scenarios: Deliverable-4C: Meteorology	06/23/2021 (online) 06/27/2021 (hardcopy)	D-4C	Technical report	Component-3
45	Climate Change Scenarios: Deliverable-4C: Meteorology 2nd submission	08/11/2021 (online)	D-4C	Technical report	Component-3
46	QPR-11	08/18/2021	Q 11	QPR-11	QPR
47	Drainage Modelling of 5 Polders at Different Coastal zones in Assessing infrastructure need for Water Management	09/07/2021 (hardcopy) 09/12/2021 (online)	D-5A:3	Technical report	Component-5
48	Micro Scale Morphology, Interim Report	07/18/2021 (online)	D-4A:3	Modelling of TRM operation	Component-4
49	The Effect of Climate Change on Water Levels, Salinity Intrusion and Storm Surges Interim Report on Salinity Modelling Current Situation	09/27/2021 (hardcopy) 09/29/2021 (online)	D-4D	Climate change effects	Component-4
50	IGDCZ Implementation Plan (Revised). October-2021	10/20/2021	D-3	Deployment & Implementation plan for IGDCZ	Component -3
51	QPR-12	11/30/2021	Q12	QPR-12	QPR

2 DATA ACQUISITION

2.1 Collecting Existing Data

IWM already has a very comprehensive database comprising hydrometric, meteorological, morphological and environmental data collected over many decades all over the territory of Bangladesh and the adjacent ocean. These data have the advantage of having been used many times over in a large model studies which have also established the quality of the data through repeated verification.

The present study requires the addition of socio-economic data and its subdivision into a polder-wise demarcated body of data. The availability of data is described in the Inception Report and is too large to be included in this progress report. The reader is directed to the Inception report for an outline of availability. Appendix A of the Second Quarter Progress Review Report gives a list of available data.

2.2 Field Surveys carried out by IWM

2.2.1 Mobilization

The survey team was mobilized on 05 February 2019. All planned data collection campaign has been already completed as per specification by February 2021. However, discharge and sediment sampling were continued until September-2021 as a part of the extended study.

2.2.2 Summary of Field Survey Activities

All field activities of IWM on data collection were completed in September 2021. To support the mathematical studies on TRM, cyclone storm surge/ flood hazard in connection with conceptual polder design, field surveys were conducted in 5 selected polders and completed in February 2021. Table 2.1 summarises the item of works of the survey and progress achievement. Survey methodology of 5 polders is described in QPR-11.

In the 12th quarter from July 2021 to September 2021, routine discharge and sediment measurements at Bahadurabad of Brahmaputra River and at Hardinge Bridge of Ganges River were continued for better understanding of the sediment rating curve. It is to be noted that as the discharge observations at Bahadurabad and Harding Bridge could not be achieved according to the planned schedule during March 2020 to September 2020 due to the lockdown of COVID-19 and also due to breakdown of two ADCP instruments, it was planned to continue the measurements over those two locations up to September 2021 during the extended period of the project. In this period, measurements have been done with a more frequency to achieve the target number of measurements. The methodologies for the discharge and sediment measurements are described in detail in the Second Quarterly Progress Report. Table 2.2 and Table 2.3 summarize the progress of discharge and sediment monitoring.

Table 2. 1: Progress of the survey for 5 polders

Sl No	Polder	Item of work	Quantity	Progress achieved	Remarks
1	(P-40/1) Patharghata, Barguna	Embankment (Km)	22	22	
		structure (Nos.)	27	27	
		Drainage Canal (Km)	27	27	
		Perepheral River Section (nos.)	43	43	
		Land Level (Km^2)	20	20	
2	(P-29) Dumuria/Batiaghata, Khulna	Embankment (Km)	49	49	
		structure (Nos.)	41	41	
		Drainage Canal (Km)	121	121	
		Perepheral River Section (nos.)	120	120	
		Land Level (Km^2)	79	79	
3	(P-59/2) Char Alexander/Kamalnagar, Noakhali	Embankment (Km)	88	88	Spot level are undertaken in the open area mainly and some representative spot levels are also recorded inside the homestead.
		structure (Nos.)	8	8	
		Drainage Canal (Km)	73	73	
		Perepheral River Section (nos.)	61	61	
		Land Level (Km^2)	209	180	
4	(P-64/1A) Bashkhali, Chittagong	Embankment (Km)	54	54	
		structure (Nos.)	5	5	
		Drainage Canal (Km)	42	42	
		Perepheral River Section (nos.)	56	56	
		Land Level (Km^2)	52	52	
5	(P-64/1B) Bashkhali, Chittagong	Embankment (Km)	83	83	
		structure (Nos.)	50	50	
		Drainage Canal (Km)	63	63	
		Perepheral River Section (nos.)	24	24	
		Land Level (Km^2)	90	50	
6	(P-15) Syamnagar, Satkhira	Embankment (Km)	27	27	Survey has been conducted during 2017 in connection with CEIP-1 for detail design. For this study revisit has been done through conducting 44 nos. embankment and 49 nos. perepheral river cross section. In addition, some structure inventory has been revisited.
		structure (Nos.)	7	7	
		Drainage Canal (Km)	20	20	
		Perepheral River Section (nos.)	36	36	
		Land Level (Km^2)	31	31	
	Total	Embankment (Km)	323	323	
		structure (Nos.)	138	138	
		Drainage Canal (Km)	346	346	
		Perepheral River Section (nos.)	340	340	
		Land Level (Km^2)	481	412	

Table 2.2: Progress of the discharge observation

SL no.	Location/ River Name	Target (Number)		Progress upto June-2021	Progress in between July -Sep 2021	Cumulative progress upto Sep-2021	Remarks
		TOR	Modified				
A	3 main rivers						
1	Bahadurabad, Brahmaputra	18	48	42	6	48	Data collection will be done up to September 2021 as a part of the extended study.
2	Hardinge Bridge, Ganges	18	48	42	6	48	
3	Bhairab Bazar, Upper Meghna	18	48	27	0	27	
Total of A		54	144	111	12	123	
B	Lower Meghna						
4	Chandpur, Lower Meghna	3	5	5	0	5	2 spring+ 1 neap during monsoon and 2 nos. 1 Spring +1 Neap for dry
C	5 nos. Tidal rivers surrounding the Polders.						
5	U/S of Mongla port, Pusur	44	8	8	0	8	For each location 8 measurement: 1 spring in every two months and -1 neap in every six months for the periods of one year.
6	Nalian, Shibsha		8	8	0	8	
7	Charduani, Baleswar		8	8	0	8	
8	Bhandaria, Baleswar		8	8	0	8	
9	Polder-17/2, Gangril		8	8	0	8	
Total of C		44	40	40	0	40	
D	Additional 3 tidal River						
10	Dasmina, Tetulia	0	2	4	0	4	2 nos. measurement during June-Oct-19, 1 Spring+ 1 Neap
11	Kakchira, Bishkhali	0	3	3	0	3	Total 3 nos. -1 spring in dry season and 1-Neap+1-Spring for monsoon
12	Taliar dwip,Shangu	0	2	2	0	2	2 nos. measurement during June-Oct-19, 1 Spring+ 1 Neap
Total of D		0	7	9	0	9	

Table 2.3: Progress of suspended sediment sampling for total concentration

SL no.	Location/ River Name	Discharge observation		Suspended Sediment Sampling for Total concentration			
		As per TOR	Modified	As per TOR	Progress upto June-2021	Progress from July-Sep 2021	Cumulative Progress upto June 2021
A	3 main rivers						
1	Bahadurabad, Brahmaputra	18	48	1056	2813	360	3173
2	Hardinge Bridge, Ganges	18	48				
3	Bhairab Bazar, Upper Meghna	18	48				
B	Lower Meghna						
4	Chandpur, Lower Meghna	3	5	234	149	0	149
C	5 nos. Tidal rivers surrounding the Polders.						
5	U/S of Mongla port, Pusur	44	40	3432	2736	0	2736
6	Nalian, Shibsha						
7	Charduani, Baleswar						
8	Bhandaria, Baleswar						
9	Polder-17/2, Gangril						
D	Additional 3 tidal River (as per modified plan)						
10	Dasmina, Tetulia	0	2	0	633	0	633
11	Kakchira, Bishkhali	0	3				
12	Taliar dwip,Shangu	0	2				

2.5 Field Surveys carried out by US Universities and Partners

2.5.1 Subsidence and Delta Building

We continue to process the continuous GNSS data, including the 9 sites in SW Bangladesh that were installed or rehabilitated in 2019. However, during the Fall we stopped being able to download data from the sites. To correct this, M. Steckler undertook a trip to Bangladesh that started in December, 2021 to visit all of the sites, replace the batteries, reset and recharge the modems, and undertake any other repairs necessary to return the GNSS systems to full working order. A significant amount of time was spent planning the trip, which also included RSET-MH servicing, during this quarter. The fieldwork itself, started in January 2022, will be covered in the next report.

During the last quarter of 2021, M. Steckler completed revisions to the paper on subsidence and it was published online in December 2021. The full citation of the paper is:

Steckler, M.S., B. Oryan, C.A. Wilsan, C. Grall, S.L. Nooner, D.R. Mondal, S.H. Akhter, S. DeWolf, S.L. Goodbred (2022) Synthesis of the Distribution of Subsidence of the Lower Ganges-Brahmaputra Delta, Bangladesh, Earth-Science Reviews, 224, 103887, doi:10.1016/j.earscirev.2021.103887.

During this quarter, Dhaka University students Masud Rana and Sharmin Akter finished writing their MS theses related to subsidence in the poldered regions. This work was a sincere collaboration between M. Steckler, C. Wilson, and students who spent much time working up data collected over the past several years from GNSS and RSET-MH located near Polder 32 and the Sundarbans. They will defend their theses in late January or February 2022.

Akter, S., 2021. Comparison between surface elevation change, vertical accretion, and shallow subsidence of anthropogenic setup (polder area) and natural setup (Sundarbans) using RSET-MH method. Dhaka University MS Thesis, 67 pg.

Rana, M., 2021. Assessment of subsidence, surface elevation change, sediment dynamics, and vulnerability of an embanked terrain on the Ganges-Brahmputra-Meghna tidal deltaplain of southwest Bangladesh. Dhaka University M.S. Thesis, 104 pg.

In October 2021, M. Steckler undertook training on the GNSS-IR technique. This technique uses the reflected signal off the water surface (or snow, ice, of bare ground) to determine the elevation of the water relative to the antenna. We collaborated with Simon Williams of the National Oceanography Centre in Liverpool, U.K., an expert on the technique to process data from several sites. During 2019 and 2020, when we visited Hiron Point, we temporarily installed a campaign GNSS system on the tide gauge there. Its 4-letter identification code is HPTG. The antenna was used to both determine its absolute height and its height above the tidally fluctuating water surface. By comparing the water surface, relative to mean sea level, to the tide gauge measurements relative to the PWD, we were able to determine the offset between them (Figure 2.1).

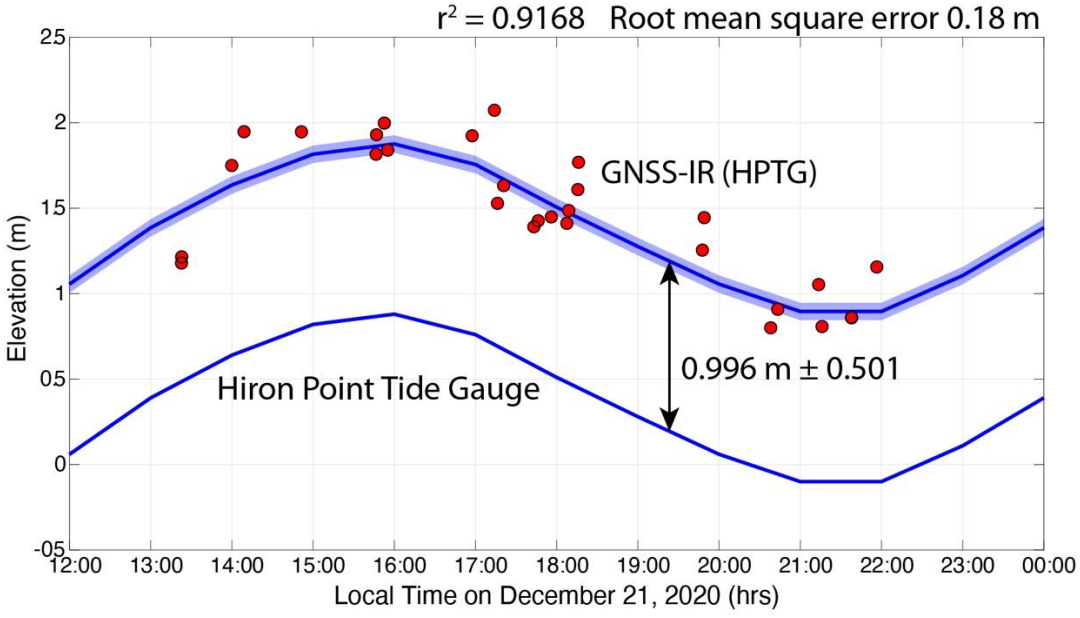


Figure 2.1: The red dots show the individual GNSS-IR measurements of water level relative to EGM96. The blue line through the dots with the lighter uncertainty range is the best fitting sinusoid. The lower blue line are the hourly measurements from the tide gauge. The offset between them, based on both the 2019 and 2020 observations is 0.996 m.

The official offset between mean sea level and PWD is 0.66 m determined in 1995. Previously, the offset was 0.46, determined in 1967 (Mondal, 2001). Here, we show the offset to MSL in the geoid

EGM96 is 0.996 m (Figure 2.1). The increase in the offset reflects both the rise in sea level and subsidence along the Chittagong coast, where the datum is established.

C. Wilson presented a talk at the Fall AGU Meeting 2021 in New Orleans (Wilson et al., 2021) examining the impact of adjusting both Hiron Point and the Mongla Tide gauges. Results reveal that once tidal datums are adjusted to the same geoid, mean high water measured at Hiron Point and Mongla tide gauge stations is the same (Figure 2.2). This suggests that tidal platforms within 100 km of the Bay of Bengal could aggrade to the same elevation relative to mean sea level (MSL EGM 96). This has grave significance as poldered (embanked) regions near the Mongla tide gauge have elevation deficits of 1-1.5 m compared to the natural Sundarbans and riverbank terraces, which still receive tidal inundation and sedimentation. If Effective Sea Level Rise from tidal amplification continues at the current rate, flood risk inside polders could increase >50% by 2050 (exacerbated by storm surges from tropical cyclones, recently documented by C. Wilson's PhD student Leslie Valentine in Valentine et al., 2021). Elevation remediation is possible, however, if the GBM maintains its current sediment supply, and practices such as Tidal River Management-- which reintroduces tidal inundation and sedimentation to embanked regions—or beneficial use of dredge spoil is pursued.

Valentine, L., Wilson, C., and Rahman, M., (2021). Flood Risk of Embanked Areas and Potential Use of Dredge Spoils as Mitigation Measures in the Southwest Region of the Ganges-Brahmaputra-Meghna Delta, Bangladesh. Earth Surface Processes and Landforms, Lowland Rivers Special Issue. https://doi.org/10.1002/esp.5303

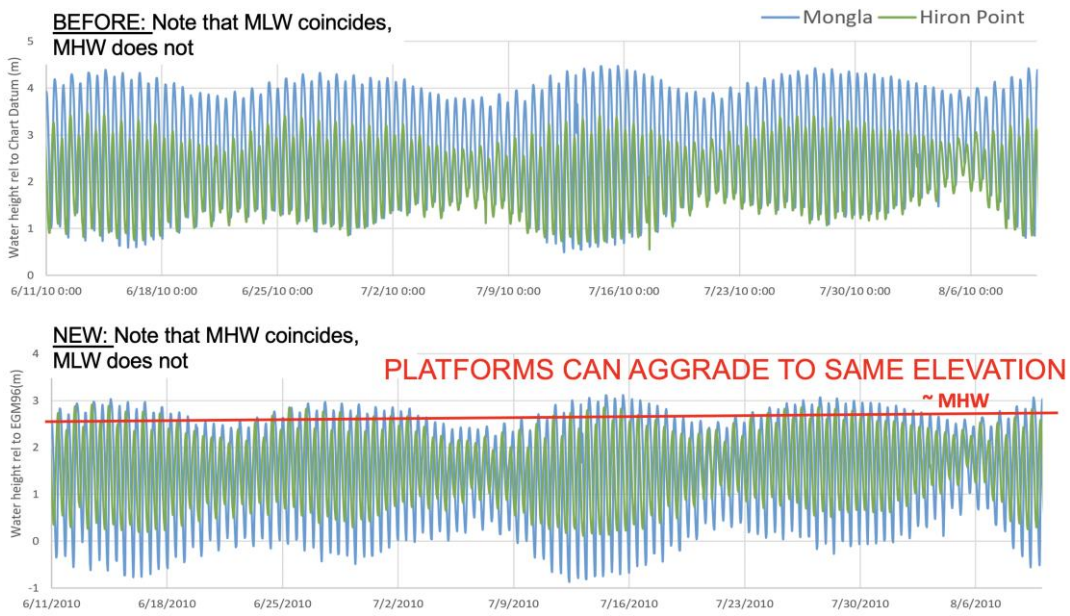


Figure 2.2: Comparison of relative heights of tidal cycles at Hiron Point and Mongla before and after adjusting the elevation to a common geoid, mean sea level, EGM96.

Wilson, C.A., Leslie Valentine, M.S. Steckler, S. Nahiduzzaman, J. Galetzka, S. Williams, and D.R. Mondal (2021) GNSS-IR advances hone platform elevation dynamics and flood risk of the lower Ganges-Brahmaputra-Meghna delta, Abstract EP51C-08 presented at AGU Fall Meeting 2021, Dec. 13-17, New Orleans, LA.

S. Goodbred worked with Md. Golam Muktadir and his team to complete the coastal drilling transects. Mr. Muktadir's team collected 15 remaining cores from the Noakhali/Feni region of the eastern coast (Figure 2.3). Results of these cores are currently being assessed in the first quarter 2022. Goodbred has also been evaluating the distribution of sediments across the delta (Figure 2.4). Data in the top panel of Figure 2.4 shows that mud-sized sediments are unevenly distributed across the Bengal basin, with much higher fractions in basin and interfluve regions (34-68%) compared with the main river valley regions (18-26%). The distribution of sand-sized sediments also appears to be unevenly distributed in the top panel, but the results are different if mud-sized sediment are not considered. In the lower

panel of Figure 2.4, the sand fraction for all settings (basins, interfluves, and valleys) is normalized to total sand mass. In this perspective, data show that dispersal of different sand fractions is uniform across all regions of the delta. These results suggest that the distribution of sand mass by the rivers is not strongly influenced by external factors such as subsidence, tectonics, and local physiography. These findings do not suggest that such factors are unimportant influences on geomorphology and river channel behavior, they certainly are. Rather, these results suggest that river channels are able to self-organize and disperse their sand and bedload similarly across vert different physical settings. The evaluation of these initial findings will be continued.

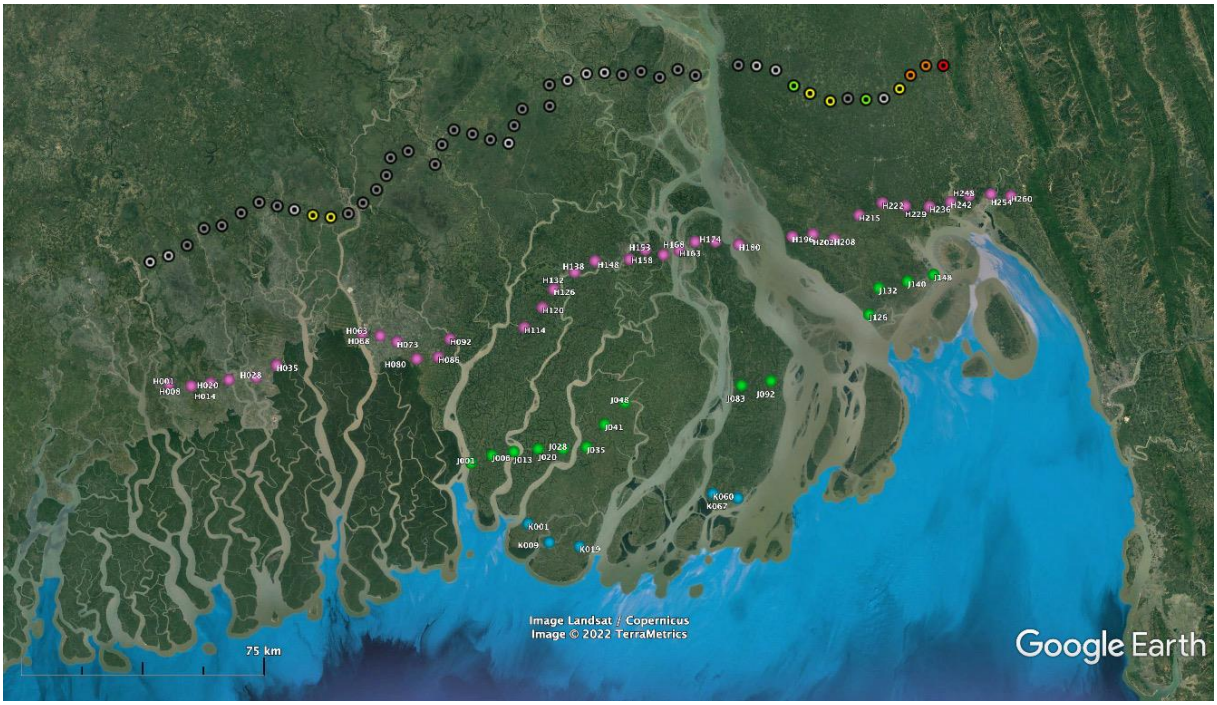


Figure 2.3: Map of all sediment cores collected to date for CEIP project. The most recent cores collected in Q4 2021 are circled. These samples now complete the cross-delta transects of Holocene delta stratigraphy. Additional cores will be collected in key location in Q1 2022, with specific sites to be determined.

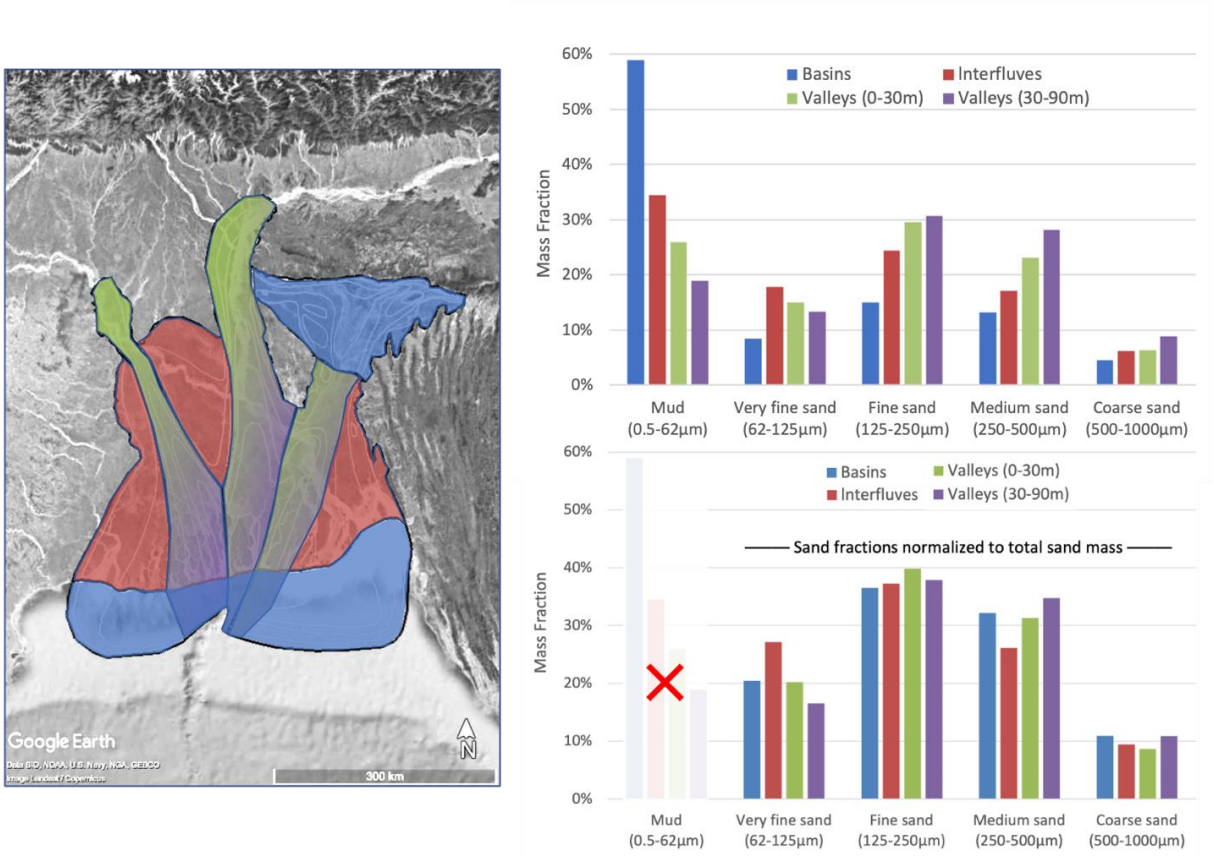


Figure 2.4: The left panel shows a physiographic map of the Bengal basin, distinguishing basin (blue), interfluve (red) and valley (green/purple) settings. Plots on the right show the distribution of size fractions for total Holocene sediment storage in each physiographic setting. The top plot is the distribution for all grain size, and the lower plot is the distribution of sand-size sediments only. Note that the distribution of mud-sized sediments is highly non-uniform (top plot), whereas the distribution of sand-sized sediment only (lower plot) is highly uniform across the same settings.

3 DEVELOPMENT OF THE INTERACTIVE GEODATABASE OF THE COASTAL ZONE

3.1 Introduction

This section presents the progress of tasks and activities for developing an Interactive Geodatabase for Coastal Zone (IGDCZ) during the 13th quarter (October 2021 to December 2021) of the project.

According to the Terms and Reference (ToR) of the project in Component-3 the objectives are:

- To collect all input datasets, undertake Quality Assurance/Quality Checking (QA/QC) and update/modify datasets as necessary for use in the modelling of the physical processes in the coaster zone of Bangladesh.
- To improve the process of data collection, QA/QC and data dissemination and sharing among the government agencies

To achieve the above objectives, a web GIS based Interactive Geodatabase for Coastal Zone (IGDCZ) has been developing under this project. IWM team have been conducting several tasks and activities during this quarter. The summary of work progress of are presented in Table 3.

Table 3.1: Summary of work progress

Sl No	Task & Activities	Progress (%) Up to 12th Quarter	Progress (%) 13th Quarter	Overall Progress (%)
1	**Inception Phase**			
1.1	Review Existing Systems	100	-	100
1.2	Consultation with Project Team	continue		continue
1.3	Consultation with Project Client	continue		continue
1.4	Requirement Analysis	100	-	100
1.5	Data Requirements and Data sources	100	-	100
1.6	Conceptual System Architecture	100	-	100
1.7	Inception Report	100	-	100
2	**Data Collection and Processing**			
2.1	Coastal Bank Erosion (Satellite Image)	100	-	100
2.2	Land use Classification (Satellite Image)	85	10	95
2.3	Agricultural Land use (Robi, Kharif-1 & Kharif-2)	85	0	85
2.4	Other Data Collection (shapefile & tabular)	90	5	95
2.5	Other Data Processing (shapefile & tabular)	90	5	95

Sl No	Task & Activities	Progress (%) Up to 12th Quarter	Progress (%) 13th Quarter	Overall Progress (%)
3	**GIS Mapping**			
3.1	Polder Maps & Processing	85	0	85
4	**Database Design & Development**			
4.1	Database Design Development	100	-	100
4.2	Database Design Report	100	-	100
4.3	Database Implement	90	3	93
5	**Web GIS Application Development**			
5.1	IGDCZ Prototype Development	100	-	100
5.2	Full Version Development	95	0	95
5.3	GIS Core Modules	95	0	95
5.4	Dashboard Development	93	0	93
5.5	Metadata Preparation	50	10	60
5.6	Metadata Interface Development	70	0	70
5.7	User Administrative Module	90	0	90
5.8	Document Archiving	100	-	100
5.9	Tutorial (help tutorial)	100	-	100
5.10	Testing & debugging	92	1	93
5.11	Data Validation and Check	92	3	95
5.12	Software & Hardware Procurement	0		
5.13	Installation of SW and HW at BDWB Data Centre	-	-	-
5.14	Migration of Database and Application to BWDB Servers	-	-	-
5.15	Fully operational commissioning	-	-	-
5.16	Preparation of User Instruction Manual	-	-	-
6	**Reports**			
6.1	Database Design Report	submitted	-	-
6.2	Validation and Compilation Report (1st version)	submitted	-	100
6.3	IGDCZ Implementation Report (1st version)	submitted	-	100

Sl No	Task & Activities	Progress (%) Up to 12th Quarter	Progress (%) 13th Quarter	Overall Progress (%)
7	**Training & Technology Transfer**	3 days training		
8	**On-the-job Training**	0	30	30
9	**Feedback and update (ongoing)**	comments were addressed		

3.2 Land Use Changes

The land use and its temporal changes in the past from the year 1989, 2000, 2010 and 2020 have been prepared from the satellite images. The LanSat/TM satellite images have been used, which were captured in several days of the dry season of years 1989, 2000, 2010 and 2020. The satellite mosaic images of 1989 and 2000 are shown in Figure3.1 and Figure 3.2.

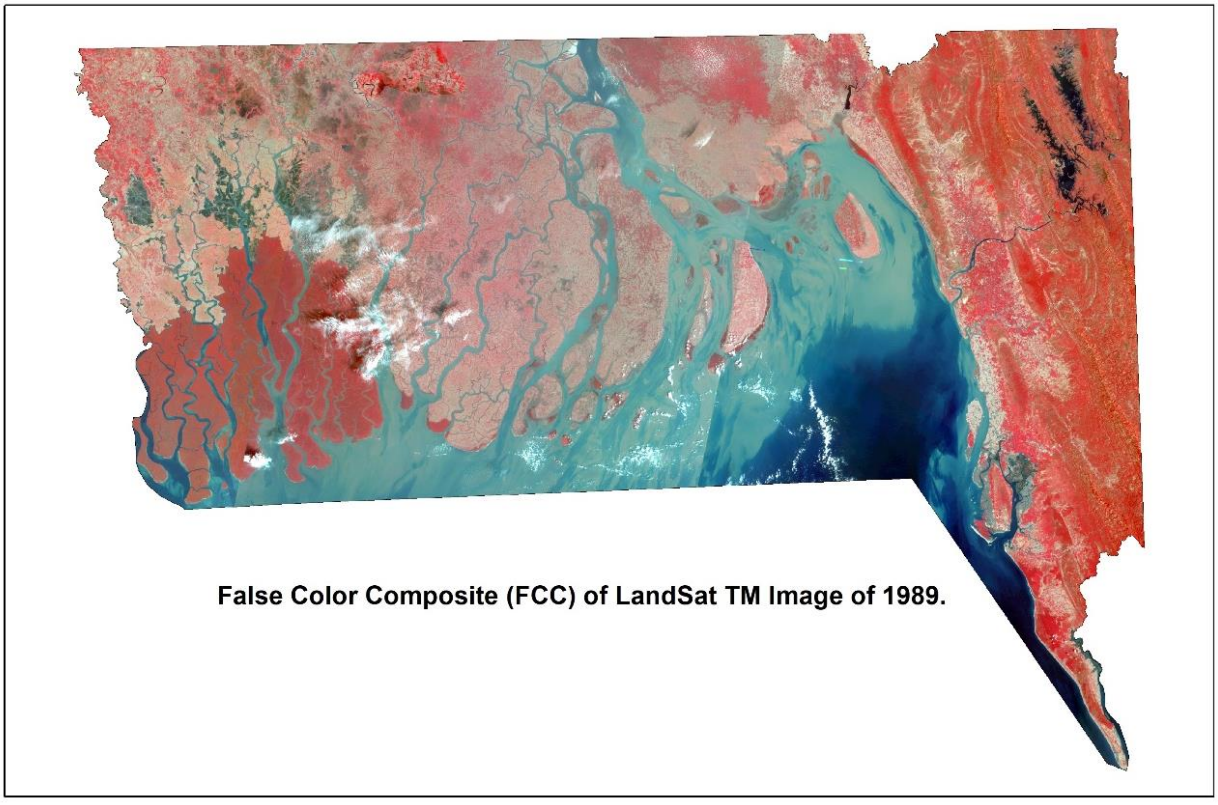


Figure 3.1: Satellite image mosaic of the year 1989 used for the study

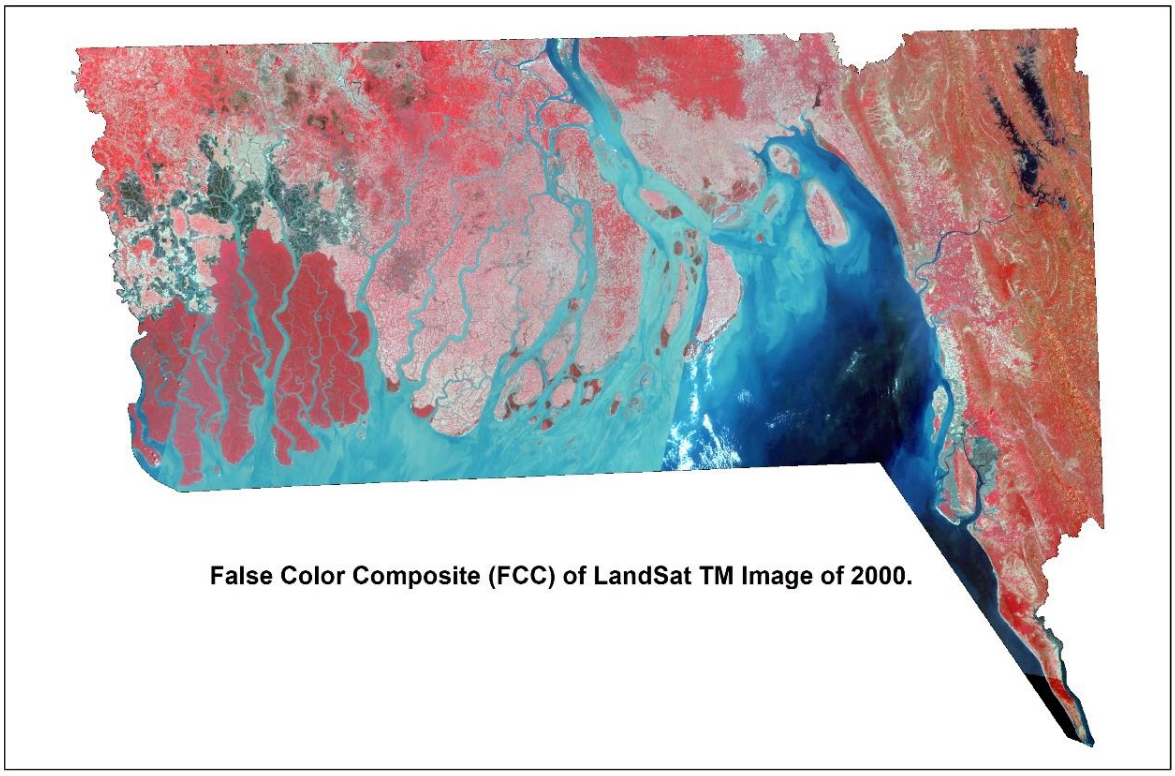


Figure 3.2: Satellite image mosaic of the year 2000 used for the study

Following Figure3.3 presents the land use class of the year 1989 and Figure3.4 presents the land use class of 2000.

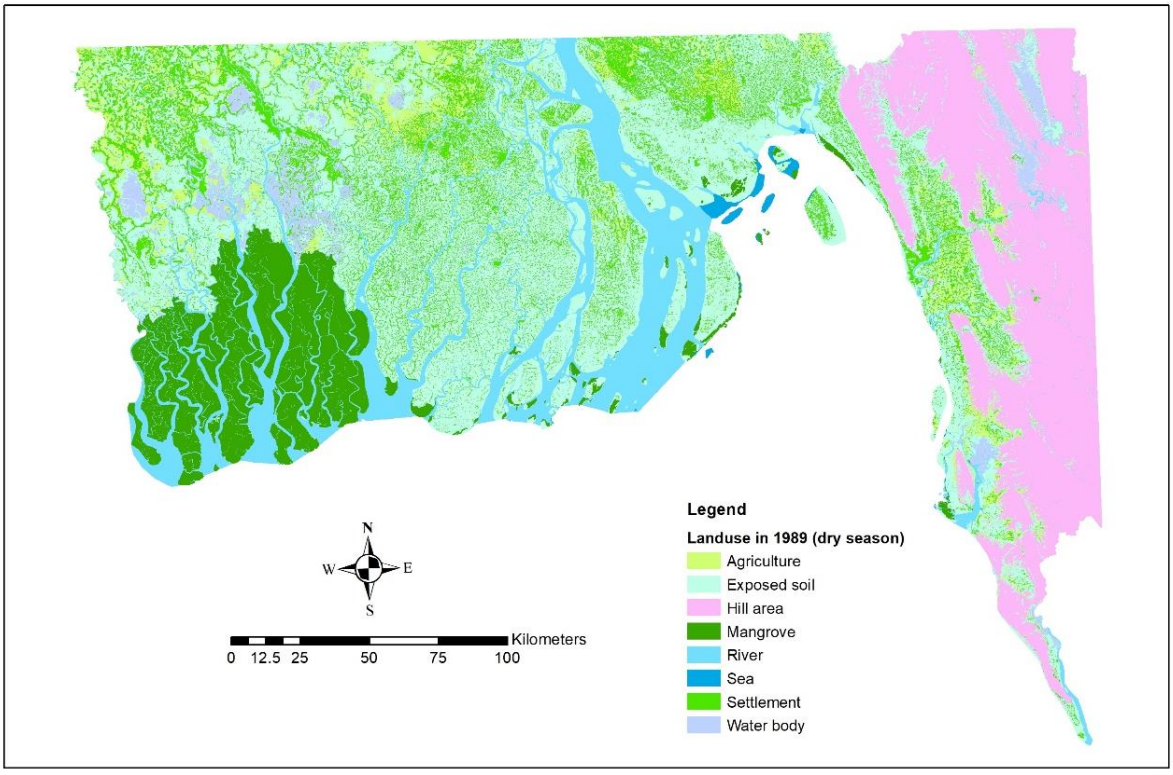


Figure 3.3: Land use Classes in year 1989

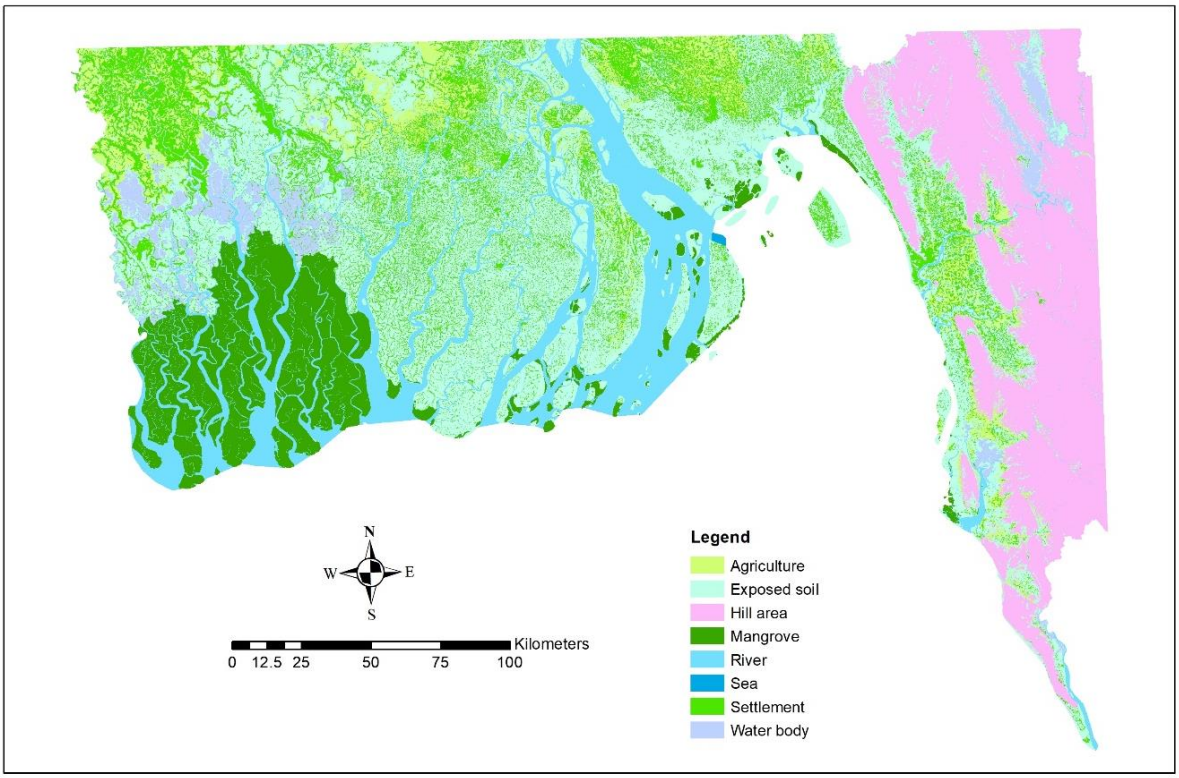


Figure 3.4: Land use Classes in year 2000

The changes of land use from 1989 to 2000 is presented in Figure3.5 below.

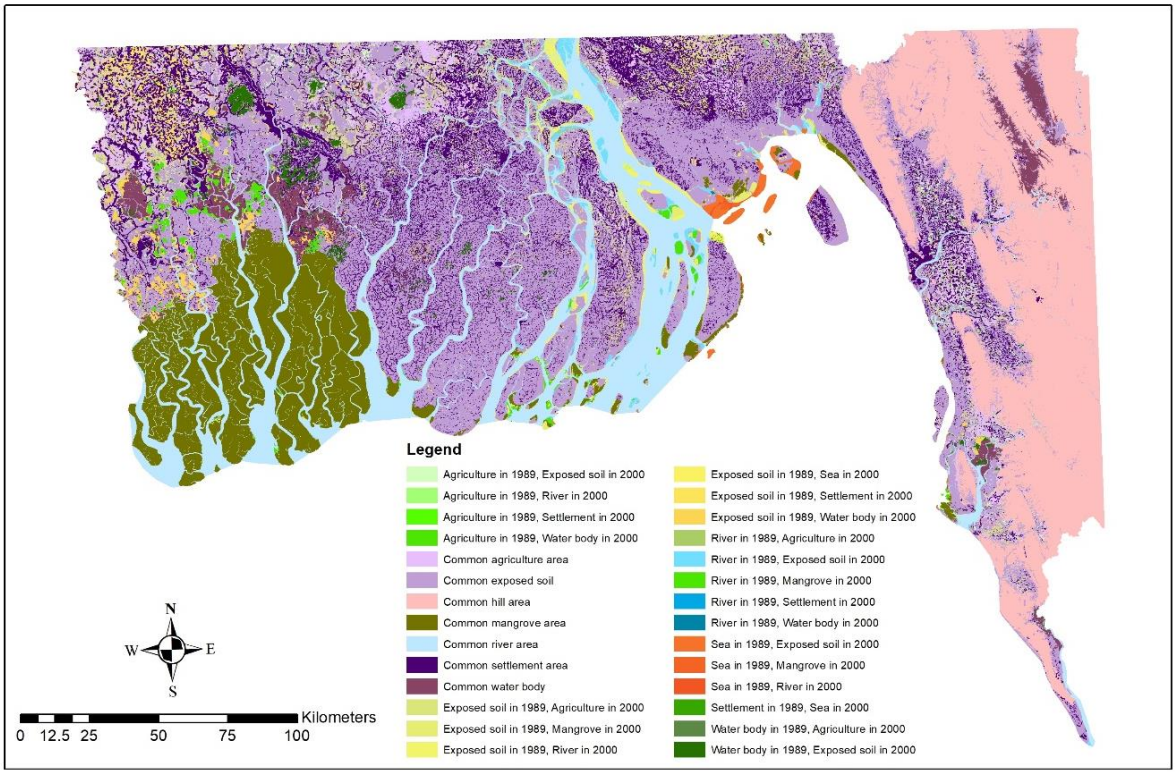


Figure 3.5: Change land use class from 1989 to 2000

The changes of land use classes from 2000 to 2010 and 2010 to 2020 in under process. The land use class and land change from 1989 to 2000 is presented in Table3.2 below.

Table 3.2: Land use change from 1989 to 2000

Land use Feature	Area, Hectares		Overall Changes	
	1989	2000	Hectares	% w.r.t 1989
Agriculture	2,64,350	3,12,278	47,927	18.13
Exposed soil	17,02,375	15,83,722	-1,18,653	-6.97
Hill area	8,60,837	8,60,837	0	0.00
Mangrove	4,39,974	4,61,502	21,528	4.89
River	6,36,684	6,28,335	-8,349	-1.31
Settlement	5,86,855	6,44,971	58,116	9.90
Water body	1,46,946	1,64,101	17,155	11.67

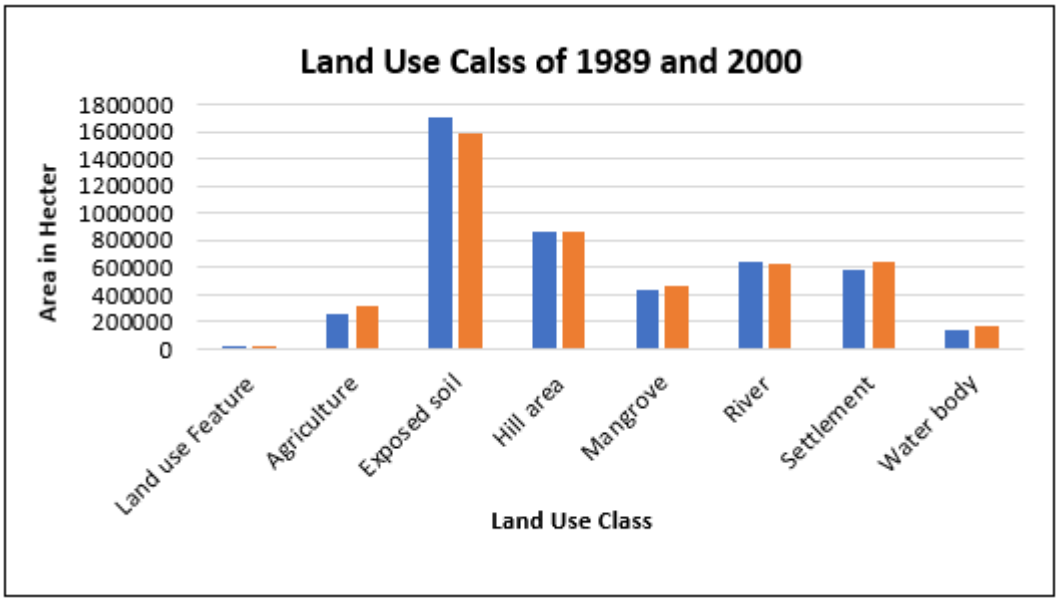


Figure 3.6: Chart for land use change from 1989 to 2000

3.3 Data Collection and Data Processing

In this quarter, several GIS layers such as groundwater arsenic contamination, locations of cyclone shelter and physiographic layers for the polders area have been collected and processed for the IGDCZ database.

3.4 Data Checking and Validation

Data checking, verification and validation process is being continued for polder and its associated layers and datasets. Several feedbacks received from BWDB offices and accordingly the corrections are made. Corrections of internal boundaries between polder 39/1B and 39/1D are made as suggested by the project officials.

3.5 On-job Training

The IGDCZ developer team is providing one-job training to a selected engineer from GIS directorate of BWDB. The schedule of this training is one day per week. This training was started from November 2021 and will continue for four months. The training includes data processing, verification and validation Geo-database development, metadata preparation, preparation of GIS services and step-by-step procedure for building up and maintaining the IGDCZ database.

3.6 Web Application Development

- **Full version development**

The full version of IGDCZ is still under development. Current version has been presented several times before the client and expert teams. Comments have been received and being addressed. Access to the full version has been provided to extended numbers of interested and relevant officials and experts endorsed by the Project Director.

3.6.1 User Feedback

The web GIS based IGDCZ still under developing stage and hosted in development server at IWM. A significant progress has been made during the reported quarter by IWM team, concurrently, online feedback and suggestions received from the potential users of BWDB, World Bank and other stakeholders. Accordingly, the received feedback and suggestions were reviewed and required modifications were made in the application. During the last quarter, several feedbacks was received and addressed accordingly.

3.7 Workplan

The development work has been conducted according a prepared workplan. Following

Work Plan (Figure 3.7) shows the workplan with status of different tasks and activities.

Workplan of IGDCZ Development

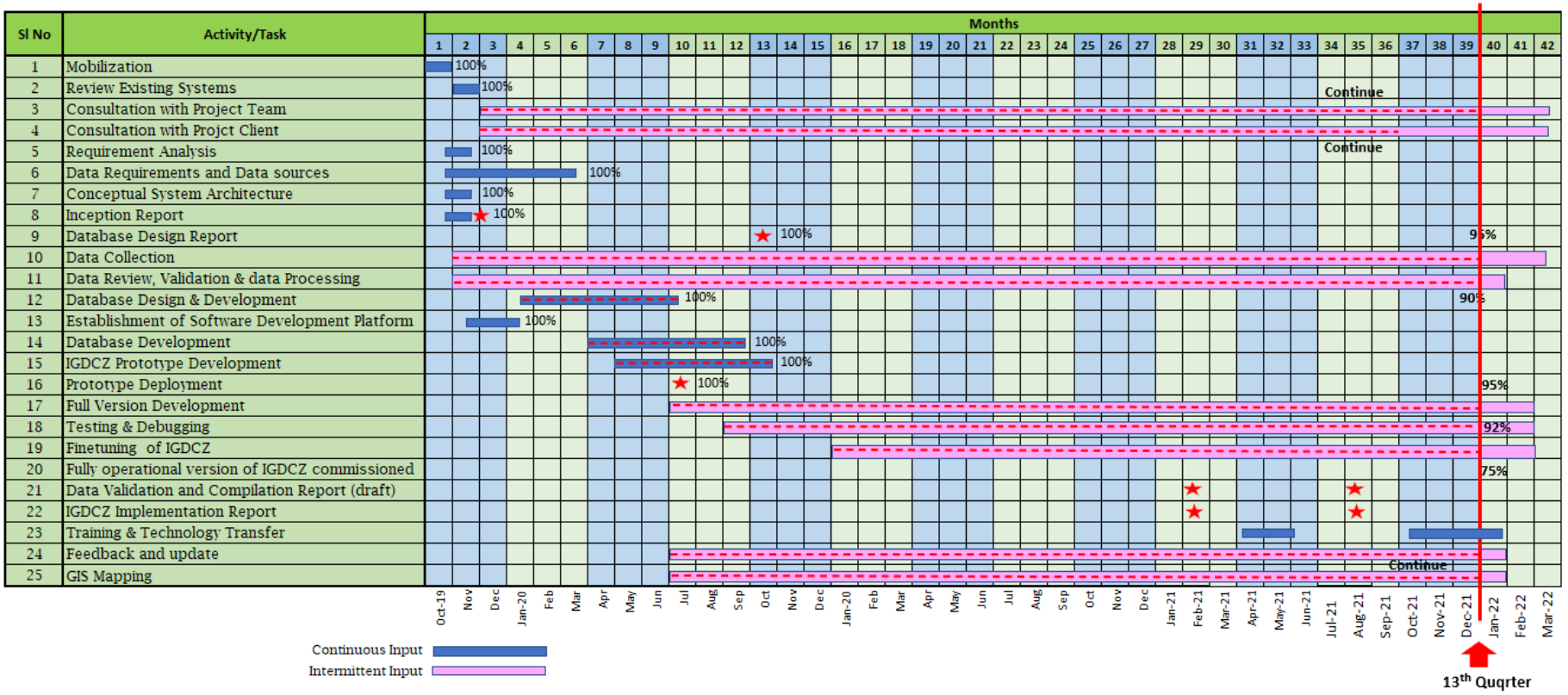


Figure 3.7: Workplan

4 MATHEMATICAL MODELLING

4.1 Salinity Intrusion Model

4.1.1 Background/ Purpose

Over the past few decades, salinity in the coastal areas has increased greatly due to decrease of transboundary flow and increase sea levels. Increased salinity intrusion in the coastal belt, especially in the south-west region of Bangladesh affects public health, livelihoods and the coastal ecosystem of the area. Climate change is already taking place, adding pressures on the management of scarce water resources.

Scarcity of freshwater in the near future would reduce the availability of safe drinking water and sufficient food, and negatively impact social conditions. The saline water intrusion is depleting the surface water irrigation water during the dry period. Due to increased salinity levels in the rivers, the practice of shrimp culture inside the embankments increased over the years, decreasing the extent of agricultural land. As a result of these adverse environmental and ecological effects, and serious social problems between the farmers and fishermen community has become evident. Major shrimp culture activities exist around Satkhira, Khulna and Bagerhat districts in the western zone, and also in Chokoria, Cox's Bazar and Moheshkhali upazilas under the Cox's Bazar District in the east. Moreover, the ecology of the Sundarbans, a large mangrove forest in this area and a world heritage site, is also being affected by salinity intrusion and sea level rise.

River salinity is highly variable with space and seasons. This study will simulate the spatial and seasonal variation of surface water salinity under present conditions as well as in the future.

4.1.2 Sea Level rise

Sea level rise at Bay of Bengal region is assessed with respect to 2019. The regional sea level rise value at year 2050 is 20 cm and at year 2100 it is 92 cm (Shown in Figure 4.1). These sea level rise values are used for the simulation of salinity model in climate change condition.

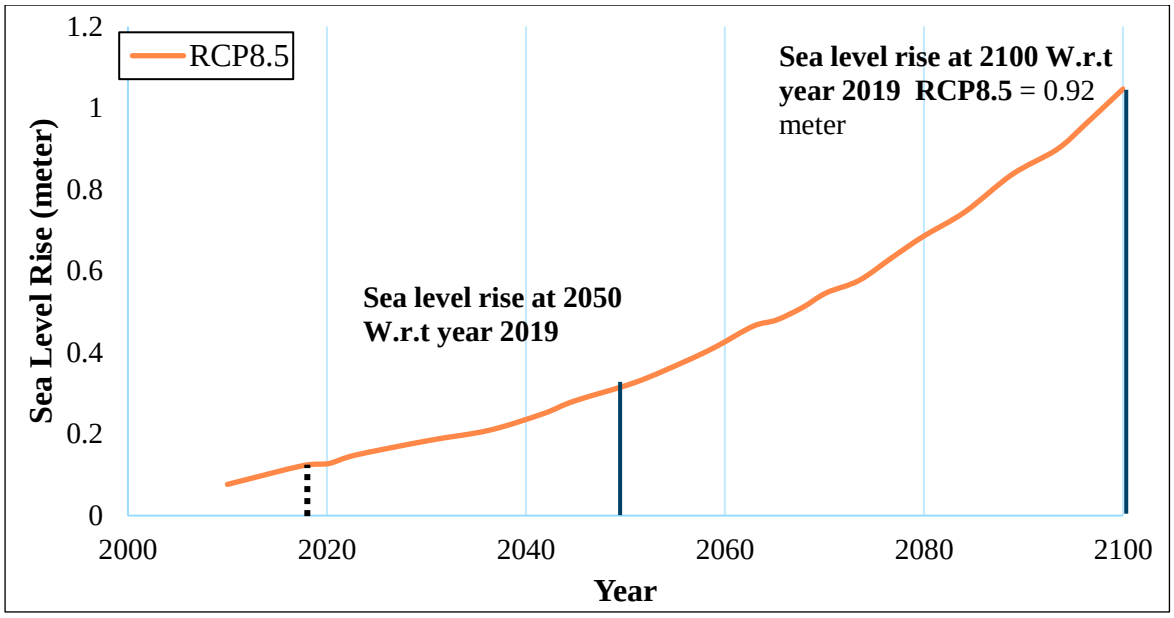


Figure 4.1: Sea level rise graph (95 percentile line) digitized from sea level projection (Source: Climate Change Scenarios, 2021)

4.1.3 Land Subsidence

Information of land subsidence is obtained from the “Interim Subsidence Report (2021)” which is published under the “Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics)” project. From the analysis of Geologist team, calculated the land subsidence rate along the entire coastal zone of Bangladesh, and they found that, land subsidence rate is variable throughout the coastal region. From the land Subsidence data, a gridded dataset was prepared using extrapolation technique. From the data, it was interpolated within South West Regional Domain. Interpolated raster is shown in mapped format on Figure 4.2.

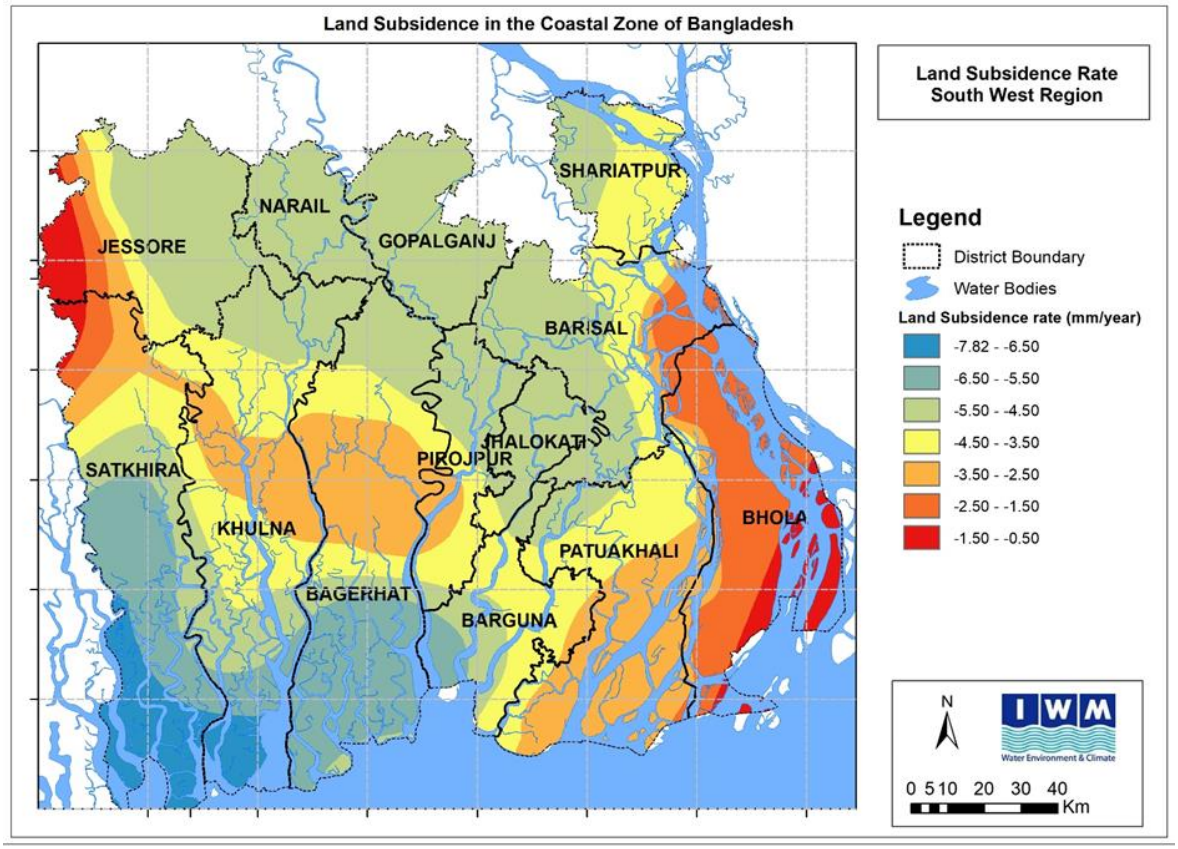


Figure 4.2: Spatial variation of land subsidence map

4.1.4 Scenarios Generation

Study will investigate the hydrometric and climatic variables that are affecting the salinity intrusion in the internal river system and the estuarine area of the coastal zone of Bangladesh. In addition to climate change model, externa intervention will also be taken into account. The intervention works that will be considered in this project are:

1. Ganges Barrage project;
2. Gorai River Restoration project;
3. Indian River linking project etc.

Scenario will be developed combining climate change (Sea level rise & rainfall change) and different project interventions. For each scenario, input of model boundary condition will be updated and model will be simulated. Rainfall-runoff model and sea level rise will be considered in hydrological model and water level boundary condition. A tentative scenario matrix was presented in Table 4.1. The scenario can be modified in future.

4.1.5 Future Plans

The future plan is to simulate the salinity in simulate salinity intrusion model according to scenario matrix. Maps, Tables will be prepared to present the output of the model. These will represent how salinity intrusion will be more severe for external intervention (Indian River Linking Project) and changing climate (especially for sea level). Also, how the

situation can be improved with flow diversion (Ganges Barrage) or river dredging (Gorai river dredging) in a changing climate.

Table 4.1: Scenario matrix

Scenario	Time frame	Upstream Flow				Sea level rise	Land subsidense
		Gorai	Padma	Upper Megna	Ichamoti		
Baseline (2019)	**Present**	Measured flow	Measured flow	Flow from NorthEast Model	Measured	RR at base + 2019 Water level	Existing topography
	2050	GBM-Model (2050) + QQ relation	GBM-Model (2050)	GBM-Model (2050)	Adjust with Sea level change 2050	RR 2050 + (SLR at 2050 = 20 cm)	Land subsidense at 2050
	2100	GBM-Model (2100) + QQ relation	GBM-Model (2100)	GBM-Model (2100)	Adjust with Sea level change 2100	RR2100 + (SLR at 2100 = 92 cm)	Land subsidense at 2100
Ganges Barrage	**Present**	Diversion from Ganges Barrage Study	Measured flow	Flow from NorthEast Model	Measured	RR at base + 2019 Water level	Existing topography
	2050	Diversion from Ganges Barrage Study	GBM-Model (2050)	NorthEast Model with rainfall + temperature change (2050)	Adjust with Sea level change 2050	RR 2050 + (SLR at 2050 = 20 cm)	Land subsidense at 2050
	2100	Diversion from Ganges Barrage Study	GBM-Model (2100)	NorthEast Model with rainfall + temperature change (2100)	Adjust with Sea level change 2100	RR2100 + (SLR at 2100 = 92 cm)	Land subsidense at 2100
Gorai River Restoration	**Present**	QQ-relation based on 20-21 data	Measured flow	Flow from NorthEast Model	Measured	RR at base + 2019 Water level	Existing topography
	2050	GBM-Model (2050) + Bangladesh River System Model with Gorai Dredging	GBM-Model (2050)	NorthEast Model with rainfall + temperature change (2050)	Adjust with Sea level change 2050	RR 2050 + (SLR at 2050 = 20 cm)	Land subsidense at 2050
	2100	GBM-Model (2100) + Bangladesh River System Model with Gorai Dredging	GBM-Model (2100)	NorthEast Model with rainfall + temperature change (2100)	Adjust with Sea level change 2100	RR2100 + (SLR at 2100 = 92 cm)	Land subsidense at 2100
Indian River Linking Project	**Present**	GBM-Model + QQ relation (Between Ganges & Gorai)	GBM-Model	Flow from NorthEast Model	Measured	RR at base + 2019 Water level	Existing topography
	2050	GBM-Model-Old (2050) + QQ relation (Between Ganges & Gorai)	GBM-Model-With River linking (2050)	NorthEast Model with rainfall +temperature change (2050)	Adjust with Sea level change 2050	RR 2050 + (SLR at 2050 = 20 cm)	Land subsidense at 2050
	2100	GBM-Model-Old (2100) + QQ relation (Between Ganges & Gorai)	GBM-Model-With River linking (2100)	NorthEast Model with rainfall + temperature change (2100)	Adjust with Sea level change 2100	RR2100 + (SLR at 2100 = 92 cm)	Land subsidense at 2100

4.2 Storm Surge and Wave Model

4.2.1 Background/ Purpose

Understanding the cyclonic storm surge propagation along with wave dynamics in the coastal region of Bangladesh including south west, south central, south east, and eastern hill regions (excluding 3 hill districts) is necessary for damage assessment and computation of design hydraulic loads on coastal protection works such as polders, roads, embankments and also of houses, structures, commercial centres, tourist zones etc. Particularly, the south-eastern coast is subject to noticeable wave attack during the monsoon. Also, during cyclone, wave height is significant, and it is added on top of cyclonic surge height and tide which creates vast damage to structures, affects public health, livelihoods and the coastal ecosystem of the area. During the cyclone, sea water intrudes the polders as a result of overtopping and causing embankment failures, which in turn results in flooding, drainage congestion, water logging and fresh water scarcity. As a result of the devastating wind speed (210 kmph for a category 4 cyclone), crops are damaged creating food shortages in the post-cyclone period. The Joint Damage, Loss, and Needs Assessment (JDNLA) estimated the total damage and losses caused by the cyclone Sidr in 2007 to be Bangladesh Taka (BDT) 115.6 billion (US$ 1.7 billion) which is 5% of Budget of Bangladesh year 2020.

Climate change is taking place and the Intergovernmental Panel on Climate Change (IPCC AR4, 2007) cites a trend since the mid-1970s toward longer duration and greater intensity of storms, and a strong correlation with the upward trend in tropical sea surface temperature (CEIP-1 report, 2018). According to WG1 report of IPCC, the proportion of intense tropical cyclones (Category 4–5) and peak wind speeds of the most intense tropical cyclones are projected to increase at the global scale with increasing global warming (IPCC AR6, 2020). It is also indicated that human-induced climate change increases heavy precipitation associated with tropical cyclones (IPCC AR6, 2020).

Under the present study cyclonic storm surge and wave fields across the coast for 19 severe cyclones are going to be modelled as well as in the future.

4.2.2 Scenarios Considered

Cyclonic storm surges are mainly forced by climatic variables like wind speed and hydrodynamic variables like tidal condition and water level. It is not influenced by upstream conditions. So, the Study will investigate the hydrodynamic and climatic variables that are affecting the storm surge propagation along with waves in the exposed coast and the estuarine area of the coastal zone of Bangladesh. In this study, a scenario has been devised considering the following climate change conditions initially based on the analysis conducted by this project *Climate Change Scenarios* (LTM 2021).

i. Sea level rise
ii. Subsidence
iii. 8% increase in maximum wind speed of cyclone.

Scenarios were developed combining climate change (Sea level rise & increased cyclonic with only one value of increased wind speed predicted for both 2050 and 2100) and subsidence for all 19 cyclones in different tidal condition (high tide or low tide or original condition). For each scenario, input of model boundary conditions were updated and storm surge models simulated. After simulation of the storm surge model, the wave model is

simulated using the generated water level and cyclonic wind speed. A tentative scenario matrix was presented in Table 4.2 and Table 4.3. The scenario can be modified in future.

4.2.3 Significant Results

The storm surge model was simulated (Figure 4.3) for all 19 cyclones in three tidal conditions (details in Table 4.2) which sums up to a total of 54 numbers of cyclones in the baseline. The statistical analysis for baseline has been done using the model results in 141 locations covering the entire coast of Bangladesh. The wave model was simulated for baseline which includes 19 production runs for 19 cyclones in the original tidal condition. The statistical analysis of the significant wave height of the 141 locations same as storm surge model were performed.

For climate change scenario, all 54 production runs of storm surge model for 2050 was performed for the year 2050. The wave model is also simulated for the year 2050.

It is noted that due to the lack of information the same increase in cyclone wind speed was used for both 2050 and 2100. This will be revised in future.

4.2.4 Future Plan

The future plan is to simulate the storm surge model for year 2100 and wave model for 2100 according to a possibly revised scenario matrix. Maps, Tables will be prepared to present the output of the model. These will represent how surge height and significant wave height is increased for changing climate (especially for sea level and wind speed). Then the design embankment design crest level will be updated to include the effect of changing climate.

Table 4.2: Tentative Scenario matrix for storm surge model

Projection Year	Cyclone year	No. Of Events	Tidal State	Wind Speed	Land Subsidence	Sea level Rise at projected year with respect to year 2019
Baseline	1960 to 2009	19 17 18	Original Tidal condition High tide Low tide	Original cyclonic wind speed	No land subsidence	No SLR
Year 2050	1960 to 2009	19 17 18	Original Tidal condition High tide Low tide	Maximum sustained wind speed increased 8% for all 54 cyclones	Land subsidence at 2050	RCP 8.5 = 0.20 meter
Year 2100	1960 to 2009	19 17 18	Original Tidal condition High tide Low tide	Maximum sustained wind speed increased 8% for all 54 cyclones	Land subsidence at 2100	RCP 8.5 = 0.92 meter

Table 4.3: Tentative Scenario matrix for wave model

Projection Year	Cyclone year	No. Of Events	Tidal State	Wind Speed	Land Subsidence	Sea level Rise at projected year with respect to year 2019
Baseline	1960 to 2009	19	Original Tidal condition	Original cyclonic wind speed	No land subsidence	No SLR
Year 2050	1960 to 2009	19	Original Tidal condition	Maximum sustained wind speed increased 8% for all 54 cyclones	Land subsidence at 2050	RCP 8.5 = 0.20 meter
Year 2100	1960 to 2009	19	Original Tidal condition	Maximum sustained wind speed increased 8% for all 54 cyclones	Land subsidence at 2100	RCP 8.5 = 0.92 meter

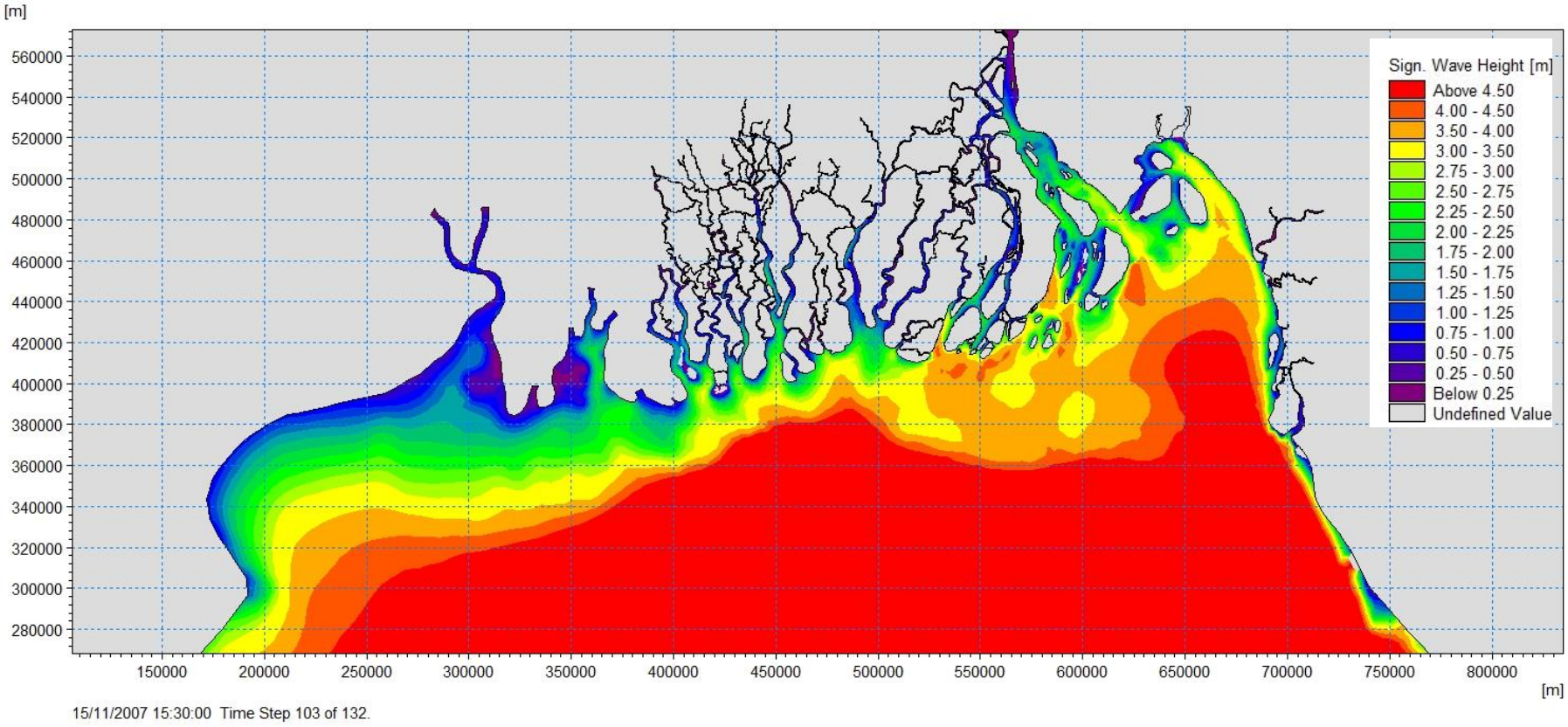


Figure 4.3: Significant wave height along the coast of Bangladesh on the onset of landfall during category 4 cyclone Sidr in 2007

5 POLDER DEVELOPMENT PLAN

5.1 Progress in October, November and December 2021

This Chapter covers progress of Work from October, November and December 2021 under Component 5.A in the Terms of Reference. During the reporting period work has focused on Deliverable 5A-3 “Conceptual Design for 5 Polders”

5.2 Workshop

An internal workshop was conducted in the first week of October 2021 to facilitate the exchange of information between the different models and provided guidance for the use of unified boundary conditions between the different models, and feed into the different designs that will be included in the investment plan. The workshop also served for the exchange between the different experts for the identification of relevant measures to be included in the investment plan. The agenda is shown in Table 5.1

Table 5.1: Agenda of the Polder sessions

Date	Time CET	Time (Dhaka)	Topic	Presenter
Tuesday 5 October “Outside in”	09.00-09.20	13.00-13.15	1. Introduction to sessions and 5 polders	Marcel
	09.20-09.35	13.20-13.35	2. Storm surge Modelling	Saiful
	09.35-09.45	13.35-13.45	Q&A	
	09.45-10.00	13.45-14.00	3. Preliminary storm surge risk assessments	Roel/Luisa
	10.00-10.10	14.00-14.10	Q&A	
	10.10-10.30	14.10-14.30	Break	
	10.30-10.45	14.30-14.45	4. River erosion	Søren
	10.45-10.55	14.45-14.55	Q&A	
	10.55-11.10	14.55-15.10	5. River salinity	Raqubul Hasan
	11.10-11.20	15.10-15.20	Q&A	
	11.20-11.35	15.20-15.35	6. Regional connections and regional economy	Mark
	11.35-12.00	15.35-16.00	Q&A followed by open discussion	
Wednesday 6 October “Inside out”	09.00-09.10	13.00-13.10	8. Introduction to the session	Mark
	09.10-09.25	13.10-13.25	9. Drainage modeling / waterlogging	Saiful
	09.25-09.35	13.25-13.35	Q&A	
	09.35-09.50	13.35-13.50	10. Groundwater salinity	Torsten
	09.50-10.00	13.50-14.00	Q&A	
	10.00-10.20	14.00-14.20	Break	
	10.20.10.35	14.20.14.35	11. Agricultural dev. / socioeconomic outlook	Mark
	10.35.10.45	14.35.14.45	Q&A	
	10.45.11.00	14.45.15.00	12. Operations and management (O&M)	Marcel
	11.00-11.10	15.00-15.10	Q&A	
	11.10-12.00	15.10-16.00	Open discussion	
Thursday 7 October	09.00-19.15	13.00-13.15	13. Conceptual designs introduction	Mark/Marcel
	09.15-09.30	13.15-13.30	14. Polder Water management	Kymo
	09.30-09.40	13.30-13.40	Q&A	
	09.40-09.55	13.40-13.55	15. River management	Bas

	09.55-10.05	13.55-14.05	Q&A	
	10.05-10.25	14.05-14.25	Break	
	10.25-10.40	14.25-14.40	16. Sediment management / TRM	Bo
	10.40-10.50	14.40-14.50	Q&A	
	10.50-11.05	14.50-15.05	17. Embankment designs	Mark
	11.05-11.15	15.05-15.15	Q&A	
	11.15-11.30	15.15-15.30	18. Disaster management	Marcel
	11.30-11.40	15.30-15.40	Q&A	
	11.40-12.00	15.40-16.00	Discussions and possible information gaps	

5.3 Computational Modelling Framework

During the second week of December, the international experts Mark de Bel and Marcel Marchand visited Dhaka as travel restrictions were finally lifted. Discussions were held with the local team (IWM) and a visit was paid to the PD for discussing the progress towards developing the polder development plan and the investment plan. During this meeting the relations were explained between the various models in the project and the polder development and design. The computational modelling framework between the models is shown in Figure 5.1. In this figure, the key objectives of the polder development are illustrated in the green boxes and are: i) Land reclamation and new polders, ii) drainage improvement, iii) embankment design and costs and iv) Land use / agriculture / aquaculture. The key parameters relevant for the polder design which can be obtained from the models are listed in

Table 5.2 5.2. Table 5.3 provides a checklist of scenarios and measures and the relevant models that will use these scenarios and measures. In Table 5. 5.4 the suggested approaches are described for modelling the respective measures.

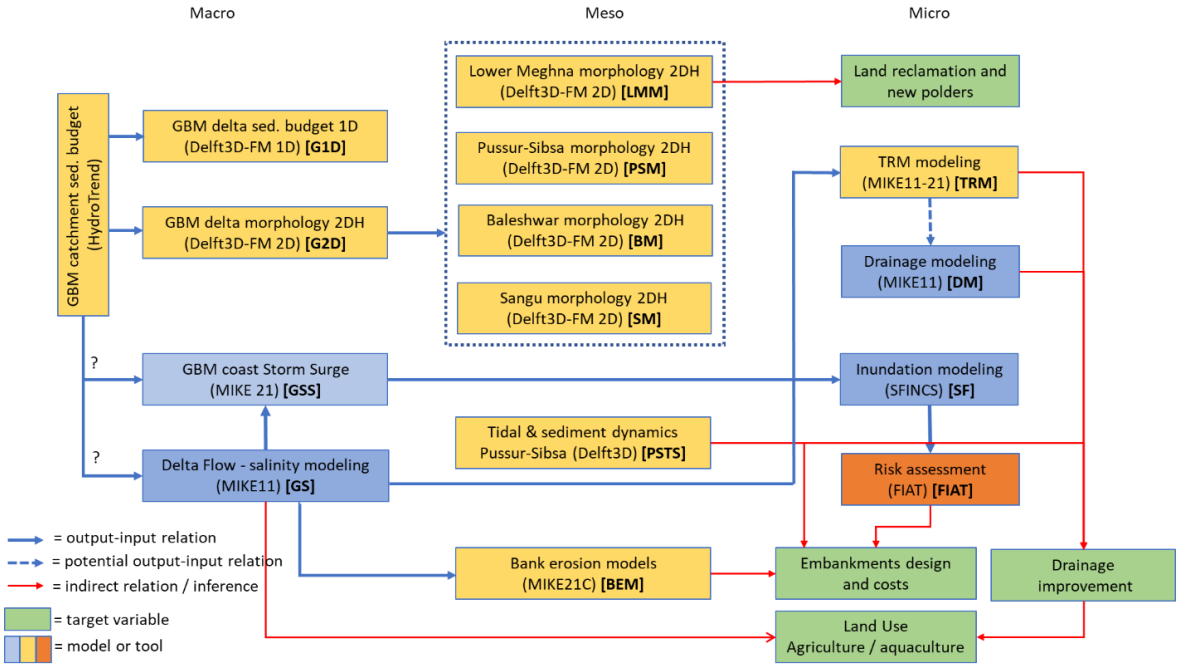


Figure 5.1: Schematized overview of the relations between the macro, meso and micro models and the polder designs.

Table 5.2: Key parameters and models

Data group	Parameter	Model
Hydrodynamic and meteorological conditions	Average water levels and tidal amplitudes	All mesoscale models, 2D macroscale morphology
	Storm Surge hydraulic conditions / frequency	GSS
	High river water levels (for fluvial flood risk)	GS, G1D, G2D
	Precipitation (for pluvial flood risk and waterlogging)	GS
Morphodynamics	Long-term morphology changes in Bay of Bengal and major estuaries	G2D, LMM, PSM, BM, SM
	Long-term morphological development major river systems	G1D
	Medium-term river bank erosion of major estuaries	BEM
	Short-term infilling peripheral rivers	TRM, PSTS
	Sedimentation rates TRM polders	TRM
Water quality	River salinity conditions during dry and monsoon season	GS
	Sediment concentrations	G2D, LMM, PSM, BM, SM, PSTS

Table 5.3: Checklist scenarios, measures and relevant models

Scenarios	G1D	G2D	GSS	GS	LMM	PSM	BBM	SM	PSTS	BEM	TRM	DM	SF	FIAT
Sea level rise	x	x	x	x	x	x	x	x	x				x	
Temperature														
Precipitation	x*	x*		x								x		
Cyclone intensity/freq			x										x	
Subsidence	x	x			x	x	x	x			x	x	x	
Population														x
Economy														x
Measures														
Ganges barrage				x										
Gorai River Restoration	x	x		x					x					
Cross dams Meghna		x			x									
Lower Meghna dredging					x									
Closure peripheral river									x					
Closure dams – estuary				x			x							
NRLP	x*	x*		x										
Smart dredging rivers										x	?			
Embankment									x	x			x	x
Merging polders														
Afforestation									x					
Drainage improvement												x		
Tidal River Management											x			
Coastal protection														
Cyclone shelters														x
Crop diversification														?
Partic. Water Manage.														
O&M water & polder														

* via HydroTrend

G1D = GBM delta sediment budget 1D
G2D = GBM delta morphology 2DH
GSS = GBM Coast Storm Surge
GS = Delta Salinity modeling
LMM = Lower Meghna Morphology
PSM = Pussur-Sibsa Morphology
BBM = Baleshwar-Bishkhali Morphology
SM = Sangu Morphology
PSTS = Pussur-Sibsa Tidal and Sediment dynamics
BEM = Bank erosion models
TRM = TRM modelling
DM = Drainage modelling
SF = SFINCS
FIAT = FIAT

Table 5.4: Suggested approaches for modelling measures

Measure	Model	Approach
Ganges Barrage	Delta Salinity model (MIKE11) [GS]	TBD
Gorai River Restoration	Delta Salinity model (MIKE11) [GS] GBM delta morphology 1D [G1D] Pussur-Sibsa Model [PSTS]	TBD TBD TBD
Cross dams Meghna Estuary	Lower Meghna morphology 2DH [LMM]	modify model schematization
Lower Meghna dredging	Lower Meghna morphology 2DH [LMM]	Simulation of dredged channel of 1 km width and 4 m dredging depth
Peripheral river closure (example for Pussur-Sibsa)	Pussur-Sibsa Model [PSTS]	Already described in report of Bas van Maren
Estuary closure (storm surge dams – salinity barriers) Bishkhali and Baleshwar rivers	Baleshwar Bishkhali Morphology [BBM] Salinity model [GS]	TBD TBD
Jogighopa-Tista-Farakka Link Project (NRLP)	GBM delta morphology 1D [G1D] GBM delta morphology 2DH [G2D]	Adjustments of model input via HydroTrend Idem
Smart dredging and dumping	Bank erosion models [BEM] (for Mongla port see model of Bas)	Select one bend with associated shoal that is eroding aggressively and test various mitigating dredging options. Example: Polder 35/1
Embankment lay-out, incl. options for managed retreat Embankment rehabilitation	Pussur-Sibsa Model [PSTS] SFINCS [FS] + FIAT	TBD Risk assessment of higher embankments
Merging polders into one	None	In Polder Development Plan
Afforestation	TBD	TBD
Drainage improvement	Drainage model [DM]	upgrade of structures and khals
Tidal River Management	TRM Modelling [TRM]	Sensitivity analysis, factors speeding up
Coastal protection	TBD	TBD
Cyclone shelters	risk assessment [FIAT]	modify evacuation percentage of population
Crop diversification	TBD	
Participatory Water Management	No modelling needed	
O&M water & polder	No modelling needed	

NB: TBD = to be determined

5.4 Risk Assessment

Work has continued regarding the assessment of the cyclone and storm surge risks for the 5 polders. A major update was made after comparing the initially used MERIT DEM with the Coastal DEM and the elevation survey that was conducted by IWM in the 5 polders (see Figure 5.25.2 for inundation map for polder 29 using the COASTAL DEM for a return period of 1:100). It appeared that the Coastal DEM is more trustworthy than MERIT DEM when compared to the surveyed DEM by IWM. In general,

the COASTAL DEM results in much higher total risk than MERIT DEM. This is especially true for polder 59/2 and 40/1 (7 to 8 times higher). This aligns with the fact that the MERIT DEM in general has a lot higher elevation. When using the COASTAL DEM, the inundation area is larger, and also deeper. Hence, for the remaining polders the Coastal DEM will be used.

For the second batch of polders to be analyzed, we made use of the selection of polders for CEIP-2 (see Table 5.55.5). During the reporting period the SFINCS model was used to estimate inundation for different return periods and currently the FIAT model is used for estimating the damages.

Table 5.5: Polders selected for the second batch of cyclone risk assessments

Sl. No.	Polders	Name of Thana	District
1	4	Assasuni	Satkhira
2	5	Kaliganj, Shyamnagar	Satkhira
3	7/1	Assasuni, Shyamnagar	Satkhira
4	7/2	Assasuni	Satkhira
5	10-12	Koyra, Paikgacha	Khulna
6	13-14/2	Koyra	Khulna
7	28/1	Dumuria	Khulna
8	28/2	Batiaghata	Khulna
9	29	Batiaghata, Dumuria	Khulna
10	31	Dacope	Khulna
11	31 part	Batiaghata	Khulna
12	39/1A	Pathargatha	Barguna
13	40/1	Pathargatha	Barguna
14	41/6A	Barguna Sadar	Barguna
15	41/7	Mirjaganj	Patuakhali
16	Mirjaganj - Rampura	Mirjaganj	Patuakhali
17	41/7A	Betagi	Barguna
18	43/2A	Patuakhali	Patuakhali
19	43/2E	Patuakhali	Patuakhali
20	45	Amtali	Barguna
21	47/1	Kalapara	Patuakhali
22	50-51	Rangabali	Patuakhali
23	55/2E	Patuakhali, Dashmina, Bouphol	Patuakhali

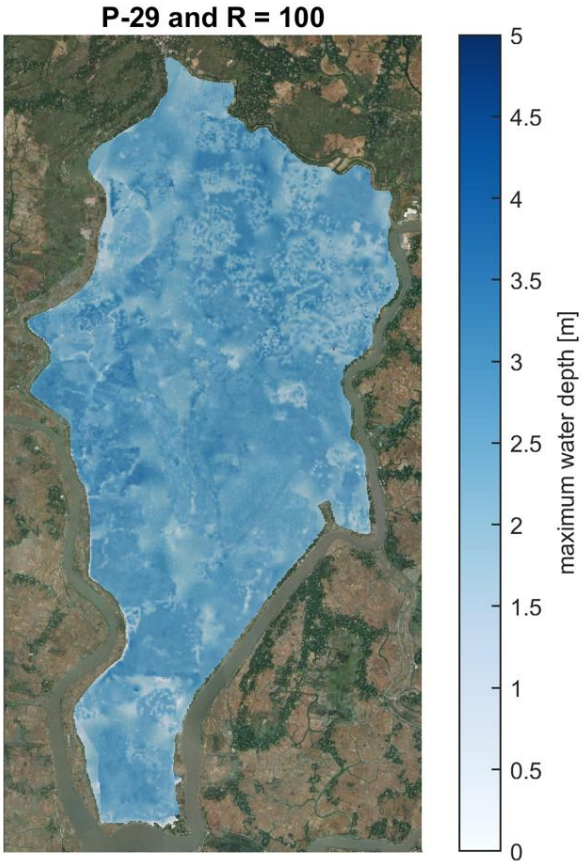


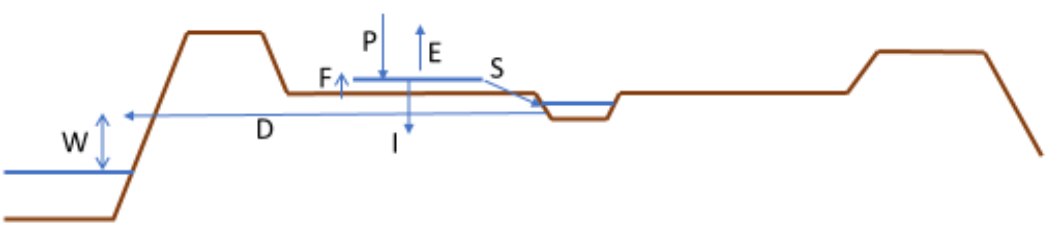
Figure 5.2: Inundation map for polder 29 for R=100.

5.5 Polder Drainage

For the assessment of required interventions for drainage improvement two approaches are being developed: 1. Using a MIKE11 drainage model and 2. Using a simplified water balance model. Work on the MIKE11 drainage model is ongoing. The water balance model is briefly described below.

A water balance is calculated for each daily time step by subtracting the drained, evaporated and infiltrated volume from the total rain volume of that day plus the balance of water that was on the field from the previous day. The volume that is not drained is then translated into a level of the water that remains on the field. This volume is considered the starting situation for the next day. The model runs for 184 days, using three different typical hydrological years: an average (normal) year, a wet year (roughly one in 10 years) and an extremely wet year (roughly one in 25-50 years).

Each day that has a water level in the polder of more than 20 cm and more than 60 cm is added together to get the total days of pluvial inundation of the monsoon season. Also, the number of cumulative days with more than 20 and 60 cm, respectively, is summed up.



The formula is as follows:

$F_i = P_i – E_i – I_i + F_{i-1} – S*MIN(D_W, D_K*k)$

in which:

i = Day
F = Water volume on field
P = Precipitation volume in one day
E = Evaporation volume in one day
I = Infiltration volume in one day
D_W = Daily drainage capacity based on the regulators and drainage window
D_K = Daily drainage capacity based on maximum khal hydraulic conveyance
k = Khal efficiency percentage
S = Surface runoff fraction to khal (assumed to be 1)
W = Drainage window, percentage of time per day that gravity drainage is possible

Hence, the drainage capacity of the polder is either limited by the drainage window or by the khal drainage capacity. It is further assumed that each regulator is linked to a khal with the same length. The length is determined by the total khal length divided by the total number of regulators. The polder elevation is assumed to be uniform over the polder (bucket approach).

The daily drainage capacity for each khal is dependent on its size, hydraulic resistance (roughness) and slope. It is calculated using the following formula:

$$Q = \frac{\mathrm{K} * \mathrm{A} * R^{2/3} * S^{1/2}}{\mathrm{n}}$$

in which:

Q = flow rate
A = cross sectional area of flow
R = hydraulic radius (cross-section area divided by wetted perimeter)
S = slope of the channel at the point of measurement
n = surface roughness
K = constant dependent upon units

In our model the uniform khal parameters are: A = 20; R=14; n=0.05. Hence the calculated maximum Q is only dependent on the length of the khal and the slope.

The drainage capacity of the regulators is taken as the total of regulator vents per polder times the average vent cross-section area. The drainage window is estimated as follows: from a nearby water level station the average flood and average eb level is determined for the month of September. Based on these an idealized sinusoid curve is prepared for a 12-hour cycle. Then the time period in which the water level is lower than the polder level is calculated, times 2 (for a diurnal tidal regime).

Based on the initial results for the 5 pilot polders, the simple water balance model shows that there are several key factors that affect the drainage capacity in a polder, such as the ratio of khal length and surface to be drained, the number of regulators and the drainage window (determined by the tide and polder elevation). In some cases, the internal (khal) drainage is limited, but more often the external drainage through the regulators is the limiting factor. Conclusions from the analysis will be used to feed into the first version of the investment plan that will be started in the next quarter.

5.6 Designs for Embankment Improvement

During the reporting period a start has been made with preparing design sketches for embankment improvements, see Figure 5.3 for basic layout of the different types. These design types are meant to be used to acquire a first approach in the footprint of the improved dike system and will be the input for an initial cost estimate for the required investments to realize the improved safety against flooding. In total 5 basic types of embankments are derived for the different loading conditions that can be found in the Bangladesh delta:

Type 1, Narrow channel with foreland

Specifications:

- Some polders are separated by relatively narrow channels.
- During extreme events the water level might rise considerably.
- Wave action and currents are absent or insignificant.
- Daily water levels are within the channel; Under daily conditions the dikes remain dry
- An example of this situation is the channel between polder P45 and P44, with design conditions given for points 39 and 50 in the appendix B of the technical report *Storm Surge, Wave, Hydrodynamic Modelling and Design Parameters on Drainage System and Embankment Crest Level*

Type 2, Narrow channel without foreland

Specifications:

- Basically, equal to type 1
- During extreme events the water level might rise considerably.
- Wave action and currents are absent or insignificant.
- No foreland presence; dike directly retains water also during daily conditions.

Type 3, along the riverbank

Specifications:

- Along the riverbank
- Foreland typically above daily water levels
- No scour erosion. (type 4 includes the conditions with scour)
- if dense mangrove forest is present wave action at the dike will be negligible. Therefore, two options: with and without wave action

Type 4, Riverbank with scour

Specifications:

- Along the riverbank
- Foreland is under attack from river scour
- In the design the presence of the foreland is neglected

Type 5, Sea defence

Specifications:

- Direct wave attack from the sea
- Sandy coast
- Due to large wave loads and storm surge, two solutions have been elaborated
    - Protected slope
    - Protected slope with spilling berm

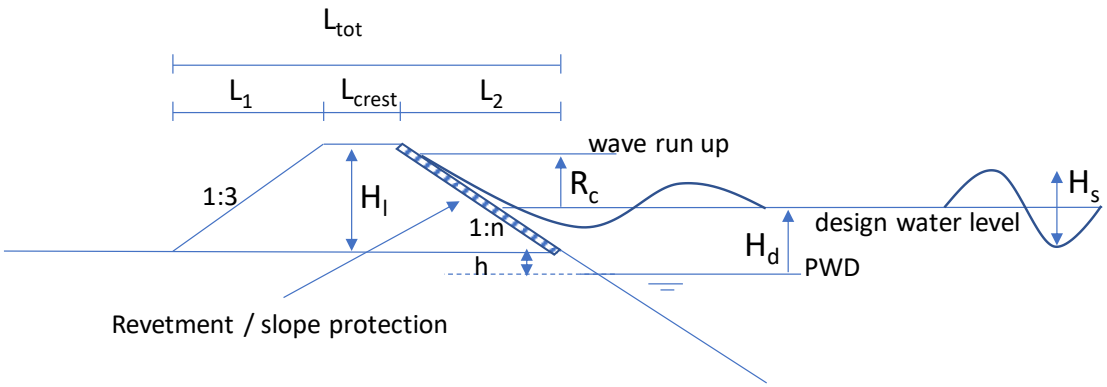


Figure 5.3: Schematized design for polder embankment for different design parameters.

5.7 Activities Next Quarter

In the next quarter the following activities will be continued, finalized and started:

- Risk assessment for 23 polders (see list Table 5.55.5)
- Polder drainage modelling and suggestions for improvement
- Discussing principal design sketches for embankments with local team and BWDB
- Interpretation of macro and meso scale model results for polder development
- Field visit to polders in the southwest region
- First version of polder development and investment plan

6 CAPACITY BUILDING

6.1 Improved technique on field survey on Discharge observation

A Training Programme on "Improved technique on field survey on Discharge observation using ADCP and Bathymetry Survey using Echosounder and GPS" was conducted by Joint Venture of DHI and Deltares in partnership with IWM under "Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone" Consultancy Service of Coastal Embankment Improvement Project, Phase-1 (CEIP-1). This was carried out as a part of Improved technique on field survey and measurement in accordance with the terms of reference (ToR) of the said project. The 2 (two) days training programme was conducted from 23 October 2021 to 24 October 2021 and addressed the overview of discharge observation and bathymetry concept, hands on training on discharge observation using ADCP and bathymetry Survey using Echosounder and GPS. This report describes the activities performed under this training programme.

The objective of the training is to build capacity within BWDB to conduct field surveys by using the improved techniques on discharge observation by using ADCP and bathymetry survey using echosounder, GPS and using the facilities available with the Survey Unit Anwesa. In addition, this training also addressed on hand on exercise on processing and analysing the data to support planning, design and implementation of potential project.

6.2 Training Activities

The training program on Discharge observation was scheduled in consultation with expatriate consultants and PMU CEIP-1, BWDB. The training program was arranged at Noria & Chandpur and BWDB survey Vessel “Anwesha” was used for this data collection training which was great opportunity of the BWDB professionals to get hand on exercise by using the existing facilities available with the Survey Unit Anwesha. The activities of the training programme is given in Table 6.1.

Table 6.1: The list of activities of the training programme on "Improved technique on field survey

Day	Time	Activities
Day-1 23/10/2021 Saturday	7:00-08:30 hour	Start from Dhaka to Shimulia Ghat by Microbus
	08:30-09:30 hour	Breakfast at Shimulia Ghat
	09:30-10:30 hour	Travel to reach *Anwesha* at Naria by speed boat
	11:00 – 13:00 hour	Hand on training on ongoing discharge observation at Naria using ADCP and sediment sampling
	13:00 – 15:00 hour	Launch and Prayer Break
	15:00 -17:00 hour	Discussion on quality control and data processing of discharge observation at Anwesha Lounge
	20:00 hour	Diner & Night halt at Anwesha
Day-2 24/10/2021 Sunday	08:00-09:00 hour	Breakfast at Anwesha
	9:00-12:00 hour	Hand on training on bathymetry survey and discharge observation using echosounder, GPS and ADCP
	12:00- 15:00 hour	Lunch/Prayer
	15:00-19:00	Discussion on data processing and quality control for field survey on the way to travelling to Narayanganj
	19:00	Return to Dhaka from Narayanganj by Microbus

6.3 List of Participants

IWM mobilized experienced survey expert to conduct the training successful and effective. In addition, one experienced hydrographic surveyor mobilized to support hand on exercise in the field survey. The list of IWM resources personnel and list of participants from BWDB are given in Table 6.2 and Table 6.3.

Table 6.2: List of IWM participants

Sl. No.	Name of Professional	Designation
1	Md Abdus Salam Sikder	Senior River & Coastal Morphologist
2	Pankaj Kumar Maitra	Senior Survey Expert
3	Md. Anwar Hossain	Hydrographic Surveyor
4	Md. Atik	Hydrographic Surveyor
5	Ashim Kumar	Land surveyor

Table 6.3: List of BWDB participants

S. L	Name	Designation & place of posting	E-mail ID & Mobile No
1.	Mr. Md. Manzur Rahman	Sub- Divisional Engineer, Central GIS Directorate, BWDB, Dhaka.	maruf.ce2k7@gmail.com Mobile No-01712-833954
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6.4 Remarks

The target of the training was to develop the capacity and skills of BWDB personnel to confidently conduct survey and data collection in the field including quality control, processing and analysis of the data by using versatile software. Moreover, the training would help them planning of survey for any required specification including selection of the right type of equipment and software. It was great achievement for participants to learn the existing facilities available with the Survey Unit Anwesha. Nevertheless, the training was completed satisfactorily.

Following are some photographs showing various activities of the training program.

Photo-1: Discussion on ADCP basics

Photo-2: Participant from BWDB and IWM

Photo-3: Anwesha at Naria

Photo-4: Survey conducted by Tender boat

Photo-5: Hand on Training on discharge observation using ADCP

Photo-6: Hand on Training on Bathymetry survey

7 OUTREACH PROGRAMME

7.1 Introduction and Background

7.1.1 Terms of Reference of Component 9.1 (Outreach Programme)

The TOR covers many activities starting with the presentation of the Inception Report (in January 2020 to the dissemination of final project outcomes towards the finalization of the project. Several objectives and related project outputs have been delivered but many project activities are incomplete, thus awaiting their inclusion in the Outreach Programme.

7.1.2 Objectives and Activities of Component-9.1

TOR Objective

To ensure that the client and stakeholders participate and are well informed of the developments and results of the project

TOR Activities

Organize the following workshops with selected group and plenary sessions:

1) At the beginning of the Inception Phase to discuss the polder problems and identify and assess the current condition
2) Upon finalizing the Inception Phase: to discuss the initial findings and proposed basin approaches
3) At the end of data collection phase: to discuss extent of existing data, identify gaps and propose improvement methods
4) At the end of the modelling phase: to discuss the findings of the analyses and its implications
5) At the end of development of design and implementation phase: to discuss the effectiveness of the selected interventions and their social, environmental and economic implications
6) At the end of the development of investment plan phase: to select the most promising alternative and discuss risk reduction investment strategy

Consultants shall actively participate in the workshops, in their development, in the discussions and in drafting the conclusions.

7.1.3 Activities Completed Up to September 2021

Activities No 1) and 2) were completed as Scheduled The following Activities await the completion of the Polder Development Plan and Investment Plan. These activities have passed the preparatory stages and await further work until they are ready for presentation to Stakeholders in a Workshop.

Activity No 3**)** is nearly complete and has been presented in several workshops and training courses related to the creation and design of the Database **(**IGDCZ**):** the training and capacity

building are illustrated in the Capacity Building plan, which has already been submitted. A comprehensive report on implementation plan is made to disseminate the functionalities and transfer the database to BWDB with a User Manual.

Activity No 4**)** This activity has been reported **(**and discussed**)** in relation to the completion of each of the multiple stages of model development**.** This series is nearing completion

Activities 5) & 6) are dependent on the culmination of the use of the database, pilot studies and modelling on 5 selected polders and the formulation of the Polder Development Plan and proceeding to the Investment Plan.

The Consultants have participated in all outreach activities conducted so far. The new outreach activities would require restricted participation of International Staff still under travel and quarantine restrictions - although an improvement is anticipated in the near future.

Deliverables

Report at each stage of the consultation including the summary of the discussions, list of participants and the conclusion reached.

7.2 Objectives and Activities of Component-9.2: Communication Strategy

Objectives

The objective of this task is to ensure that all analysis and results of the study, the data collected and generated, cost-benefit analysis are able to be updated, interactively communicated and understood by a wide range of stakeholders

Activities

7) Upload and store all collected and generated data in the Database of BWDB, Up-to-date

8) Share all analysis and results from this study with all stakeholders

9) Communicate the results of the project and benefit-cost analysis through a series of stakeholder workshops. This should include production of dissemination material such as brochures with results and illustrative material that will inform various stakeholders

Deliverables

1) All datasets will be stored in Database of BWDB for use in a variety of ministries, with illustrative material, Up-to-date

2) Communication materials such as brochures, animations etc. that will help communicate the proposed improvements, Pending

The activities are included in the Tabulated Action Plan as given below in Table 7.1

Table 7.1: Summary of the Outreach Activities

	Activity/Sub Activity	Type of Outreach	Target Group	Completion Date	Comments/Reports and Brochures
1 & 2	Inception Report and Work Plan (W/S) Present initial findings	Workshop	GoB Water Sector, University and related NGOs	January 2020	Report submitted on 30 Jan 2019
3	Data Collection Programme, Creation of Database (IGDCZ)	Progress Reports	PMU, WB	6 reports published between 2020 and Sept 2021	Reports submitted
		Database Design Report, Software etc	PMU, WB, BWDB	21 May 2020	Revised Report Submitted
		Database Access, Data Entry etc	PMU, WB, BWDB, CEIP teams	28 Feb 2022	Expected date for completion
		Interactive Geo-database for Coastal Zone (IGDCZ) Operations	PMU, WB, BWDB	30 May 2021	Successfully completed
4	Presentation of Model results and findings Training Courses on specific model applications	A large number of modelling Reports published	PMU, WB, BWDB	15 reports published between 2020 and Sept 2021	Reports submitted
		Riverbank Erosion	PMU, WB, BWDB	12 Oct 2021	Successfully completed
		Polder Water Management Modelling	PMU, WB, BWDB	22 February 2021	Successfully completed
		Interactive Geo-database for Coastal Zone (IGDCZ) Operations	PMU, WB, BWDB	30 May 2021	Successfully completed
		Salinity Intrusion Modelling in the coastal river system of Bangladesh	Ministry of Water Resources, PMU, WB, BWDB	23 Sept 2021	Successfully completed
	International Workshop on Modelling and strategies for coastal development of Bangladesh (Hybrid Format)	Reach the entire international coastal experts and modelling community	PMU, WB, WARPO, RRI,BWDB,MOWR. Ministry of Environment Forest and Climate, Ministry of Relief Disaster Management. Special Invitees	May 2022 (under planning)	Preparatory Stages (Also included in Capacity Building Plan)
5	Polder Development	Regional Stakeholder's	GoB Water Sector, University and related	30 Mar 2019	Report submitted on 24 Sep 2019

	Activity/Sub Activity	Type of Outreach	Target Group	Completion Date	Comments/Reports and Brochures
	Plan Water Management Designs Overall Design Guidelines	Consultation Workshop, Barisal	NGOs		
		Regional Stakeholder's Consultation Workshop, Khulna	GoB Water Sector, University and related NGOs	27 Apr 2019	Report submitted on 24 Sep 2019
		Mid-term Progress Workshop	GoB Water Sector, University and related organizations	6 Feb 2020	Report submitted on 08 Jun 2020
	Investment Plan	Workshop	PMU, WB, BWDB		

Planning is underway for holding the two day International Workshop on a suitable date in later March or early May 2022. This workshop/ conference will be held in a hybrid format where those participants who are unable to be present because of travel restrictions will participate remotely.