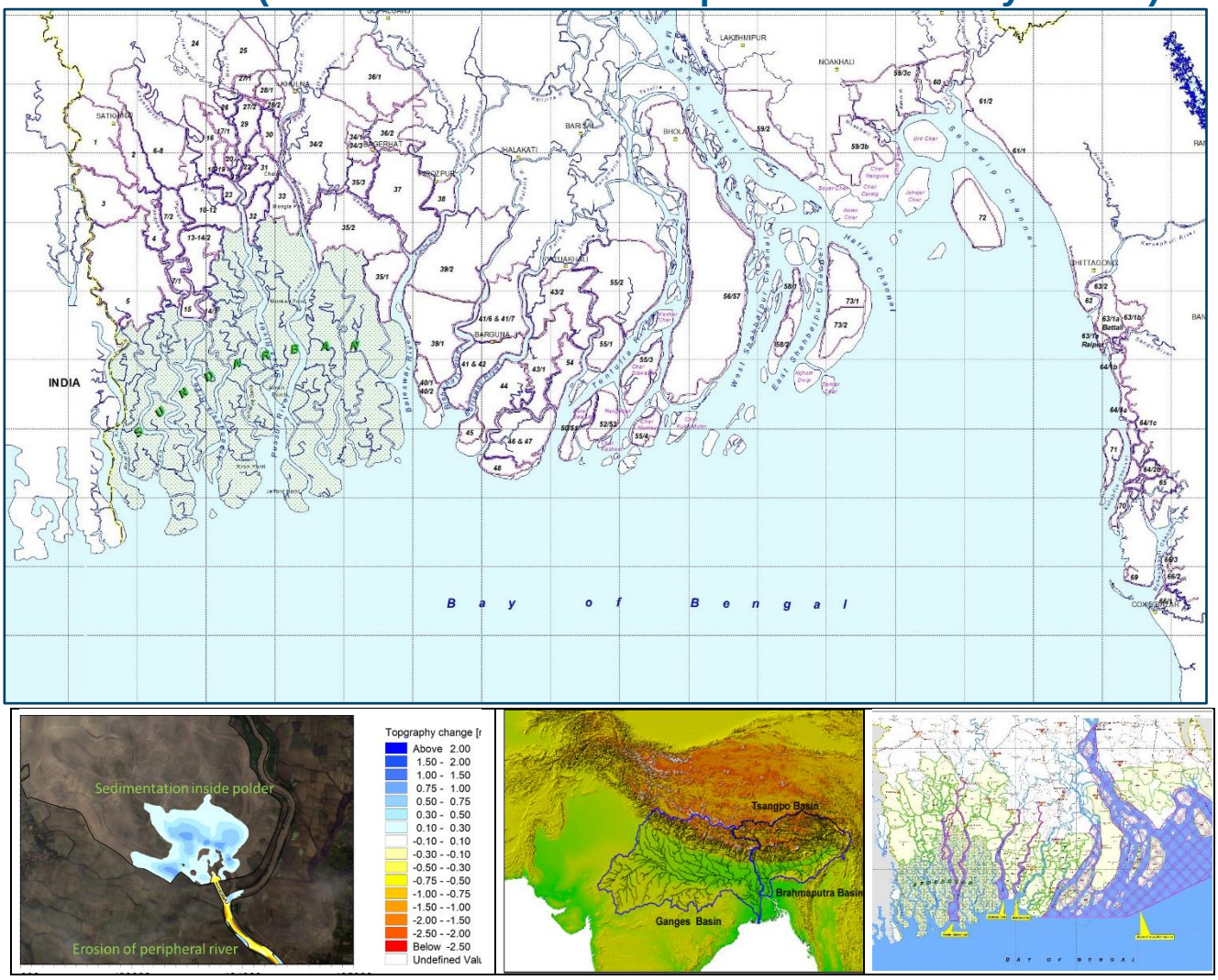
Ministry of Water Resources

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-12

November 2021

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

Ministry of Water Resources

Bangladesh Water Development Board

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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/1121/140 30 November 2021

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-12

It is our pleasure to submit herewith three copies of the Quarterly Progress Report-12. This is the 12th Quarterly Progress Report describing the progress made between 1st July 2021 to 30 September 2021. We regret that the submission of the report has been slightly delayed due to interruption of travel and our intra-project communications by the COVID-19 crisis.

The amount of progress made during this quarter has been less than optimal on all fronts because of restrictions on staff travel because of COVID-19 lockdowns which have been accommodated within the extended schedule and other adjustments re-negotiated with you in recent months, which resulted in an extension of the project duration by 9 months to enable all the expected project outputs to be realised.

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 deals with progress made in Salinity Modelling determining climate Change Scenarios, and Chapter 5 describes the work done to lay the groundwork for completion on the Polder Development Plan in the next two quarters. Chapter 6 deals with Capacity Building. While work has continued in the development and applications of many models, a separate chapter is not devoted to this subject. Instead, several modelling reports submitted to you on this subject are listed in Table 1.4.

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
Dr Alessio Giardino, Deltares Project Manager
Mr Zahirul Haque Khan, Deputy Team Leader
Mr AKM Bodruddoza, Procurement Specialist
Swarna Kazi, Sr. Disaster Risk Management Specialist, World Bank

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ACRONYMS AND ABBREVIATIONS

ADCP- Acoustic Doppler Current Profiler

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

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

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.

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 and 11th Quarters had to be completed without a single International Consultant being permitted to travel to Bangladesh.

This report (QPR-12) covers the progress of work in the period 1st July 2021 to 30th September 2021. 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 this Quarter truly paves the way for rapid progress to be made with the incentive of the anticipated return of International Stuff to Bangladesh in the next (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 23 September 2021, the Consultants submitted 2nd revised contract (Contract Modification-2) to the Project Director, PMU, CEIP-1 proposing the project duration to be extended till April 2022. The second variation proposal is under evaluation by PMU which will officially the sent to World Bank after the evaluation.

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. This 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 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.

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)			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
No	TOR Reference/ Deliverables Code	**TOR Deliverables**	**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**
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)																																										
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	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
		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
		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
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)
		Other special purpose models
D-4D-3	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 D-4D:4,5 D-4D:6	**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. 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. 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.

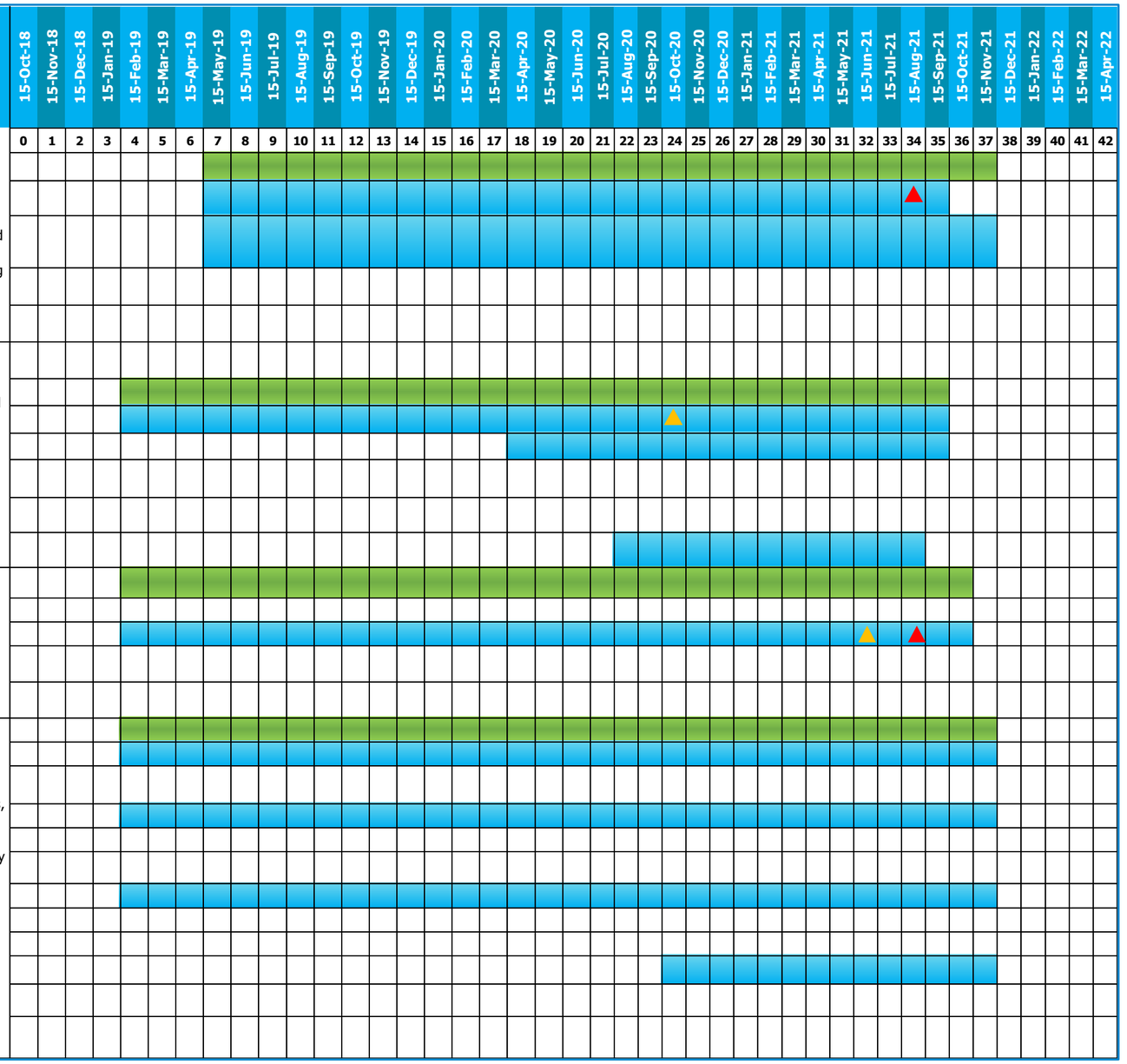
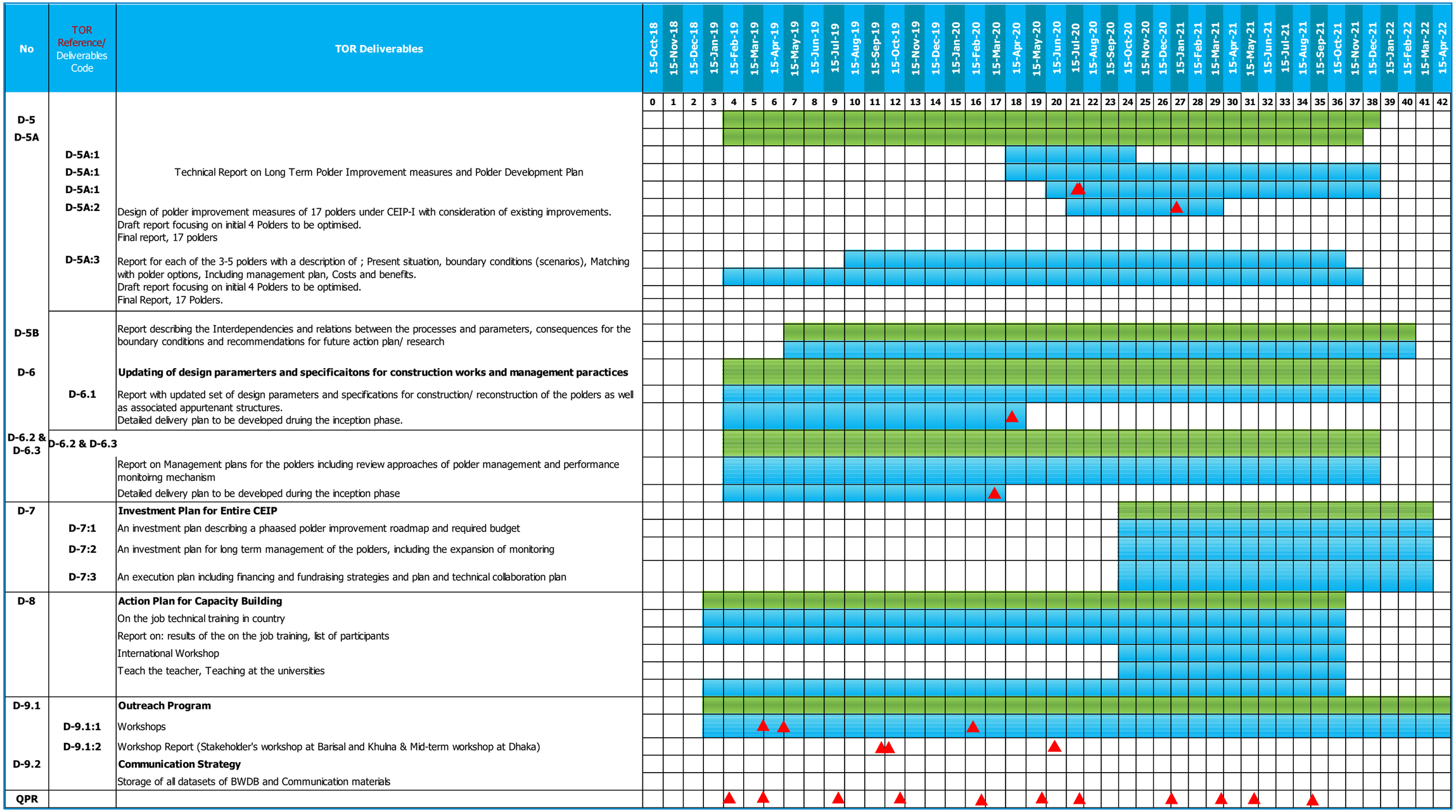


Table 1. 1 (contd) : New Activity Schedule Page 4

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
		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
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
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 Ammendment)**
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	Pending	4-Oct-20		31-oct-2021
	Literature Review & Lessons Learnt	Literature Review & Lessons Learnt	Pending	4-Oct-20		31-Dec-21
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		28-Feb-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	Revised version submitted on June 21, 2021	30-Nov-20
	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		28-Feb-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	31-Dec-20
	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		31-Dec-21
D-5A	Technical Report on Long Term Polder Improvement measures and Polder Development Plan	Draft	Pending	4-Apr-21		31-Dec-21
		Final	Pending			31-Jan-22
D-5A:2	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	Submitted 18-01-2021
		Final	Pending			
D-5A:3	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-Oct-21
		Final	Pending			30-Nov-21
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		30-Dec-21
	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 participation**					
	Report on Management plans for the polders	Polder Management Plan	Pending	4-Apr-21		31-Dec-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		30-Nov-21
	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)

No	ToR Deliverables	Program Item	Status	Deadline as per Signed Contract	Date of Submission to PIU	Proposed Deadline (2nd Contract Ammendment)
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-Mar-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-Dec-21
	International Workshop	International Workshop	Pending	4-Jul-20		28-Feb-22
	Teach the teacher, Teaching at the universities	Curriculum Development	Pending	4-Apr-21		28-Feb-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		31-Dec-21
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				
	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**	**Delivery Dates (by Consultant)**	**Proposed Deadline (2nd Contract Ammendment)**
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	At the end of each model	
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)	Mar-20	
		Macro	Macro scale River Model	Submitted		Mar-20	30-Sep-21
		Macro	Macro scale River Model	Submitted		Mar-20	
		Macro	GBM Basin Model Applications	Pending		7th Quarter	
		Macro	Macro scale River Model Applications	Pending		7th Quarter	
		Macro	Macro scale River Model Applications	Pending		7th Quarter	
		Macro	Sediment Budget Analyses	Pending		Apr-20	
D-4A-1:-4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Jan 21)	Oct-20	30-Sep-21
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	Mar-20	
		Meso	Baleswar-Bishkhali Model	Submitted		Mar-20	
		Meso	Lower Meghna	Submitted		Mar-20	
		Meso	Sangu	Submitted		Mar-20	
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)	7th Quarter	31-Oct-21
		Meso	Baleswar-Bishkhali Model	Pending		7th Quarter	
		Meso	Lower Meghna	Pending		7th Quarter	
		Meso	Sangu	Pending		7th Quarter	
D-4A-2: 4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Oct 20)	Nov-20	31-Oct-21
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	Apr-20	Interim Report: October 2020 Final Report: 15-08-2021
		Meso	Sibsa	Submitted		Apr-20	
		Meso	Baleswar	Submitted		Apr-20	
		Meso	Bishkali	Submitted		Apr-20	
		Meso	Lower Meghna	Pending		Apr-20	
		Meso	Sangu	Pending		Apr-20	
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)	Dec-20	15-Sep-21
		Meso	Sibsa	Pending		Dec-20	
		Meso	Baleswar	Pending		Dec-20	
		Meso	Bishkali	Pending		Dec-20	
		Meso	Lower Meghna	Pending		Dec-20	
		Meso	Sangu	Pending		Dec-20	
		Meso	Pussur-Sibsa fine sediment model- ext	Submitted		Jan-20	
D-4A-2: 4	Technical report (one report for 4A-1 and 4A-2)	**Meso**	**FINAL REPORT ON BANK**	Pending	Draft (Jul 20) Final (Oct 20)	Jan-21	15-Sep-21
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.	**Micro**	Pilot TRM Model for Polders 24 etc	Pending	4-Oct-20	Mar-20	Interim (31-08-2021) & Final (30-09-2021)
		Micro	5 or more polder models	Pending		20-Sep	Current situations/Interim: Polder modelling report 15-08-2021 Final Version: 30-11-2021
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)

TOR Reference	TOR Deliverables	Scale	Model	Status	Delivery Dates as per signed Contract	Delivery Dates (by Consultant)	Proposed Deadline (2nd Contract Ammendment)
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.		Field Campaigns (several)	Pending	D-4B: 1, 2 (Oct 20) D-4B: 3 (Report: Draft - July 20, Final - Oct 20)	Dec-20	30-Sep-21
			Subsidence Geospatial Datasets	Submitted		Oct-20	
				Pending		Oct-20	
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)		
CLIMATE CHANGE EFFECTS							
			Climate Change & Preciptation,	Submitted		Oct-20	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		Oct-20	30-Nov-21
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		Oct-20	30-Nov-21
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		Nov-20	Current situations/Interim: Storm surge and wave modelling 9-08-2021 Salinity Modelling 9-08-2021 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	**Bay of Bengal**	Storm Surge Model	CANCELLED		Dec-19	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		Dec-20	Current situation: 9-09-2021 Future situation: 30-11-2021
		Bay of Bengal	Wave Propagation Model	Pending		Dec-20	
		Bay of Bengal	Salinity Model	Pending		2020 end	

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
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	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

2 DATA ACQUISITION

2.1 Collecting Existing Data

IWM already has a very comprehensive database comprising hydrometric, meteorological and 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 in to 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 is being continued up to September-2021 as a part of the extended study.

2.2.2 Summary of Field Survey Activities in the 12th Quarter (ending September 2021)

In the quarter from July 2021 to September 2021, routine discharge and sediment measurements at Bahadurabad of Brahmaputra River and at Hardinge Bridge of Ganges River are being continued for the 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 No.ADCP, 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 survey methodology employed by IWM survey teams is described in this Quarterly Report and the methodology for the others survey is described in detail in the Second Quarterly Progress Report.

The progress of discharge and sediment monitoring has been shown in Table 2.1 and Table 2.2.

Table 2.1: 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 2.2: 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				

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 12th quarter (July 2021 to September 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 3.1.

Table 3. 1: Summary of work progress

Sl No	Task & Activities	Progress (%) Up to 11th Quarter	Progress (%) 12th 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	0	85
2.3	**Agricultural Land use (Robi, Kharif-1 & Kharif-2)**	**0**	**85**	**85**
2.4	Other Data Collection (shapefile & tabular)	90	-	90
2.5	Other Data Processing (shapefile & tabular)	90	0	90

Sl No	Task & Activities	Progress (%) Up to 11th Quarter	Progress (%) 12th Quarter	Overall Progress (%)
3	**GIS Mapping**			
3.1	Polder Maps for Data Collection	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	0	90
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	0	50
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	0	92
5.11	Data Validation and Check	92	0	92
5.12	Software & Hardware Procurement	-	-	-
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 Implementation Report	submitted	-	-

Sl No	Task & Activities	Progress (%) Up to 11th Quarter	Progress (%) 12th Quarter	Overall Progress (%)
6.2	Validation and Compilation Report (1st version)	submitted	-	-
6.3	IGDCZ Implementation Report (1st version)	submitted	100	100
7	**Training & Technology Transfer**	3 days training		
8	**Feedback and update (ongoing)**	12 comments were addressed		

3.2 Preparation of Agricultural Land Use Layers

The agricultural land use for the Robi, Kharif-1, and Kharif-2 season has processed classified and classified from the latest satellite images of Sentinel-1 and Sentinel-2 for the year 2020 and verified with the Google Earth images for the coastal area of Bangladesh. The classified layers are crop land (cropped and cultivable land), forest, mangrove forest, rivers, waterbodies (Lake, Beels etc.), aquaculture, salt pan, rural settlement, urban and industrial areas, and accreted land areas. These layers are now under final verification and validation processes for uploading into the IGDCZ database. A sample agricultural map of Robi season of coastal area is given in the following Figure 3.1.

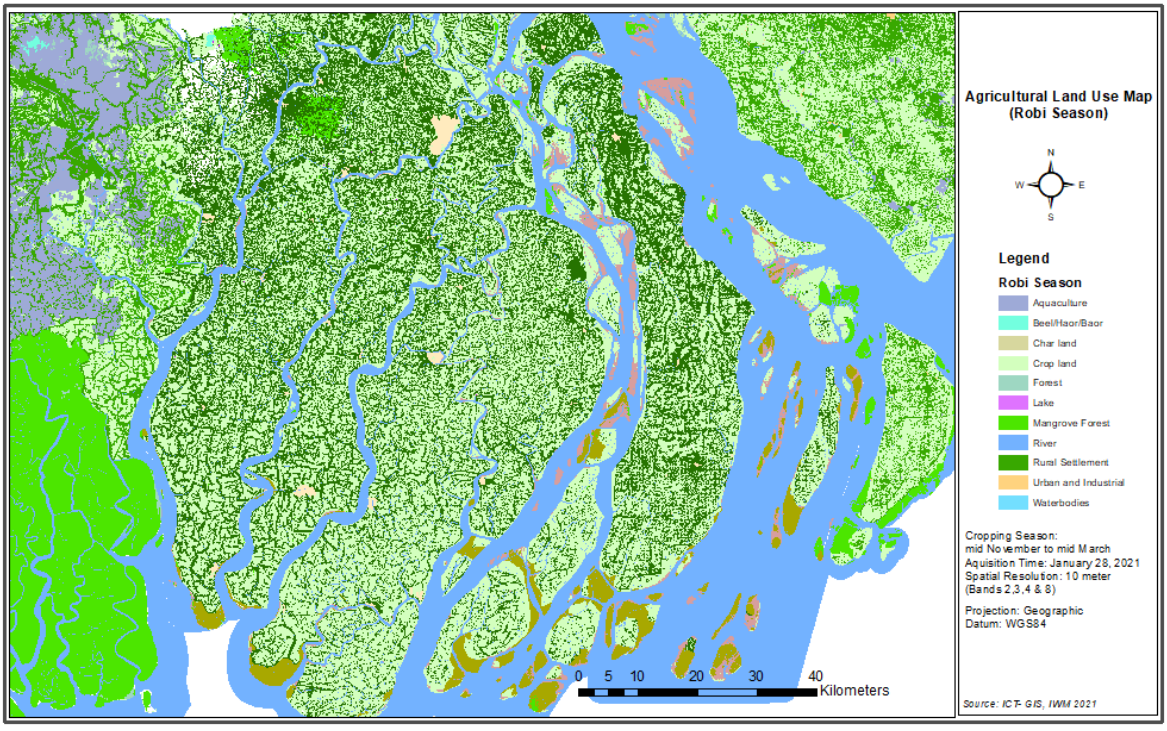


Figure 3.1: Agricultural Land use Map for Robi Season

The workflow for preparing the agricultural land use feature classification from satellite images is illustrated in the following flow chart shown in Figure 3.2.

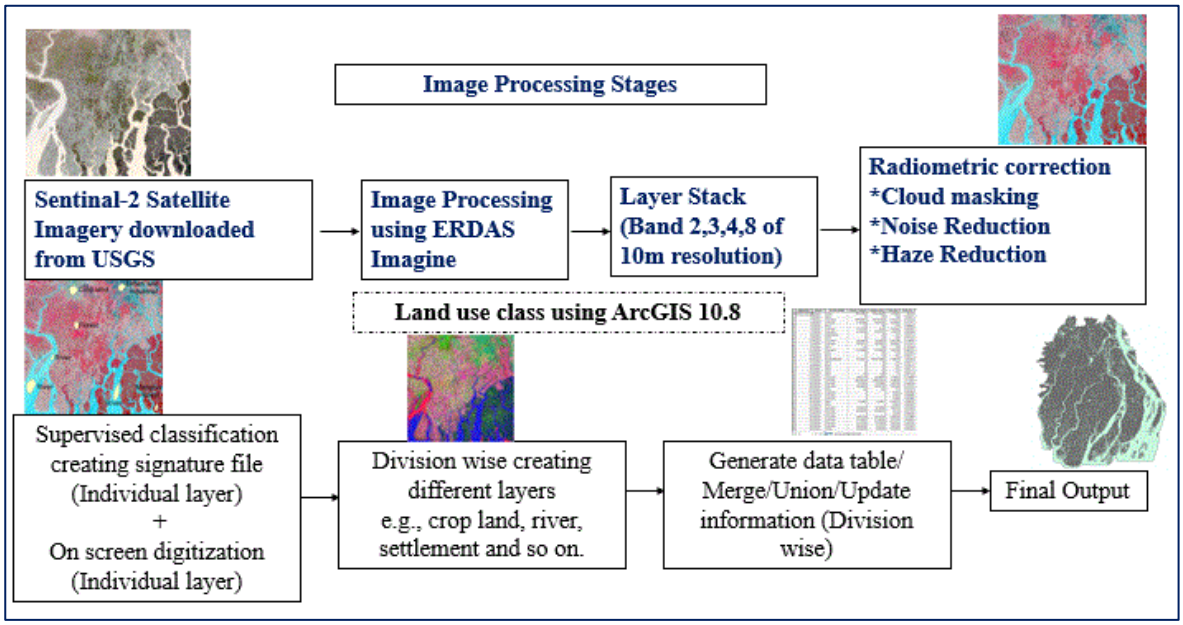


Figure 3.2: Workflow of Agricultural Land use features classification

3.3 Web Application Development

- **Full version development**

A significant part of the Full version IGDCZ has been developed and remaining parts are 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.

3.3.1 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.

3.4 Workplan

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

Work Plan (Figure 3.3) shows the workplan with current status of different tasks and activities.

Workplan of IGDCZ Development

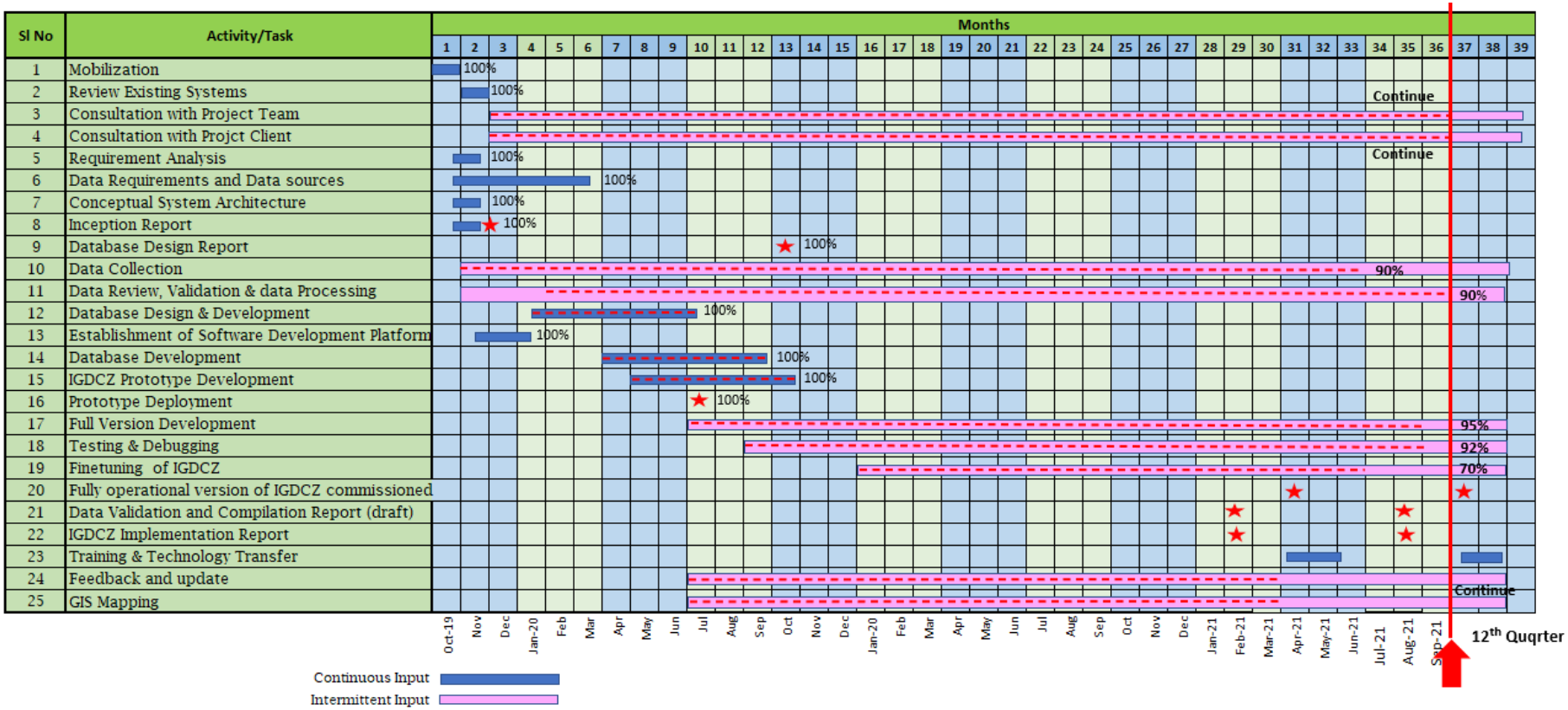


Figure 3.3: Workplan

3.5 Plan for the Next Quarter

Table 3.2: Plan activities for next quarter

Sl No	Task & Activities	Progress (%) Upto 12th Quarter	Plan Progress (%) for Next 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	15	100
2.3	**Agricultural Land use (Robi, Kharif-1 & Kharif-2)**	85	15	100
2.4	Data Collection (shapefile & tabular)	90	5	95
2.5	Data Processing (shapefile & tabular)	90	5	95
3	**GIS Mapping**			
3.1	Polder Mappings & Processing	85	5	90
4	**Database Design & Development**			
4.1	Database Design Development	100	-	100
4.2	Database Design Report	100	-	100
4.3	Database Implement	90	5	95
5	**Web GIS Application Development**			
5.1	IGDCZ Prototype Development	100	-	100
5.2	Full Version Development	93	5	98

Sl No	Task & Activities	Progress (%) Upto 12th Quarter	Plan Progress (%) for Next Quarter	Overall Progress (%)
5.3	GIS Core Module	93	5	98
5.4	Dashboard Development	90	5	95
5.5	Metadata Preparation	50	20	70
5.6	Metadata Interface Development	60	20	60
5.7	User Administrative Module	90	5	95
5.8	Document Archiving	100	-	100
5.9	Tutorial (help tutorial)	100	-	100
5.10	Testing & debugging	90	5	95
5.11	Data Validation and Check	92	5	97
5.12	Software & Hardware Procurement	-	-	-
5.13	Installation of SW and HW at BDWB Data Canter	-	-	-
5.14	Migration of Database and Application to BWDB Servers	-	-	-
5.15	Fully operational commissioning	-	-	-
5.16	Preparation of User Instruction Manual	-	20	20
6	**Reports**			
6.1	Database Implementation Report	Submitted		
6.2	Validation and Compilation Report (1st version)	Submitted		
6.3	IGDCZ Implementation Plan	Draft Submitted	Will submit final version	
7	**Training & Technology Transfer**	3 days training	-	-
8	**Feedback and update (ongoing)**	12 comments were addressed	-	-

4 SALINITY MODELLING CURRENT SITUATION

4.1 Introduction

The Interim Report on Salinity Modelling Current Situation is submitted to the client on 27 September 2021. This chapter includes a very brief summary of the report. For details, main report needs to be followed.

The report is primarily a technical report, describing the work done so far on the modelling of salinity intrusion into the Southwest and South-Central Delta in Bangladesh. At this point the modelling framework has been calibrated and verified to be capable of predicting the distribution of salinity in time and space within the modelled area.

At the beginning, the report describes the problems caused by an increasing salinity intrusion, due to a lowering of transboundary flow. It is also illustrated how dredging in Ganges distributaries have a significant impact on salinity. This is followed by a description of the study area and the available salinity measurements.

Section 4 of the report describes the model framework consisting of a 2-dimensional model of Bay of Bengal and a detailed 1-dimensional model of the Southwest Region model. These two models are solved in an iterative manner to achieve proper boundary condition for the 1-dimensional regional model, which finally is used to depict salinity intrusion into the delta.

Finally, the report offers a plan for future work.

4.2 Study Area

The problem of salinity intrusion in the southwest coastal zone (Figure 4.1) is acute. Gorai River is the largest distributary of Ganges River. Moreover, there are other distributary rivers, such as Mathabhanga, Ichamoti and Baral (upper). However, almost all these distributaries of Ganges River are disconnected from the Ganges and tidal influence is stronger during dry season because of minimum downward push of fresh water flow. As a result, salinity intrusion is higher during the dry season.

Gorai River is one of the major tributaries of Ganges River that supplies fresh water flow to southwest and southcentral region. Offtake of the river remains dry from December to March and the river comes alive during monsoon season. Salinity of Rupsha River, Pussur River and Sibsha River depends on the flow of Gorai River.

Unlike Gorai River, Arial Khan River is very much alive in all seasons. Arial Khan River is a distributary of Padma River. Buriswar, Bishkhali and Baleswar Rivers receive fresh water flow from Arial Khan river and Lower Meghna River and therefore, salinity intrusion in these rivers are lesser compared to the Ganges-dependent and Gorai dependent rivers.

Lower Meghna and Tentulia rivers receive fresh water from Padma, Upper Meghna and Brahmaputra Rivers. Combined Fresh water flow of these rivers, push down the salinity and salinity level in these rivers remain much less even during the dry season. The mixed zone (Figure 4.1) is dependent on both Padma and Meghna rivers.

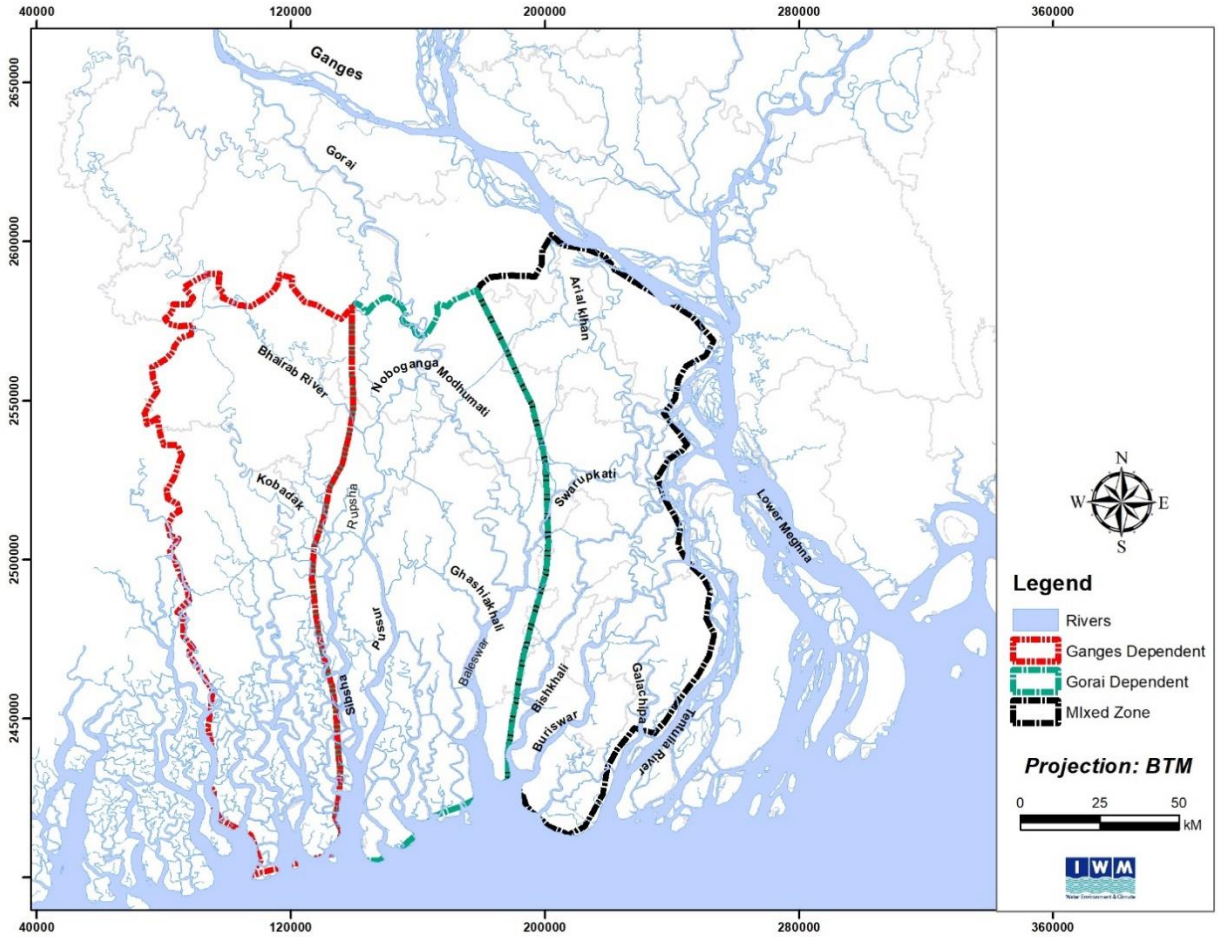


Figure 4.1: Southwest region is divided into three regions according to salinity level and availability of fresh water.

4.2.1 Impact on Upstream flow condition on River Salinity

Transboundary flow significantly affects the salinity intrusion in the river system of Bangladesh. Fresh water flow pushes down the saline water. In the southwest region, salinity intrusion in the Ganges and Gorai-dependent area (Figure 4.1) is dependent on fresh water flow of Gorai River. Salinity increases with decreased flow in Gorai River, alternatively salinity decreases with high flow of Gorai River.

Figure 4.2 shows the “Gorai-Nabaganga-Rupsha-Pussur” river system. Available salinity monitoring station (for year 2019-2021) in this river system is super-imposed. The effect of Gorai river flow on the salinity level at Nabaganga and Pussur River is discussed in following paragraphs.

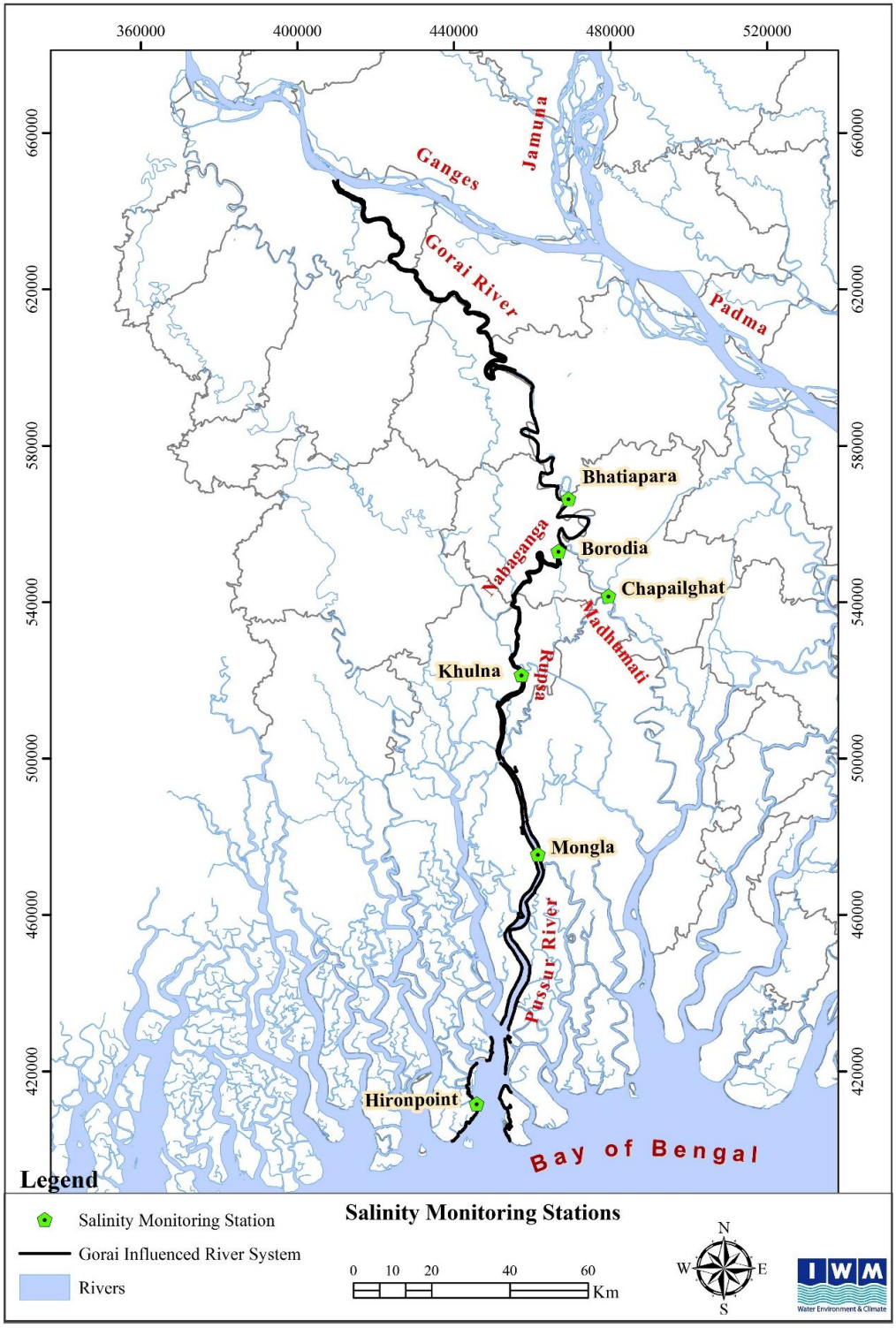


Figure 4.2: Schematics of Gorai- Nabaganga-Rupsha-Pussur river system.

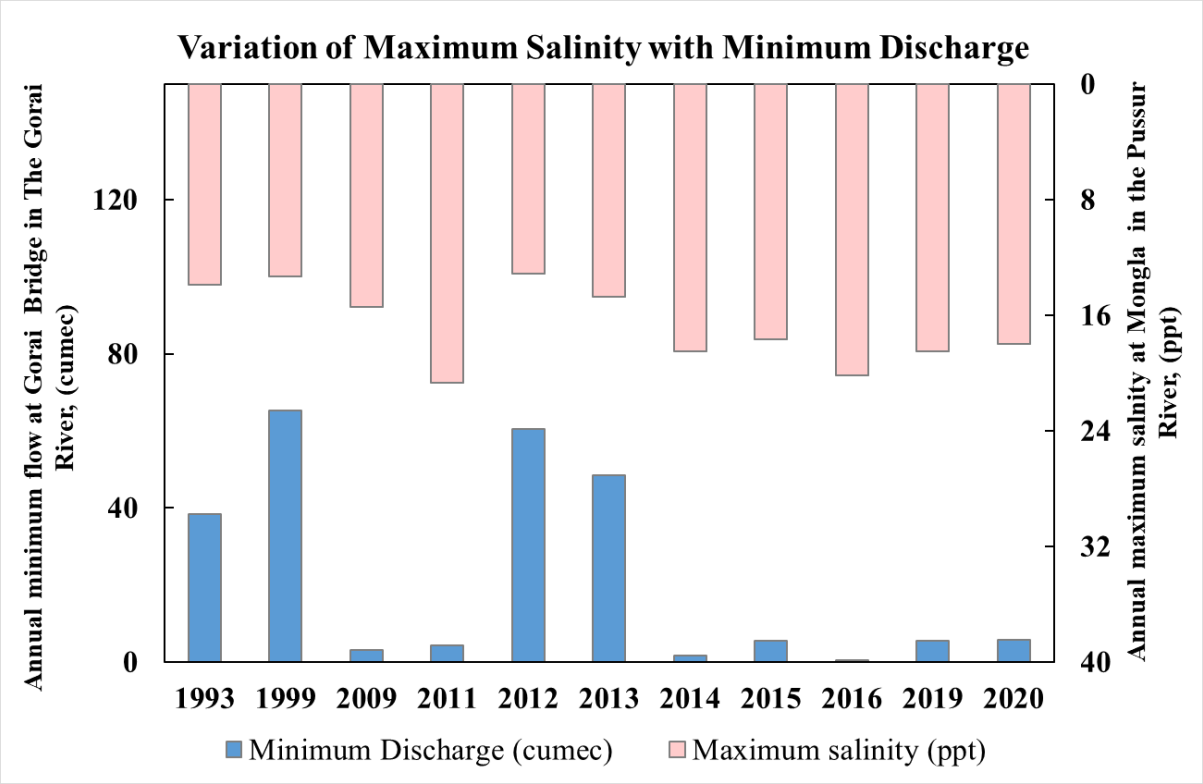


Figure 4.3: Change of salinity at Mongla in Pussur River with the flow of Gorai river.

Figure 4.3 shows change of maximum salinity at Mongla in Pussur River with the dry season flow of Gorai River. Mongla is on the bank of Pussur River at about 62 km north of the Bay of Bengal coast. Gorai does not receive adequate flow from Ganges River in dry season due to siltation at its offtake. Government of Bangladesh has a project to dredge the offtake of Gorai River periodically. The Gorai offtake was dredged and had significant dry season flow in 2012-2013 and consequently, salinity drastically reduced in the Gorai dependent area. This scenario also indicates the influence of water flow through the Gorai River on salinity intrusion in the river system. Figure 4.4 and Figure 4.5 shows comparison of salinity at Bardia and Khulna before dredging (year 2011) and after dredging conditions (year 2012).

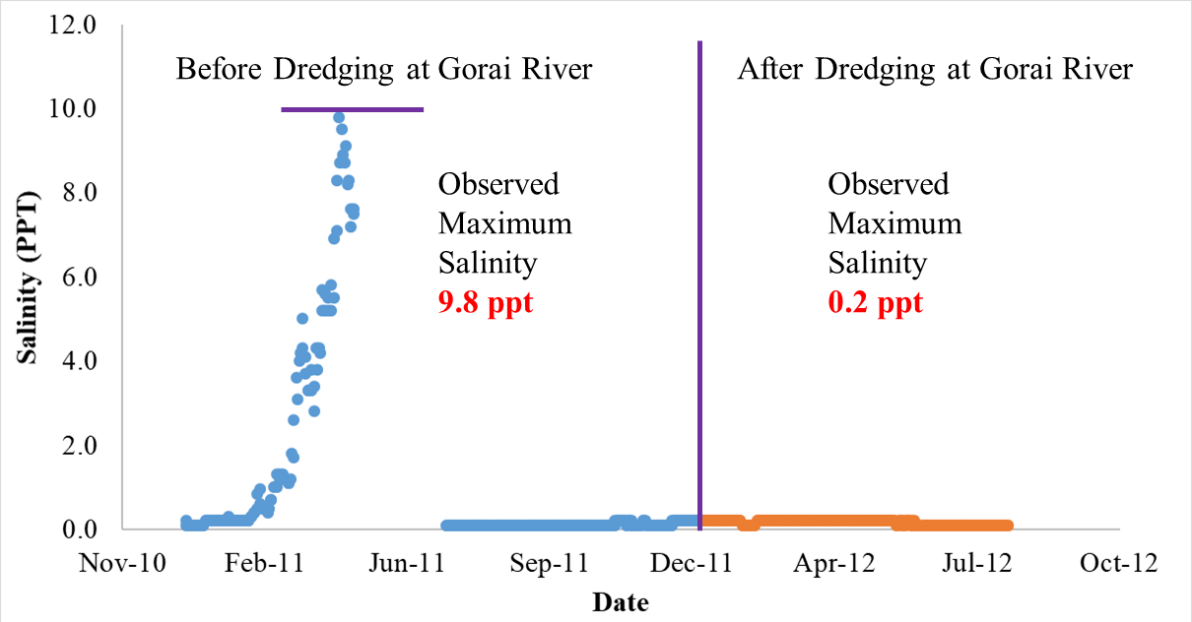


Figure 4.4: Salinity change at Nabaganga River (Bardia) for Dredging of the Gorai river

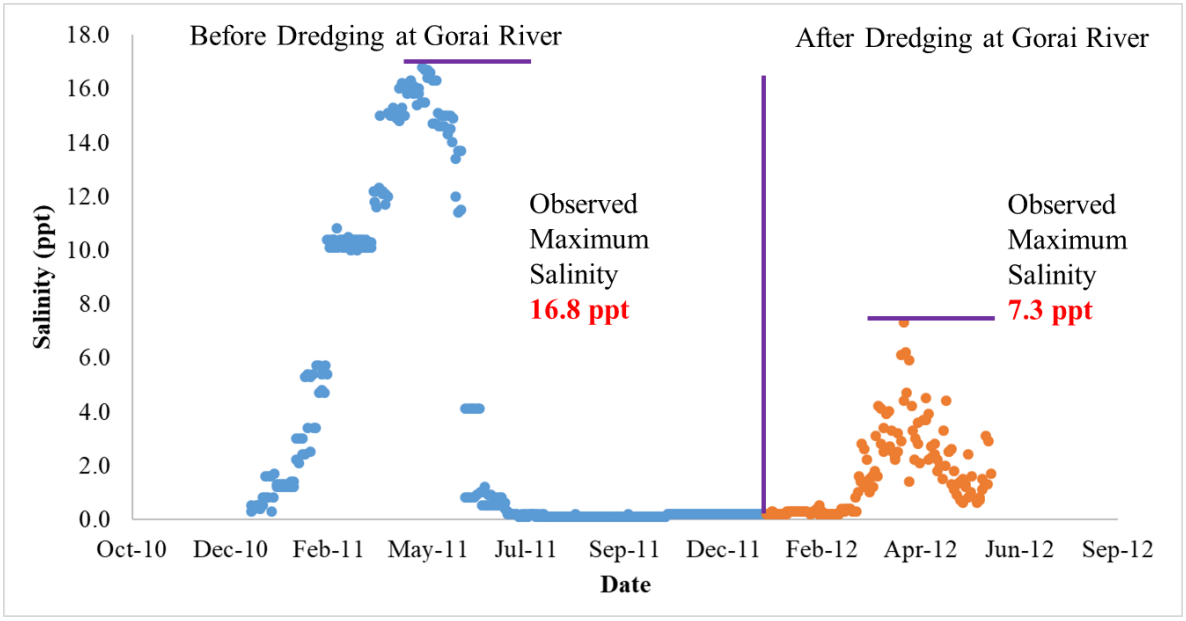


Figure 4.5: Salinity change at Rupsha River (Khulna) for Dredging of the Gorai river.

It is apparent that, flow augmentation of Gorai River is necessary to check the salinity intrusion at the Ganges dependent area. And this can be achieved with Engineering intervention, such as Ganges Barrage.

In the Ganges Barrage Study Project (2012), IWM simulated the calibrated salinity model as per planned flow diversions from Ganges River for limiting salinity considering the proposed Ganges Barrage in operation mode. The Main Consultant (MC) suggested two options for flow diversions (Table 4.1) in the Gorai River, Bhairab Upper River + Mukteswari - Hari River, Kobadak River + Harihar River and Betna River for limiting salinity level at key locations.

Table 4.1: Proposed flow diversions for salinity control (Source: Ganges Barrage Study Project, 2012)

River Name	Flow diversion (m^3/s) for salinity control		
	No diversion (Base)	With diversion	
		Option-1	Option-2
Gorai	0	150	150
Bhairab Upper	0	25	10
Mukteswari-Hari	--	0	15
Kobadak	0	50	25
Harihar	--		25
Betna	0	25	39

The model simulation was conducted from January to June. The model results indicate that in option-1 and option-2, some of the major rivers such as Gorai-Madhumati, Nabaganga, Chitra, Atai, Bhairab Upper would be saline free and all other rivers will have significant reduction of salinity. Figure 4.6 shows the comparison of long profile salinity along Gorai -> Nabaganga -> Rupsha -> Pussur river system for without Ganges barrage (on year 2010-2011), with Ganges barrage condition (on year 2010-2011) and with Ganges Barrage (year 2010-2011+ 67 cm Sea level rise).

Figure 4.6 shows the long profile of maximum salinity (month April and May) intrusion for year 2011. The profile starts from Hironpoint (Downstream) to inland propagation up to Bhatiapara. The profile is shown for no flow diversion and flow diversion scenarios (Ganges Barrage, Option-2). The maximum salinity intrusion occurs up to Bhatiapara, approximately 220 km upward from the Bay following waterway, for no flow diversion scenario. While for with Ganges Barrage condition, salinity level propagation reduces up to Khulna, approximately 100 km down from Bhatiapara.

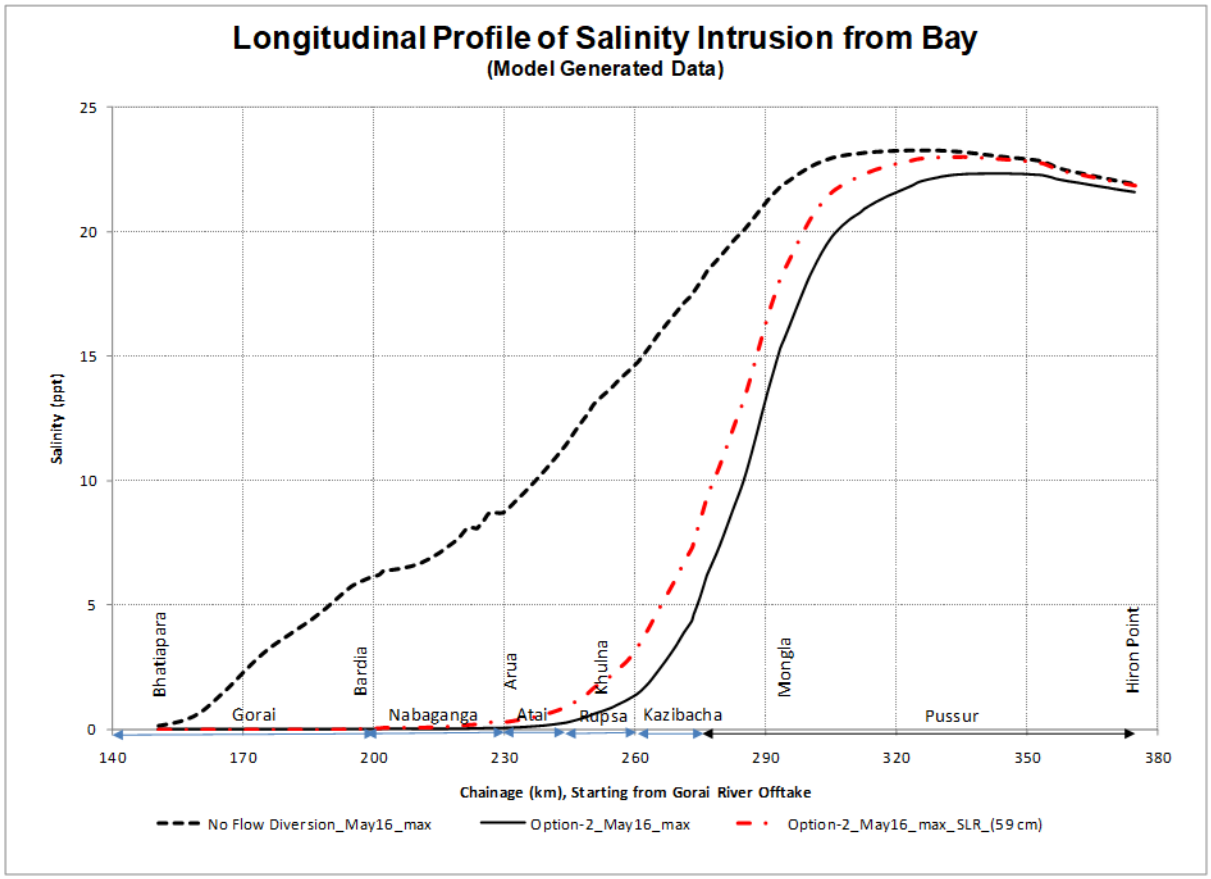


Figure 4.6: The longitudinal profile of saline intrusion from the Bay due to sea level rise (Without Ganges Barrage, with Ganges Barrage, with Ganges Barrage + 59 cm sea level rise) (Source: Ganges Barrage Study Project, 2012)

Detail approaches on the assessment of changes in river discharges and sediment loads are described in the report on Climate Change Scenario.

4.3 Data

The coastal zone of Bangladesh is primarily divided into three hydrological regions:

a. South west/southcentral zone
b. South East Hydrological zone
c. Eastern Hill Hydrological zone

Salinity measurements are proposed to cover up these three hydrologic zones. A total of 30 nos. of salinity monitoring stations are established from February 2019 to continuously monitor salinity of surface water at the major rivers. Among the salinity monitoring stations, 23 are situated in southwest/ south central zone, 4 stations are situated in southeast hydrological zone and 3 stations are situated in Eastern Hill hydrological zone. Figure 4.7 shows the location of salinity monitoring stations. For surface water salinity measurement saline water samples are collected from top of the river water.

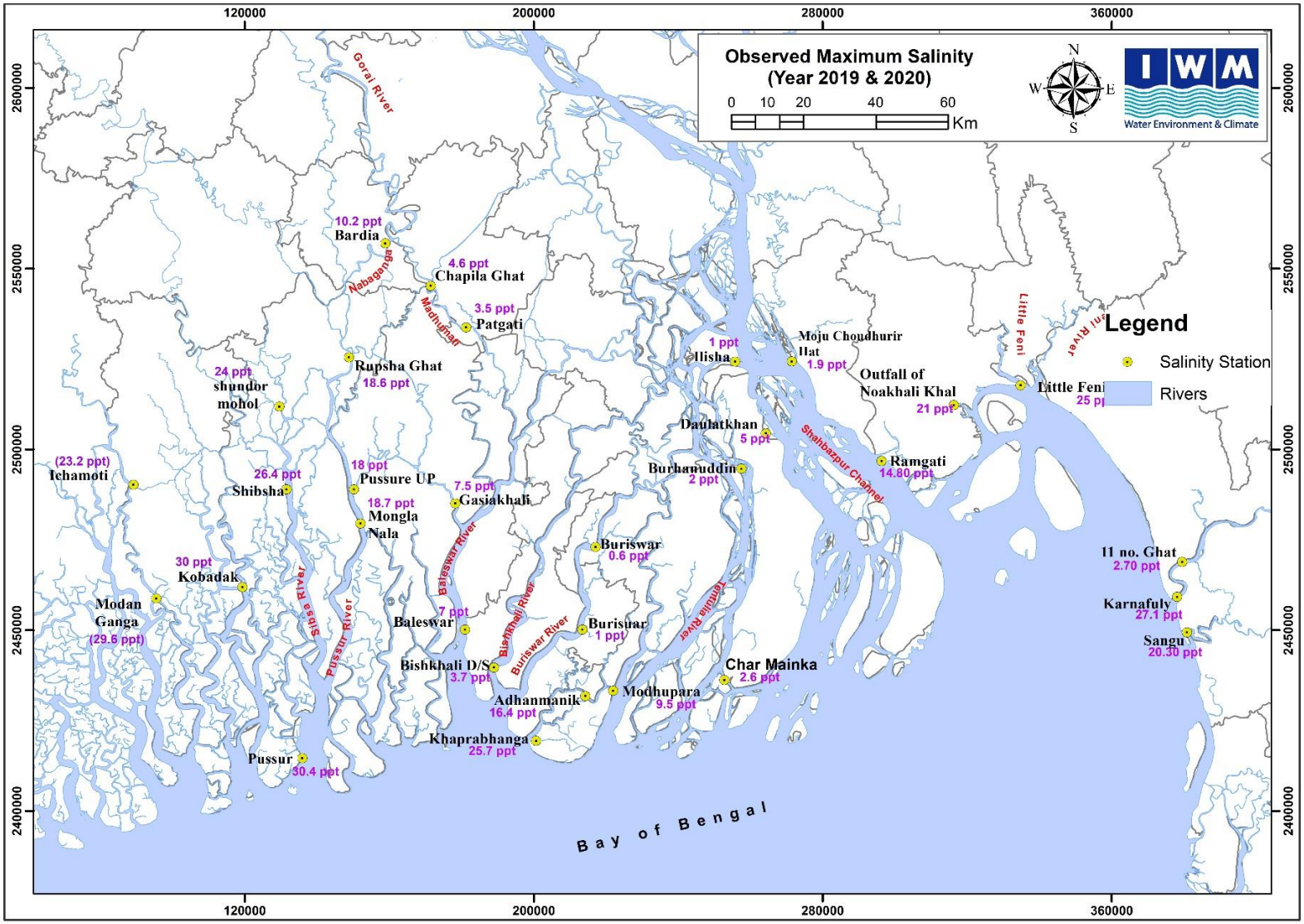


Figure 4.7: Salinity Monitoring stations.

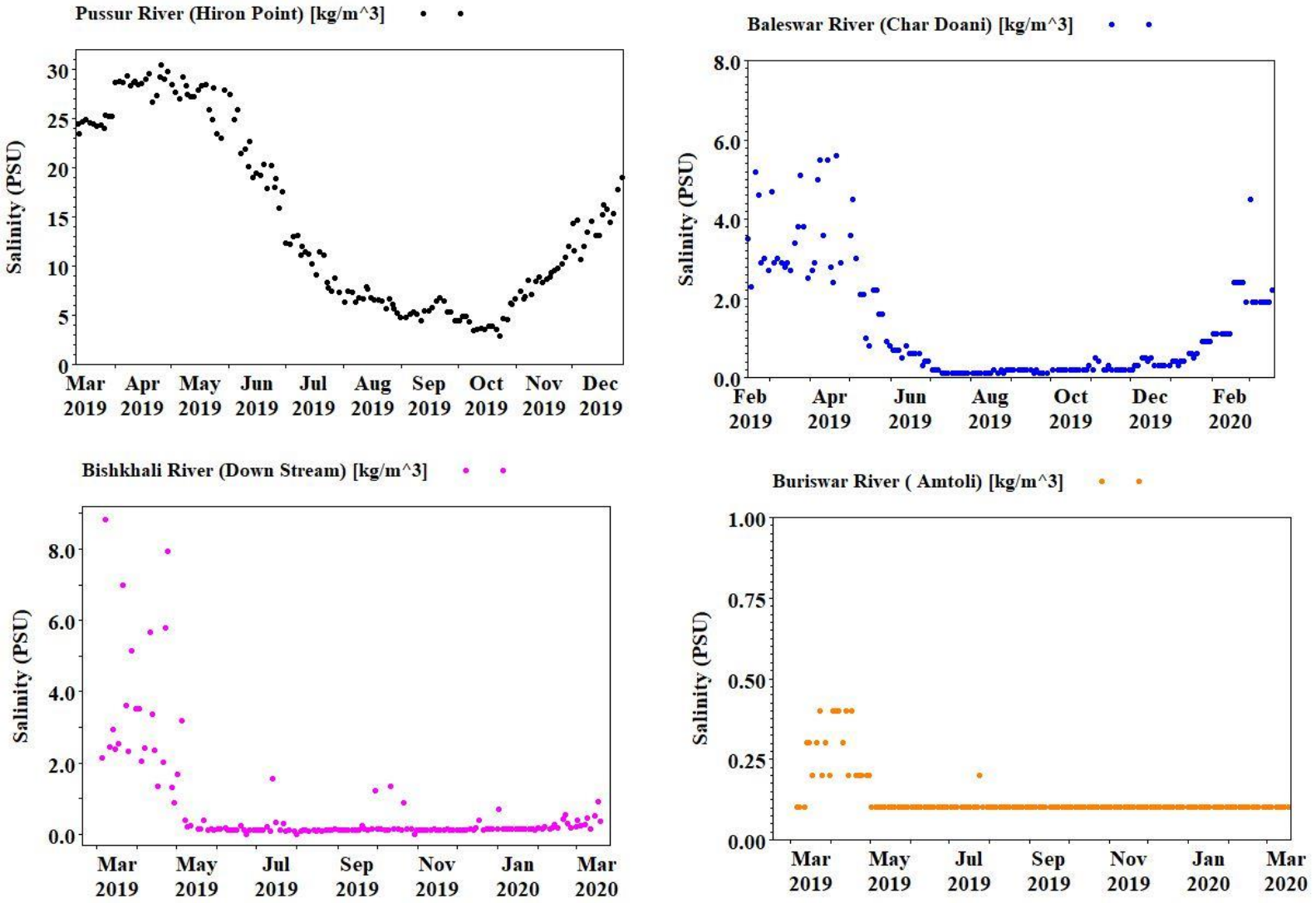


Figure 4.8: Seasonal variation of surface water salinity at Pussur River (Hironpoint), Baleswar river (Char Doani), Bishkhali river (downstream), Buriswar River (Amtali)

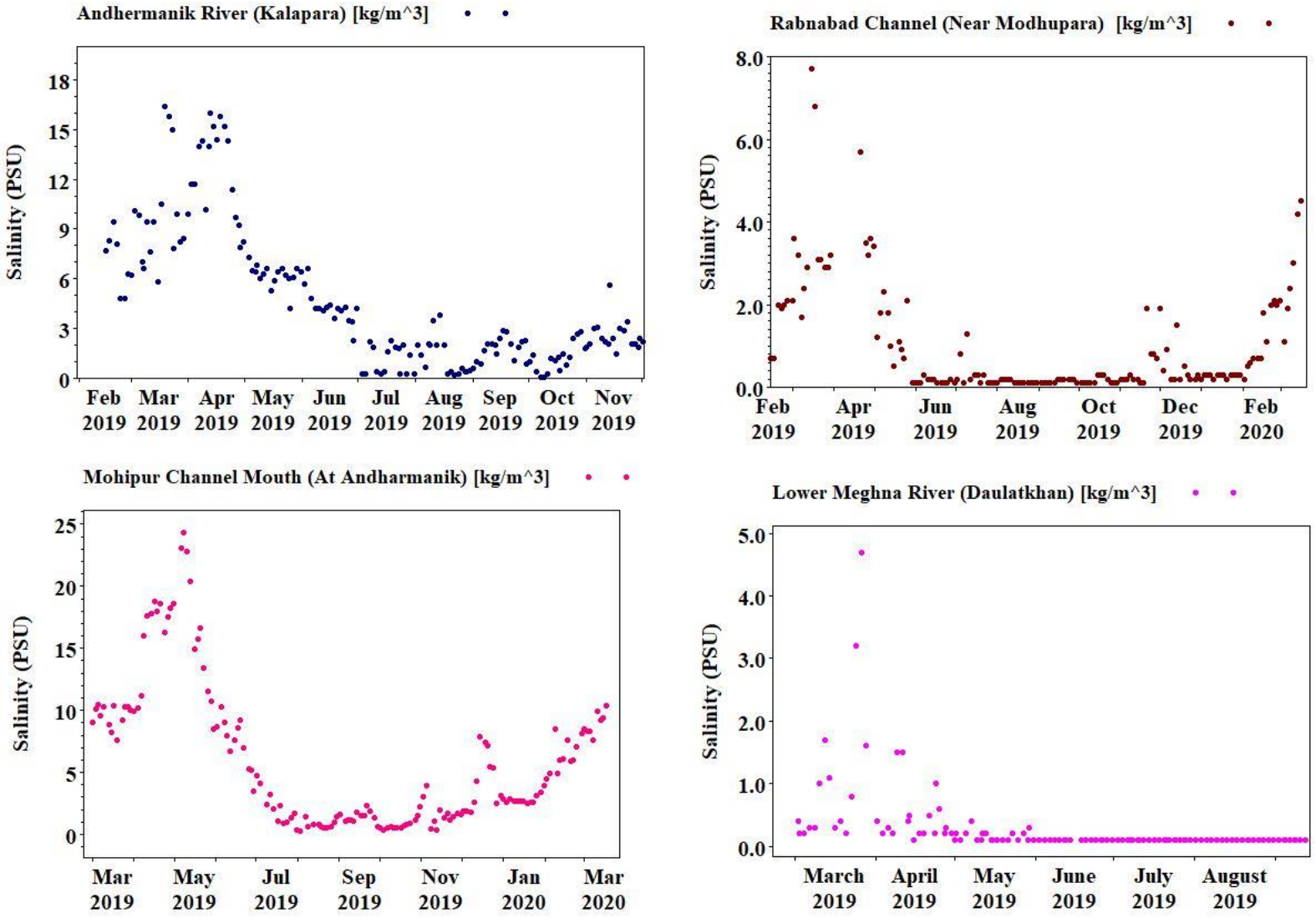


Figure 4.9: Seasonal variation of surface water salinity at Andharmanik River (Kalapara), Rabnabad Channel (Modhupara), Mohipur channel and Lower Meghna River (Daulatkhan).

Location of salinity monitoring stations are shown in Figure 4.7. Figure 4.8 and Figure 4.9 shows the time series of river salinity at Pussur River (Hironpoint), Baleswar river (Char Doani), Bishkhali river (downstream), Buriswar River (Amtali), Andharmanik River (Kalapara), Rabnabad Channel (Modhupara), Mohipur channel and Lower Meghna River (Daulatkhan). The Graphs show that, river salinity begins to rise up from December and the salinity level reaches to maximum level at the end of March/beginning of April. Afterwards, salinity level begins to drop down, because upstream fresh water contributes to channel. It is apparent from the graphs that salinity is higher in Pussur river. Pussur Sibsa river system receives freshwater water from Gorai River. Gorai River receives little fresh water during the dry season.

On the contrary, Baleswar, Buriswar, Bishkhali, Tentulia and Lower Meghna Rivers obtain enough fresh water from upstream; hence river salinity in the downstream reaches of these rivers is much less than that of the Southwest River systems.

In the south-central region, salinity in Rabnabad channel (near Modhupara) and Lower Meghna River (near Daulatkhan) is low because these rivers receive combined fresh water from Padma, Jamuna and Upper Meghna Rivers. Fresh water contribution from Rabnabad channel in Andharmanik River and Mohipur channel is minimum. Therefore, salinity in these rivers is high and it is dominated by tidal influence from sea.

4.3.1 Salinity long Profile variation along the River

Figure 4.8 and Figure 4.9 show the timely varying salinity at a single point. Along the river variation of salinity is a crucial information. Long profile variation of salinity depends primarily on longitudinal dispersion of salinity and supply of upstream freshwater flow. Long profile salinity measurement was conducted along eight major rivers namely, Kobadak River, Pussur River, Sibsha River, Baleswar River, Buriswar River, Bishkhali River, Tentulia River and Lower Meghna River.

To measure the change of salinity along the length of the river, sample of river water was collected from the surface of river/channel at 2 km interval. Long profiles of salinity plots together with location plots are provided in the main report. Salinity long profile data shows that, from the upstream to downstream, the increment of salinity is exponential at Baleswar, Pussur, Bishkhali, Payra and Lower Meghna River is exponential. In Sibsa River, the long profile curve is almost linear. Dominant of fresh water flow at Lower Meghna River, Baleswar River, Bishkhali River and Payra River is quite evident. For Baleswar river, at Pirojpur the salinity value is 3.0 ppt. salinity is reduced to below 1 ppt just 3 km upstream. At Bishkhali River, near Barguna, salinity value is 2 ppt, just 1 km upstream salinity value reaches to 0.4 ppt. Salinity value at Betua launch ghat is 12 ppt at 40 km upstream along the Lower Meghna River it reduces to 1 ppt. Lower Meghna is a large river and effect of tide is dominant that's why salinity gradient in the downstream side of the river is milder than Baleswar, Bishkhali and Buriswar river.

4.3.2 Variation of salinity across the Depth

River and estuarine salinity variation across the depth is negligible. In 1991 an extensive survey was carried out by SWMC in co-operation with DANIDA project. The vertical profile measurement was conducted within Southwest region and in Meghna estuary during dry season, 1991. Typical graph of vertical salinity and temperature variation in southwest zone, Meghna estuary and Chittagong zone are provided in the Interim Report on Salinity Modelling Current Situation. In most cases the graphs show almost negligible change in the slope of salinity along the depth of river/ channel.

4.4 Development of Mathematical Model

Salinity in the river, strongly depends on seasonal rainfall and transboundary flow. Tidal water movement from Bay of Bengal also plays a key role for salinity intrusion.

Two different regional models, e.g., Bay of Bengal (BoB) regional model and South West Regional model (SWRM) are used to simulate salinity intrusion. Bay of Bengal model is a two-dimensional hydrodynamic model. Domain of the model extends from the Bay of Bengal to Chandpur. For upstream flow boundary of BoB is dependent on SWRM. South west regional model is a one-dimensional model. The methodology used in the development and simulation of Salinity model is shown in the flow chart in Figure 4.10.

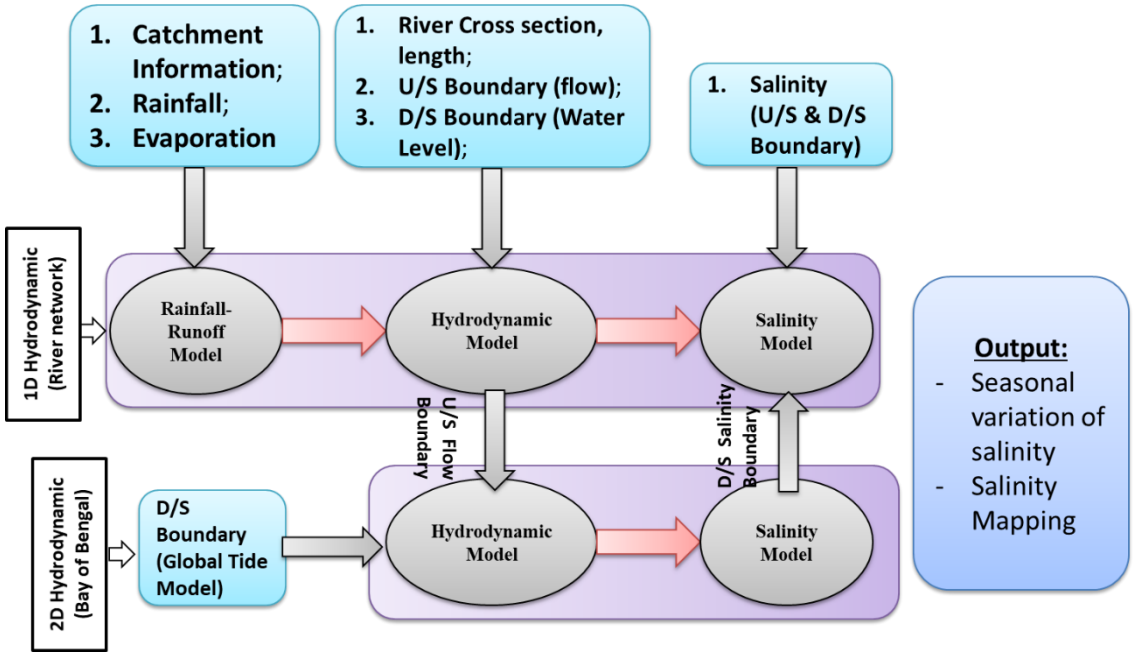


Figure 4.10: Flow chart of salinity model

Downstream water level and salinity boundary SWRM model is obtained from BoB model. For Boundary generation, both 1D and 2D model depends on each other. Several trial simulations are required therefore, to obtain a suitable boundary for two dimensional and one-dimensional model setups.

Detail descriptions on 2D and 1D Hydrodynamic and Advection Dispersion Model with calibrations are covered in the main report (Interim Report on Salinity Modelling Current Situation).

4.5 Model result

From data analysis and model results, it is observed that salinity varied with time and distance along the rivers. Dry season is the most vulnerable for coastal zone of Bangladesh in perspective of salinity intrusion. Specifically, February, March, April and May are the most vulnerable month. However, firstly a threshold value needs to be defined to delineate boundary of vulnerable location. For drinking water purpose, 1ppt salinity is the threshold value and for irrigation 2 ppt salinity is the threshold value for irrigation for agricultural purposes. 1ppt and 2ppt salinity contours at Southwest regional model in dry season as obtained from the model result analysis are shown in Figure 11 and Figure 12.

Salinity spatial map (Figure 4.13) is generated from the simulation data of mathematical modelling. Mathematical model simulation generates salinity value at the discretized nodes of each river within

the model domain. Each discretized node in the river stores the value of time series. A simulation was carried out during dry season of 2019 (from December, 2018 to mid-June, 2019).

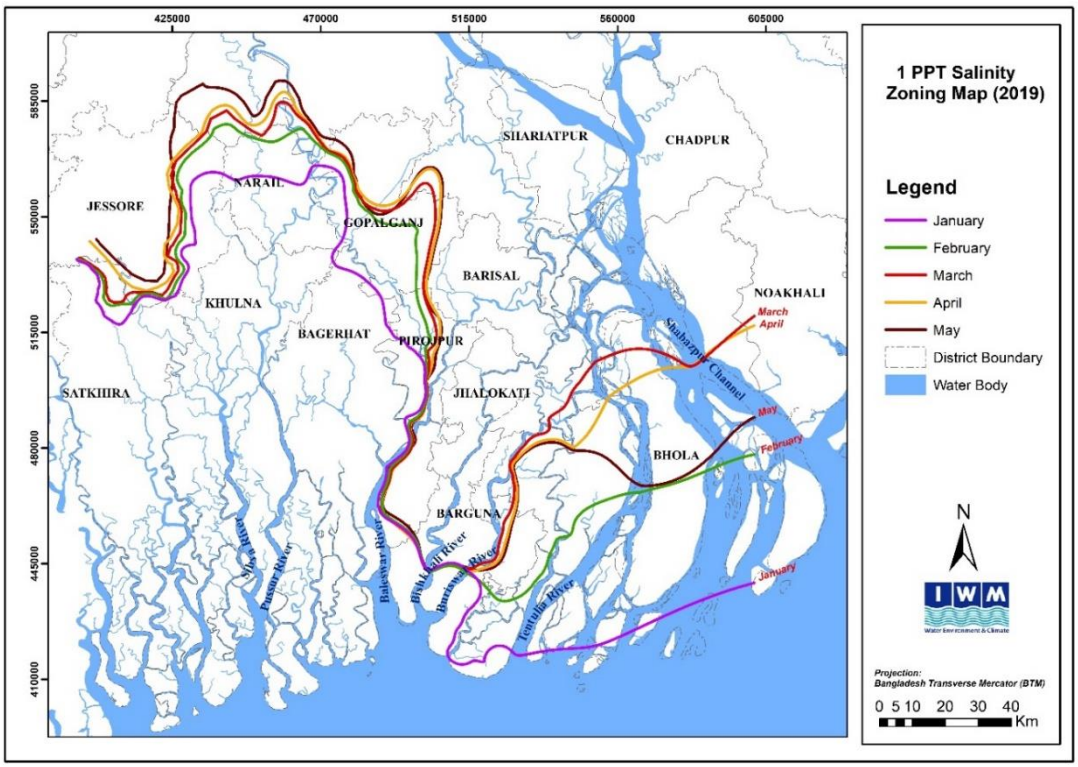


Figure 4.11: 1ppt salinity contour at Southwest regional model in dry season

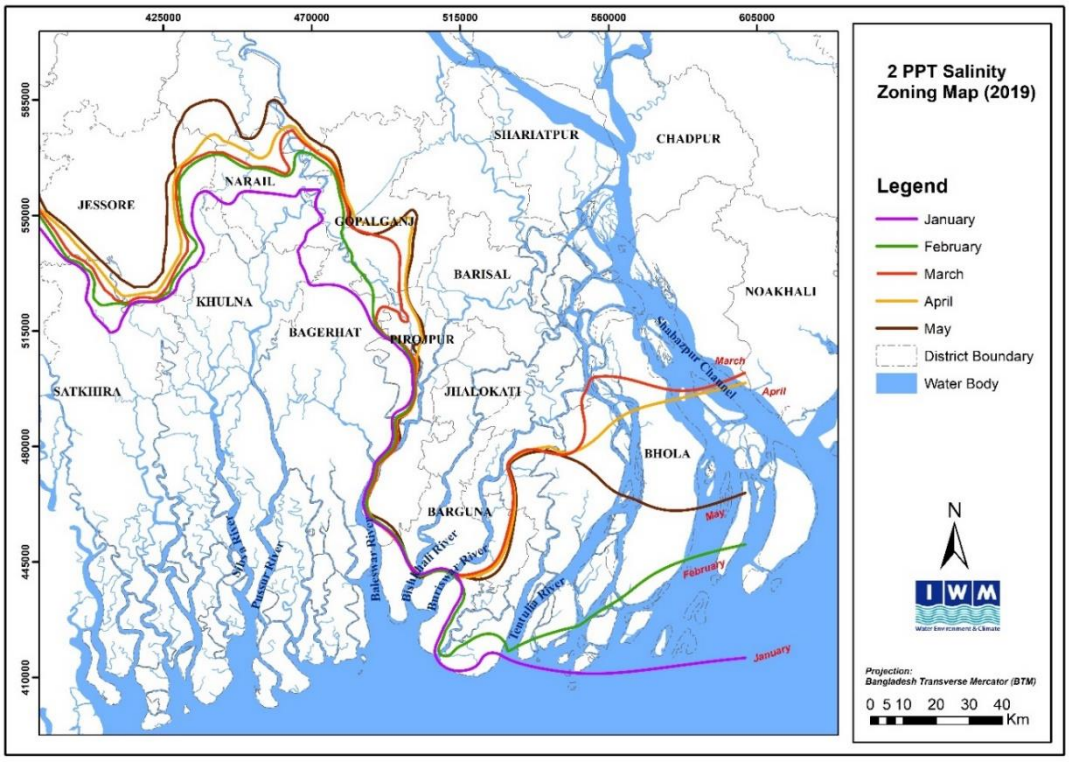


Figure 4.12: 2 ppt salinity contour at Southwest regional model in dry season

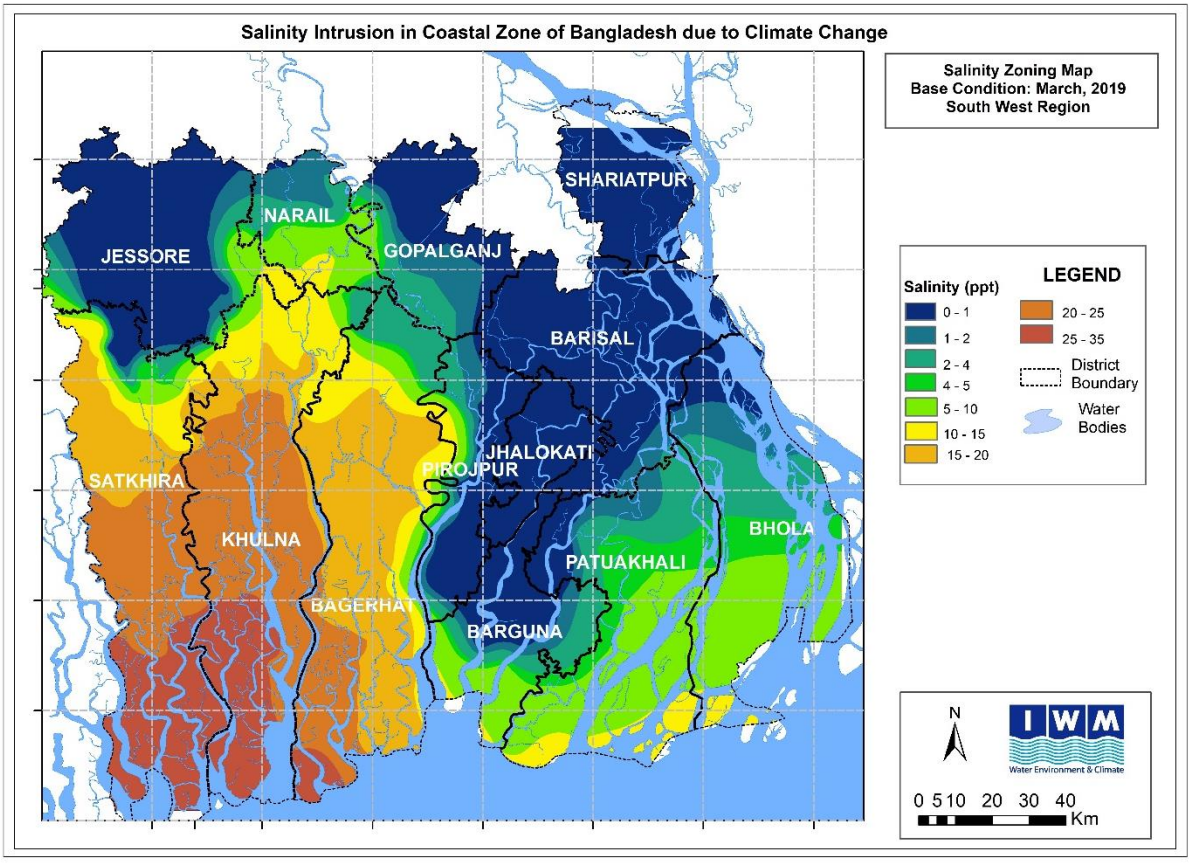


Figure 4.13: Salinity Raster during March 2019

4.6 Future Work Plan

Followings are the future work plan of the project

- Development of scenarios for climate change condition (change in rainfall, Sea level rise) and for in upstream withdrawal;
- Establishment of salinity iso-haline for different scenarios.

5 POLDER DEVELOPMENT PLAN

5.1 Progress in July, August and September 2021

This Chapter covers progress of Work from July, August and September 2021 under Component 5.A in the Terms of Reference.

Comp. 5A consists of three deliverables:

5A-1: Long Term Development Plan
5A-2: Review/Improvements on-going work (CEIP-I).
5A-3: Conceptual Design for 5 Polders

During the reporting period work has focused on Deliverable 5A-2 and 5A-3.

Deliverable 5A-2 "*Reconstruction of the Polder at different coastal zones including their phasing and construction program. Review/Improvements on-going work (CEIP-I)*" was again submitted on 27 September 2021 to the Client after updating the first version with comments from the Client.

Deliverable 5A-3 "Conceptual Design for 5 Polders"

A start has been made of preparing the report for this deliverable, in which for each of the 5 polders the following topics will be described:

1. Present situation and problems
2. Boundary conditions
3. Polder design options and measures
    a. Embankments
    b. Sediment management
    c. Water management
    d. Land use
    e. Disaster management
4. Costs and benefits

Polder designs will be developed using an iterative process supported by a number of models as described in the previous QPR. Intervention strategies are also based on the risk profile of each polder, that will be used to assess economic rationale for targeting interventions in the different polders. Each polder design consists of a selection of measures (such as embankment improvements, drainage improvements or tidal river management). The impact of these measures is calculated using the appropriate models. For instance, the effectiveness of drainage measures is estimated by using a drainage model, which on its turn provides input to an agricultural model. All models are run under specific boundary conditions at meso scale, which on their turn are influenced by both basin strategies (at delta scale) and long-term delta change scenarios, including climate change and socioeconomic development.

During the reporting period work progressed on the development of the risk profiles that are based on the inundation models for the 5 polders, including sensitivity analysis for the flood extent in the inundation model based on the source of the different elevation data. Furthermore, work continued to develop and calibrate the storm surge model, to better describe the boundary conditions for the modelling of the flood extend. Also work on the drainage model and the salinity model continued.

A workshop is planned for October 2021 to facilitate the exchange of information between the different models and provide guidance for the use of unified boundary conditions between the different models.

Below a summary of the present situation for each polder is given, as well as some key questions, that will be answered in the next quarter.

Polder 15

Polder 15 has a relatively high population density (10 persons/ha), is located remotely from a district capital (51 km from Satkhira) and the water in the peripheral rivers is characterized by a high salinity. Because of the high salinity, land use in the polder consists almost entirely of shrimp culture (Ghers). It was observed during the field visit (on 8 June 2020) that the 5 existing sluices are not fully functional for proper drainage and have deteriorated due to long use and the high salinity of the water. Local people are constructing cross dams to store the fresh water which creates water logging problems in the polder (CEIP-I, 2021). Hand tube-wells have been installed through horizontal boring pipe on embankment by the Gher owners for lifting water from the river to fulfil their demand of water inside the polder (CEIP-I, 2012).

Bank erosion from the Kobadak river is a main problem for the embankments. Many segments of the embankment have been damaged by wave action and eroded due to river flow. The CEIP-I Feasibility Study Report (CEIP-I, 2012) advised to protect about 15 km of embankments by afforestation on the foreshore area and several sections to be strengthened by bank and slope protection works. Note that Polder 15 is one of the CEIP-1 polders for which currently a feasibility design is ongoing.

Polder 15 also has a high cyclone risk. During cyclone AILA the embankment was overtopped, causing the polder area to be submerged by 1 to 1.5 m of surge water. About 75 people died, damage occurred and breaches formed at several places along the embankment. The polder area has remained under saline water due to the damaged embankment since AILA (CEIP-I, 2012). In 2020, Polder 15 was affected severely by cyclone AMPHAN. Another breach on the embankment occurred and caused flooding in the polder.

Questions to better target interventions:

- Is or was there a conflict between farmers and fishpond owners? Who owns the shrimp farms?
- How is water management organized? Should it be optimized for shrimp farming? Who makes decisions?
- Is the shrimp culture sustainable? Any problems with diseases, water quality? How many yields per year?
- Does current shrimp culture provide a good basis for economic development of the polder?

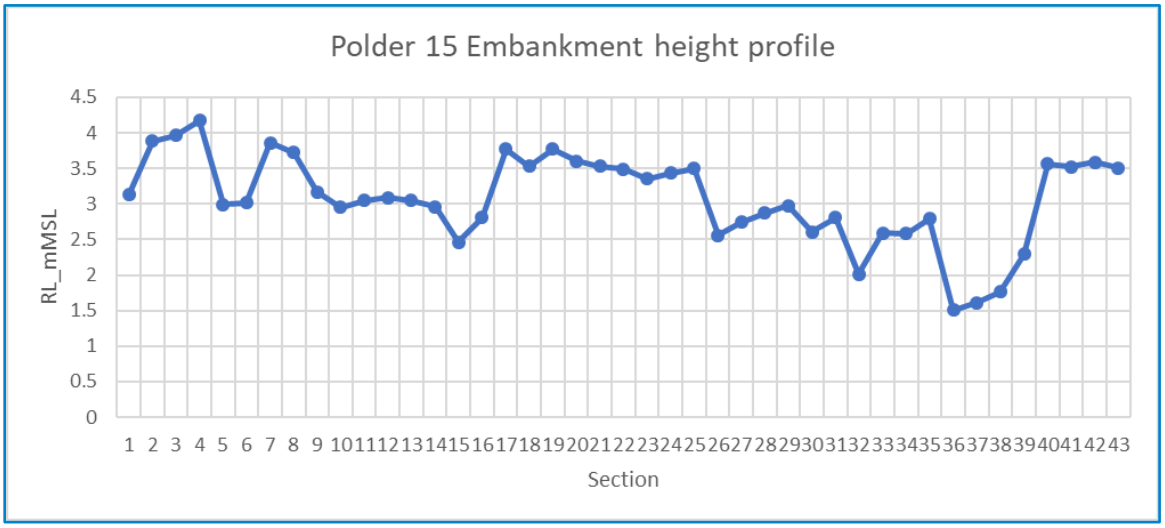


Figure 5.1: Polder 15 Embankment height profile

Table 5.1: Basic data of Polder 15

gross area (ha)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
3,441	27	34,766	10.1	22	51	25.2	26.6	2,975

Polder 29

Polder 29 has a moderate population density and is located close to Khulna (10 km). Salinity is moderately high. Large parts used to be poorly drained and have relatively high soil salinity. Problems include a lack of fresh water, river erosion and a high cyclone risk (cyclone shelter capacity is very low). According to the local residents there was no major storm surge flooding in Polder 29 during cyclones Aila (2009) and Sidr (2007) (CEGIS, 2016).

The cropping pattern as based on the statistics of the Upazilla Batiagata is as follows: large area is under single crop (T. Aman), whereas a substantial part has a double crop with T. Aman in Kharif 2 and Boro during Rabi season.

Polder 29 was one out of nine polders selected for the Integrated Planning for Sustainable Water Management (***IPSWAM***) project implemented by BWDB and IPSWAM project staff between 2004 and 2011. This project followed the Guidelines for Participatory Water Management (Ministry of Water Resources, 2001) that stipulated local stakeholder participation in any water management project. During this project IPSWAM helped create village level Water Management Groups (WMGs) and 1 polder level organization, the Water Management Association (WMA). WMGs are locally known as water committees and the WMA is called central or polder committee. These water management organizations (WMOs) are meant to represent the interests of local stakeholders, provide feedback on engineering design as well as coordinate labour for earthworks through Labour Contracting Societies and take over the responsibility of operation of sluice gates and minor maintenance after the project has completed (Dewan & Das, 2012).

Polder 29 is a ***Blue Gold*** Polder. The Blue Gold program since 2013 has conducted various interventions for rehabilitation of the polder which have apparently mitigated the existed drainage and water logging problems. The various interventions done under Blue Gold program have been re-sectioning of the existing embankment, repairing of drainage/flushing sluices, repairing of drainage outlets and excavation of drainage canals, etc.

The major embankment problem at present in the Polder as observed during the field visit (June 2019) was erosion at the Bhadra River along the right bank at Chandghar and Baroaria. Probably due to development of a bar at the middle of Bhadra river which made the flow area constricted on the side channels. As a result, the near bank velocity along the right bank of Bhadra river at Baroaria is increased and caused bank erosion. Precautionary protective work by geobags is also been done under Blue Gold program at Chandghor and other places (CEIP-I, 2021).

Questions to better target interventions:

- Has the waterlogging problem completely been solved by the Blue Gold Program?
- Which specific measures have been taken by Blue Gold in Polder 29?
- What will happen when Blue Gold stops?

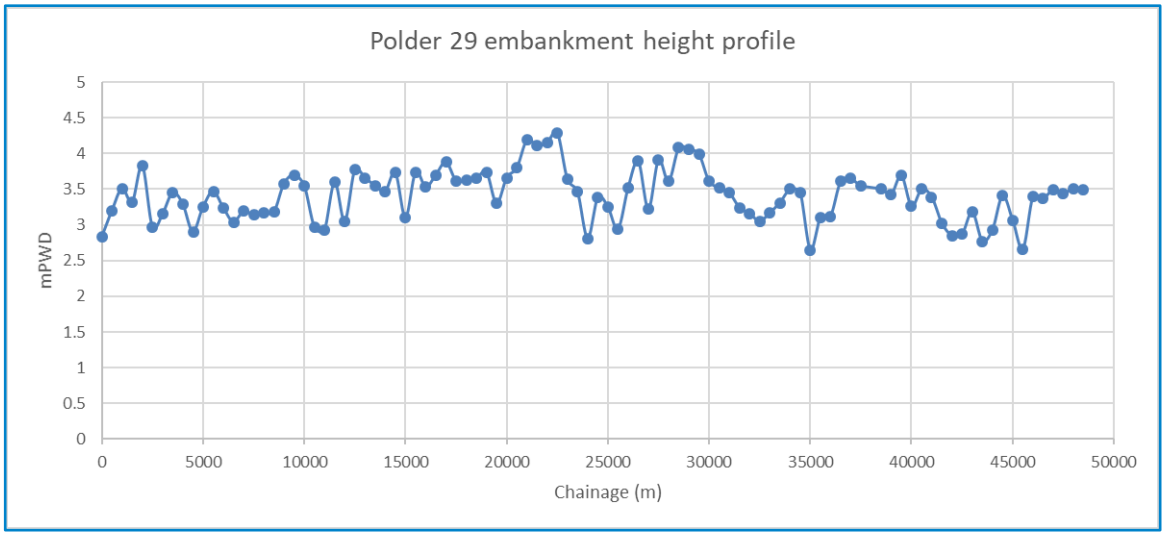


Figure 5.2: Polder 29 Embankment height profile

Table 5.2: Basic data of Polder 29

gross area (ha)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
8,218	49	59,072	7.2	13	10	9.9 – 10.3	12.6	825

Polder 40/1

Polder 40/1 is situated on the southern-most tip of the coastal area and is therefore a bit isolated, also because of the lack of major roads (distance to Barguna 23 km). The foreshore facing the BoB is very wide and long, where mangrove forest was planted in the past. It has a relatively low population density and moderate salinity. Waterlogging seems absent, but the main problem is erosion due to cyclonic storm surges. The polder was severely damaged during the Cyclone SIDR in 2007. Near Rohita the embankment was destroyed, after which a retired embankment was built. Unfortunately, the stretch in Padma Hat area is currently under erosion attack, which prompted BWDB to execute emergency protective works by using geo-bags.

The cropping pattern in the polder, using statistics of Upzilla Pathargatha, is as follows: majority of land is under double cropping, with T. Aman during Kharif 1 and mostly pulses during Rabi. Kharif 2 season mostly fallow.

Questions to better target interventions:

- Why is there no water logging problem?
- Is cropping intensity in the polder really 203%? Or lower than Upzilla average?
- Embankment is on average 4 m with two gaps (to 3 m). Can the gaps easily be closed?

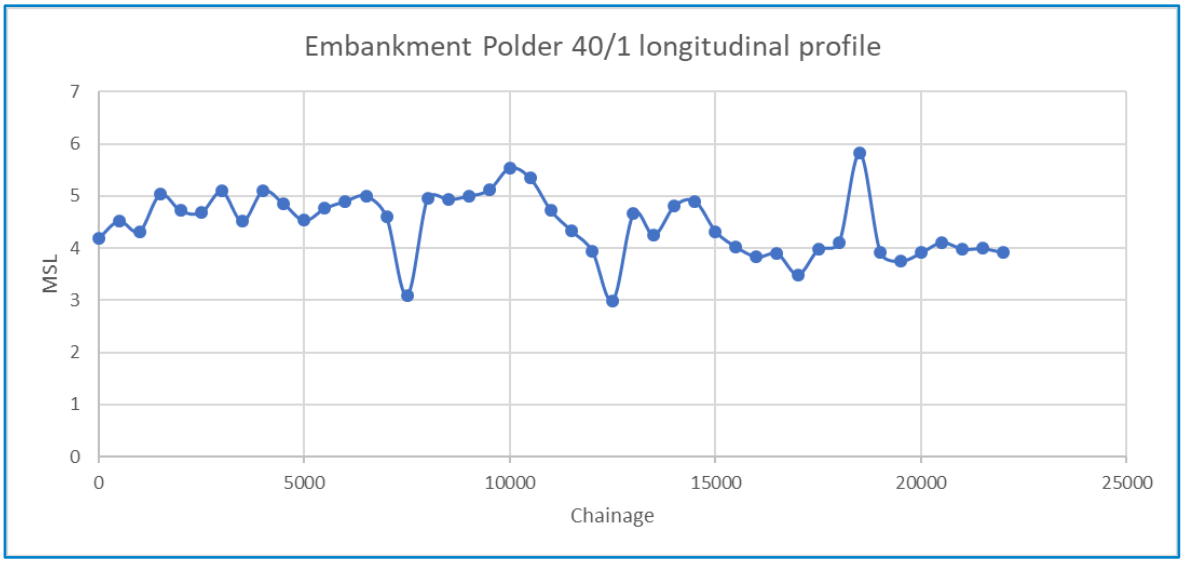


Figure 5.3: Polder 40/1 Embankment height profile

Table 5.3: Basic data for Polder 40/1

gross area (ha)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
2,105	23	12,200	5.8	-	23	6.3	8.3	8,250

Polder 59/2

Polder 59/2 has a high population density and is not isolated (distance to Noakhali 17 km). Lying next to the Meghna river there is always freshwater available and no salinity problem. However, the same river causes serious river erosion. Large parts of the land area were lost to the river over the past decades. A protection work has been carried out during 2016 -17 and 2017 – 18 in the severely eroded areas. Part of the protection works of 600m at the tail end of Ramgati and 3000m at Kamal Nagar has been implemented and the performance is satisfactory except areas at terminal points (CEIP-I, 2021). From the field visit in February 2020 it was known that around 36 km bank protection work was recommended by placing CC blocks in different phases in different sections. So far 5.5 km protection work in four different sections have been completed/being completed. A DPP was submitted for the rest area to be protected.

Currently the polder has a small cyclone risk, but it is projected to increase significantly in the future (5-fold increase of expected annual damage).

The cropping pattern in the polder, using statistics of Upzilla Ramgati, is as follows: majority of land is under double cropping, with T. Aman during Kharif 1 and pulses/soybean during Rabi. Also substantial triple cropping with Soybean – T. Aus – T. Aman.

Questions to better target interventions:

- As per field visit in February 2020, no water logging was reported. But needs to check.

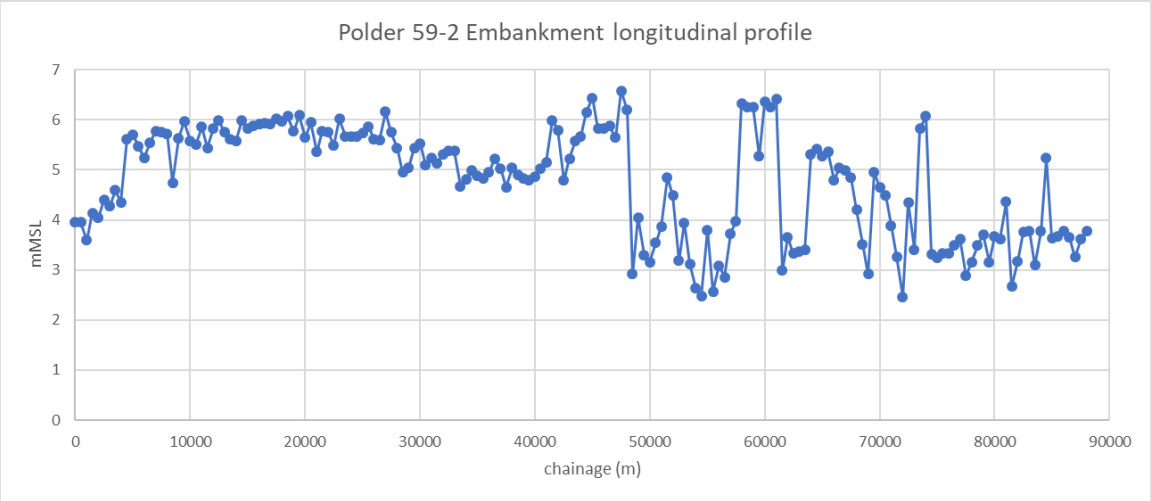


Figure 5.4 Polder 59/2 Embankment height profile

Table 5.4: Basic data for Polder 59/2

gross area (ha)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
21,255	82	372,021	17.5	4	17	0	0	105,525

Polder 64/1

Polder 64/1 has a high population density, is not isolated (good road to Chittagong) and has no salinity problems. According to local people the low land area face water logging problem due to silted up of drainage khals. The embankment at the sea side of the polder is partly damaged. Flash floods are a special risk of these polders (CEIP-I, 2021).

The cropping pattern in the polder, using statistics of Upazilla Baskhali, is as follows: majority of land is under double cropping, with T. Aman during Kharif 1 and Boro or vegetables during Rabi. Also a substantial part under triple cropping, with Boro – T. Aus – T. Aman. Also worth mentioning is a rather wide diversity of other crops growing, such as spices, potato, fruits, tomato, beetle leaf etc.

Cyclone risk is high, as storm surges can reach very high levels. Over the past decades many shelters have been built so that their capacity is very high.

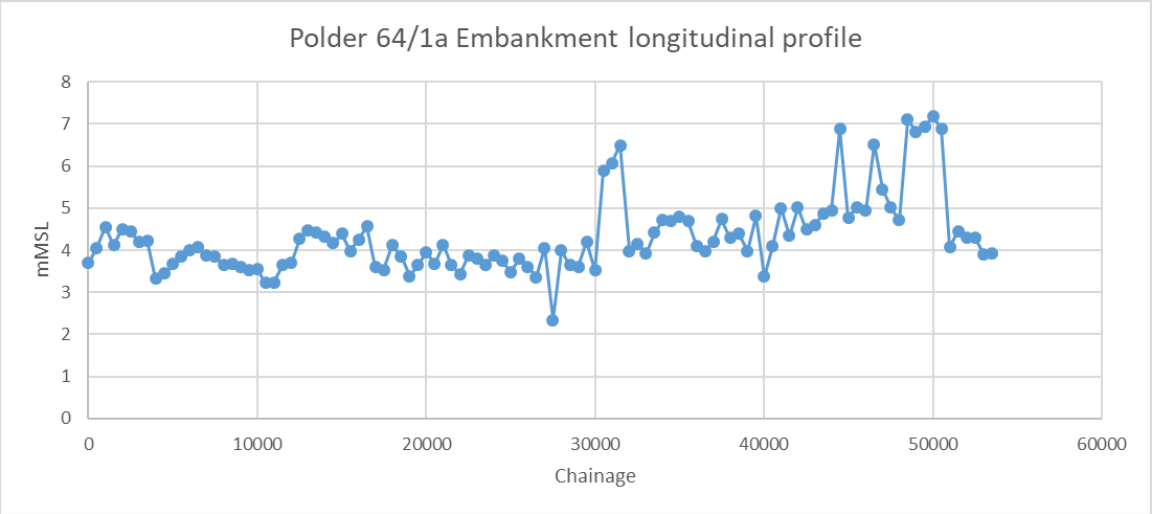


Figure 5.5: Polder 164/1a Embankment height profile

Table 5.5: Basic data of Polder 64/1a+b

gross area (ha)	perimeter (km)	pop (2011)	pop density (#/ha)	erosion (km)	distance to main town (km)	salinity current	salinity future	shelter capacity
13,750	111	268,910	19.6	2	25	0	0	103,735

6 CAPACITY BUILDING

6.1 Training Course on Salinity Modelling in the Coastal River System of Bangladesh

A 3-day training programme on “Salinity Modelling in the Coastal River System of Bangladesh” was conducted by the 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). The programme was planned for the BWDB engineers which commenced from 21 September and closed on 23 September 2021 at the office of the Consultant: Flat#3/B, House#4, Road#23/A, Banani, Dhaka-1213. Md. Syed Hasan Imam, Project Director, CEIP-1, BWDB virtually inaugurated the programme on 21 September 2021. The training course was closely supervised by Mr. Zahir-ul Haque Khan (Deputy Team Leader of the project). Farhana Akhter Kamal and MD Raqubul Hasib carried out the hands-on training program on a virtual platform zoom. On 23 September 2021, the training was closed by Mr. Md. Syed Hasan Imam, Project Director, CEIP-1, BWDB.

6.2 Training Activities

Day wise activities of the training program are

Day-1:

Introductory presentation was provided on the river salinity dynamics in coastal zone of Bangladesh. The presentation focussed on the salinity variation along the coast, change of surface water salinity with time, methodology of data collection, change of salinity with sea level rise and transboundary flow etc.

Developed one dimensional hydrodynamic and salinity model for Pussur Sibsa river system from scratch.

Day-2:

Continued development of one dimensional hydrodynamic and salinity model for Pussur Sibsa river system from scratch. Observe sensitivity of calibration parameter such as Dispersion factor and Manning’s M.

Day-3:

Discussed on scenario generation with Sea level rise, proposed interventions, and transboundary flow on the salinity intrusion. In the end, Mr. Md. Syed Hasan Imam, Project Director, CEIP-1, BWDB delivered the closing speech.

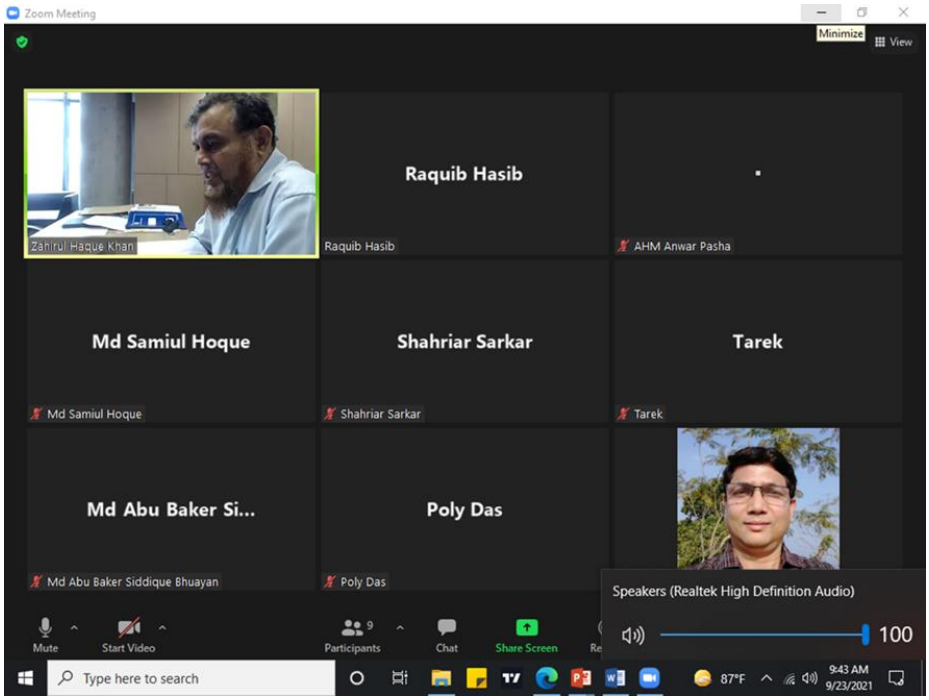
6.3 List of Participants

The participants of the training program were the professionals of BWDB and the details of the participants are given in the table below.

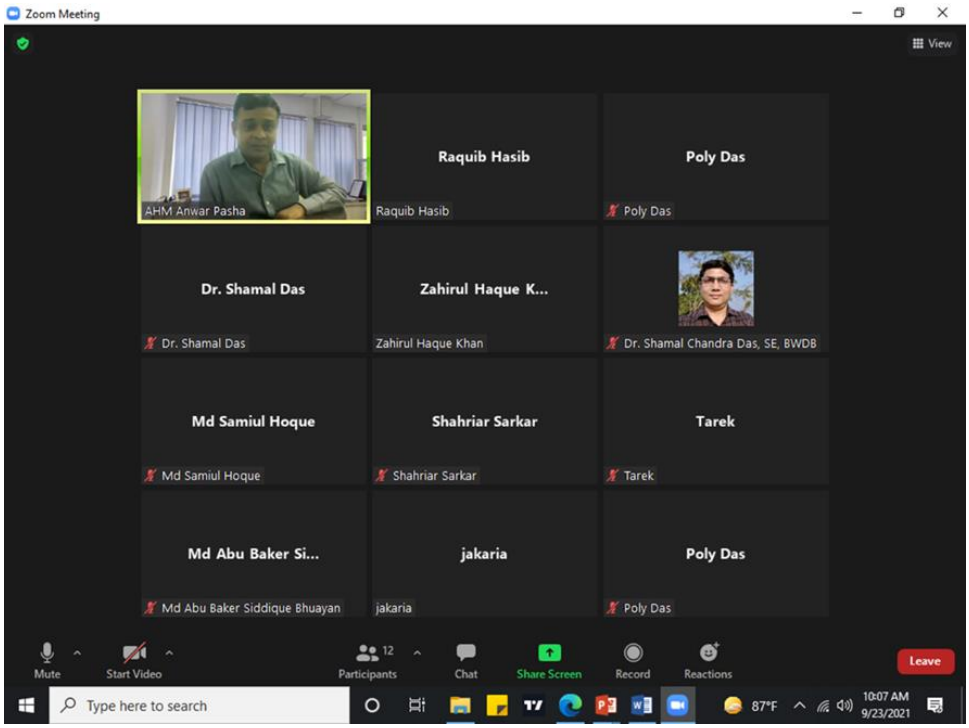
Table 6.1: List of Participants

S.L. No	Name	Designation& Place of Posting	E-mail ID & Mobile No
1	Dr. Shamal Chandra Das	Superintending Engineer Planning-1, BWDB, Dhaka	shamaledas@gmail.com Contact: 01759693375
2	Mr.A H M Anwar Pasha	Deputy Secretary Ministry of Water Resources, Dhaka	pasha6892@gmail.com Contact: 01550019907
3	Mr.Nur Alam	Deputy Secretary PS to Honorable State Minister Ministry of Water Resources, Dhaka	nuralam24@gmail.com Contact: 01718681845
4	Mr. Md Abu Baker Siddique Bhuayaw	Superintending Engineer PMU, CEIP-1, BWDB, Dhaka	seceip1@gmail.com Contact: 01712218500
5	Mr.Jakaria Parvez	Executive Engineer Design Circle-8, BWDB, Dhaka	jakariapervez@gmail.com Contact: 01712660025
6	Mr.Md Samiul Hoque	Executive Engineer PMU, CEIP-1, BWDB, Dhaka	ee2pmuceip1@gmail.com Contact: 07126233262
7	Mr.A.F.M. Touhid Jaman	Executive Engineer Design Circle-2, BWDB, Dhaka	tauhid.jaman@gmail.com Contact: 01750063089
8	Mr.Md. Arif Hossen	Executive Engineer Patuakhali WD Division, BWDB, Patuakhali	xen.kalapara@gmail.com Contact: 01729583955
9	Ms.Poly Das	Executive Engineer Design Circle-2, BWDB, Dhaka	engpoly@yahoo.com Contact: 01670681427
10	Mr.Shahriar Sarkar	Sub-Divisional Engineer PMU, CEIP-1, BWDB, Dhaka	shahriaranik@gmail.com Contact: 01954479232

Computer screen shots as given below visualises the participants of the training program.



Photograph 1: Computer screen shot 1



Photograph 2: Computer screen shot 2

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	February-March 2022	Preparatory Stages (Also included in Capacity Building Plan)
5	Polder Development Plan	Regional Stakeholder's Consultation	GoB Water Sector, University and related NGOs	30 Mar 2019	Report submitted on 24 Sep 2019

	Activity/Sub Activity	Type of Outreach	Target Group	Completion Date	Comments/Reports and Brochures
	Water Management Designs Overall Design Guidelines	Workshop, Barisal			
		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		