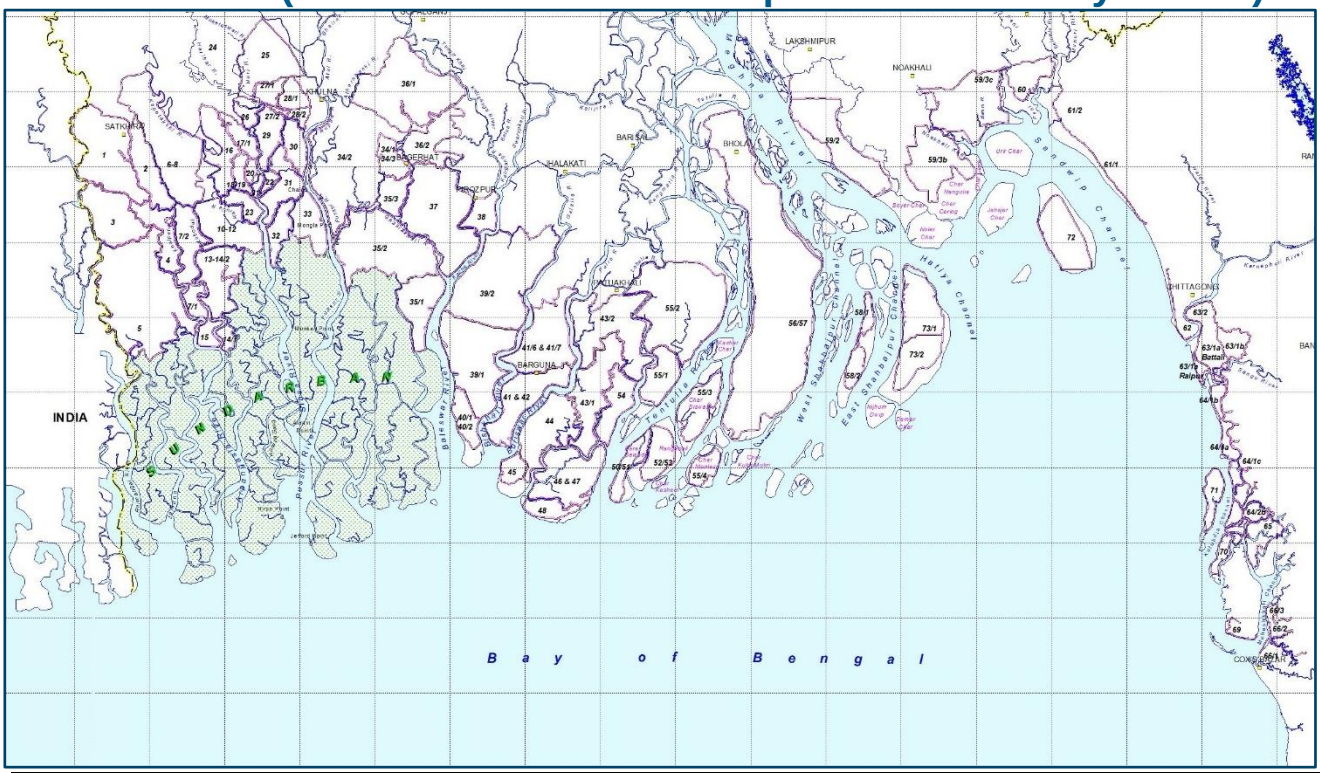
Ministry of Water Resources

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-14

April 2022

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

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-14

April 2022

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

Memo No: CEIP/LTMRA/0522/162 11 May 2022

Project Management Unit
Coastal Embankment Improvement Project, Phase-I (CEIP-I)
Pani Bhaban, Level-10
72, Green Road, Dhaka-1212

Attn: Mr. Syed Hasan Imam, Project Director

Dear Mr Imam,

Subject: Submission of Quarterly Progress Report-14

It is our pleasure to submit herewith three copies of the Quarterly Progress Report-14. This is the 14th Quarterly Progress Report describing the progress made between 1st January 2022 and 31 March 2022.

This report comprises 6 chapters, including the first three chapters that, as usual, describe progress in development of input datasets for modelling including coastal database. Chapter 4 which usually deals with a variety of modelling work, in this report covers Storm Surge and Cyclone Modelling, Chapter 5 describes the progress made on the Polder Development Plan and the Investment Plan during the January, February, and Mach 2022 under component - 5.

Chapter 6 deals with Capacity Building which was a Training Programme to the BWDB personnel on "Basic Theory on Improved technique on field survey and Data Processing"

Thanking you,

Yours sincerely,

Dr Ranjit Galappatti
Team Leader

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

Table of Contents

List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

ADCP- Acoustic Doppler Current Profiler

AGU- American Geophysical Union

BDP2100- Bangladesh Delta Plan 2100

BIWTA- Bangladesh Inland Water Transport Authority

BMD- Bangladesh Meteorological Department

BoB - Bay of Bengal

BWDB- Bangladesh Water Development Board

CBA- Coast Benefit Analysis

CCP- Chittagong Coastal Plain

CDMP-Comprehensive Disaster Management Program

CDSP- Char Development Settlement Project

CEA- Cost Effectiveness Analysis

CEGIS- Centre for Environmental and Geographic Information Services

CEIP- Coastal Embankment Improvement Project

CEP- Coastal Embankment Project

CERP-Coastal Embankment Rehabilitation Project

CPA- Chittagong Port Authority

CPP-Cyclone Protection Project

CSPS-Cyclone Shelter Preparatory Study

DDM- Department of Disaster Management

DEM- Digital Elevation Model

DOE- Department of Environment

EDP- Estuary Development Program

FAP- Flood Action Plan

FM- Flexible Mesh

GBM- Ganges Brahmaputra Meghna

GCM- General Circulation Model

GIS- Geographical Information System

GNSS- Global Navigation Satellite System

GNSS-IR- GNSS interferometric reflectometry

GPS- Global Positioning System

GTPE- Ganges Tidal Plain East

GTPW- Ganges Tidal Plain West

HD- Hydrodynamic

IGDCZ- Interactive Geo-Database for Coastal Zone

InSAR- Interferometric Synthetic Aperture Radar

IPCC- Intergovernmental Panel for Climate Change

IPSWAM- Integrated Planning for Sustainable Water Management

IWM- Institute of Water Modelling

LCC- Life Cycle Costs

LGED- Local Government Engineering Department

LGI- local Government Institute

LRP- Land Reclamation Project

MCA- Multi Criteria Analysis

MES- Meghna Estuary Study

MoWR- Ministry of Water Resources

MPA- Mongla Port Authority

MSL- Mean Sea Level

NAM - Nedbor Afstromnings Model

PPMM- Participatory Polder Management Model

RCP- Representative Concentration Pathways

RSET-MH- Rod surface elevation table – marker horizon

RTK- Real-Time Kinematic

SET-MH- Surface Elevation Tables – Marker Horizons

SLR- Sea Level Rise

SOB- Survey of Bangladesh

SSC- Suspended Sediment Concentration

SWRM- South West Region Model

TBM- Temporary Bench Mark

ToR- Terms of Reference

WARPO- Water Resources Planning Organization L - Water Level

1 INTRODUCTION

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

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

After a very long gestation period, the study was initiated on 15 October 2018 and the Inception Phase was completed in January 2019. The Inception Report was treated as the first Quarterly Progress Report (QPR-1). Since then, 12 separate quarterly progress reports were submitted till February 2022. This present report is QPR-14 covering the period 1 January 2022 to 31 March 2022.

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

1.1 The New Work Plan

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

Table 1.1 shows the schedule of activities based on Contract Modificaiton-2. On 13 December 2021 (Letter No DHI/CEIP-12-13-2021), the Consultants submitted 2nd revised contract (Contract Modification-2) to the Project Director, PMU, CEIP-1 requesting the project duration to be extended up to the end of June 2022. The second variation proposal has been approved on 7 March 2022 by the PMU.

The original workplan (not shown here) was published in the Inception Report in December 2018. Later a revised work plan was published in QPR-10 showing an extension of the project duration

until January 2022. That revised work plan was planned based on signing of the 1st revised contract on 26 April 2021.

The work programme has been modified to accommodate the rapidly evolving travel restrictions imposed by the COVID-19 crisis. This programme involves some staffing and budget changes. Section 1.2 and section 1.3 describe the non-modelling and modelling milestones and deliverables in Table 1.2 and Table 1.3. The total list of deliverables including the revised reports submitted to the PMU office are shown in Table 1.4.

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

Table 1. 1: New Activity Schedule Page 1

Overview of Deliverables (Effective Date of commencement is 15 October 2018)

No	TOR Reference/ Deliverables Code	TOR Deliverables
D-1	D-1	Inception Workshop
		Inception Report (Workplan etc
D-2	D-2	**Literature Review & Lessons Learnt**
		Literature Inventory & Interim Review 1
		Literature Inventory & Interim Review 2
		Literature Review & Lessons Learnt
D-3		**Development of Input datasets for modelling the physical processes**
	D-3:1,2	1) Soft and hard copies of map of the location of all the current field measurement stations, by tape, stored in Database of BWDB, Map showing the location of primary BM with values
	D-3:1,2	2) Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB
	D-3.3	Completed and validated dataset including meta-data, stored in Database of BWDB (Database design report)
	D-3:4	GIS based National Coastal Polder Database/ Management Information System/ Database (GIS based map)
	D-3:4	GIS based National Coastal Polder Database/ Management Information System/ Database
	D-3:5	Boundary conditions and data for calibration and validation of models
	D-3:6	Monitoring results on sedimentation rate in rivers and floodplain
	D-3:7	Annual and seasonal sediment load of major rivers and to Bay of Bengal
	D-3:8	Technical memorandum describing the validation and completion procedures that have been udes by the consultant for all type of data; for reproducibility purposes and to be stored in Database of BWDB
	D-3:9	Memorandum with recommendations to improve the data collection, processing, validation and dissemination within the GoB
D-4		**Modelling of the long-term physical processes**
D-4A-1		**Morphology on a macro scale**
	D-4A-1:1	The software newly developed under this project with all source code and accompanying technical document with detailed explanation of the methodology and assumptions
	D-4A-1:2	
	D-4A-1:2,3	Geospatial datasets of main sources and deposits of sediment at present, including full meta-data a restored and archived in Database of BWDB;
		Geospatial datasets of main sources and deposits of sediment for 100 years from present, including full meta-data are published and archived in Database of BWDB.
	D-4A-1:4	Technical reports (one report for 4A-1 Final Report on Morphological Trend)

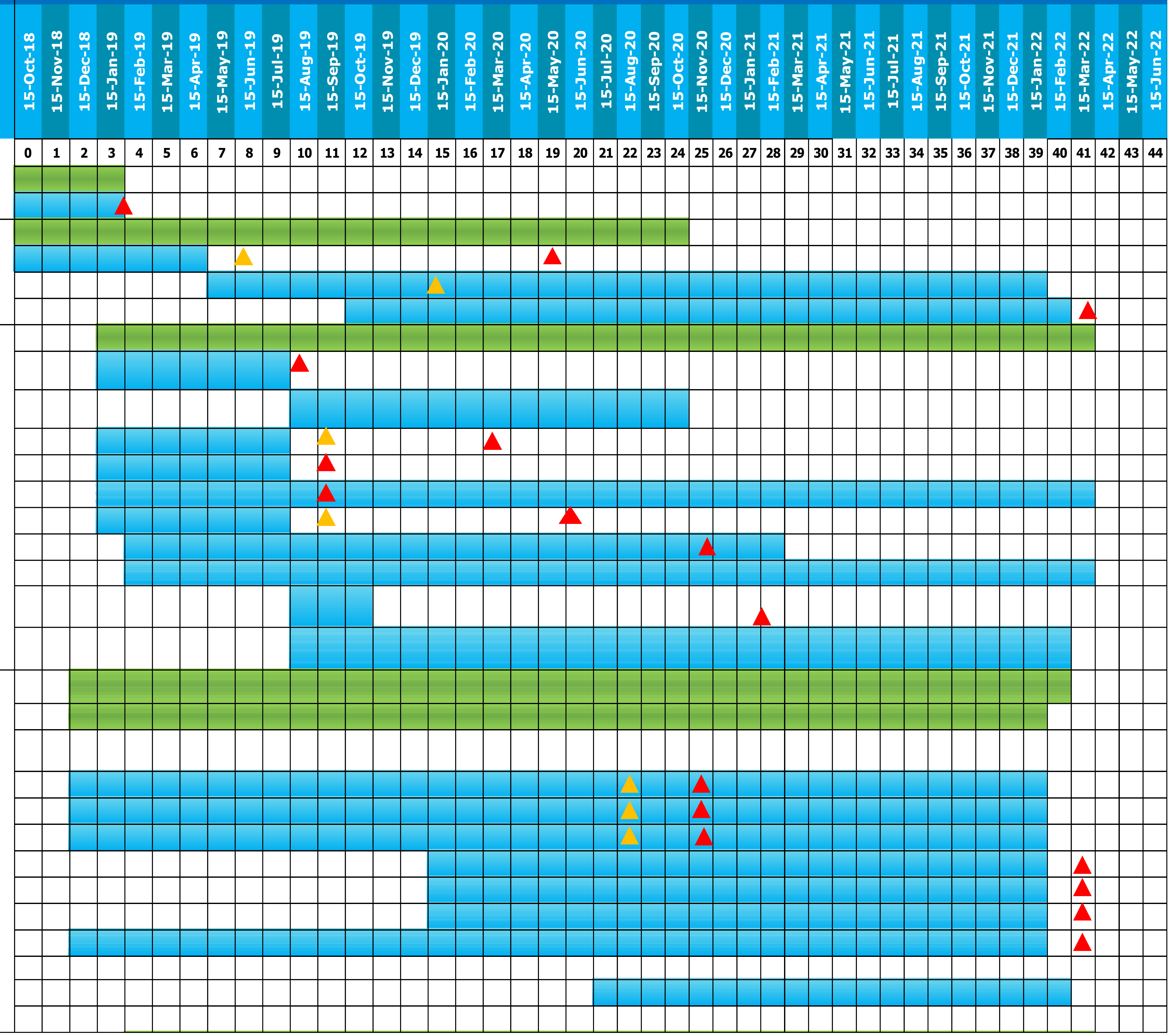


Table 1.1 (contd) : New Activity Schedule Page 2

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

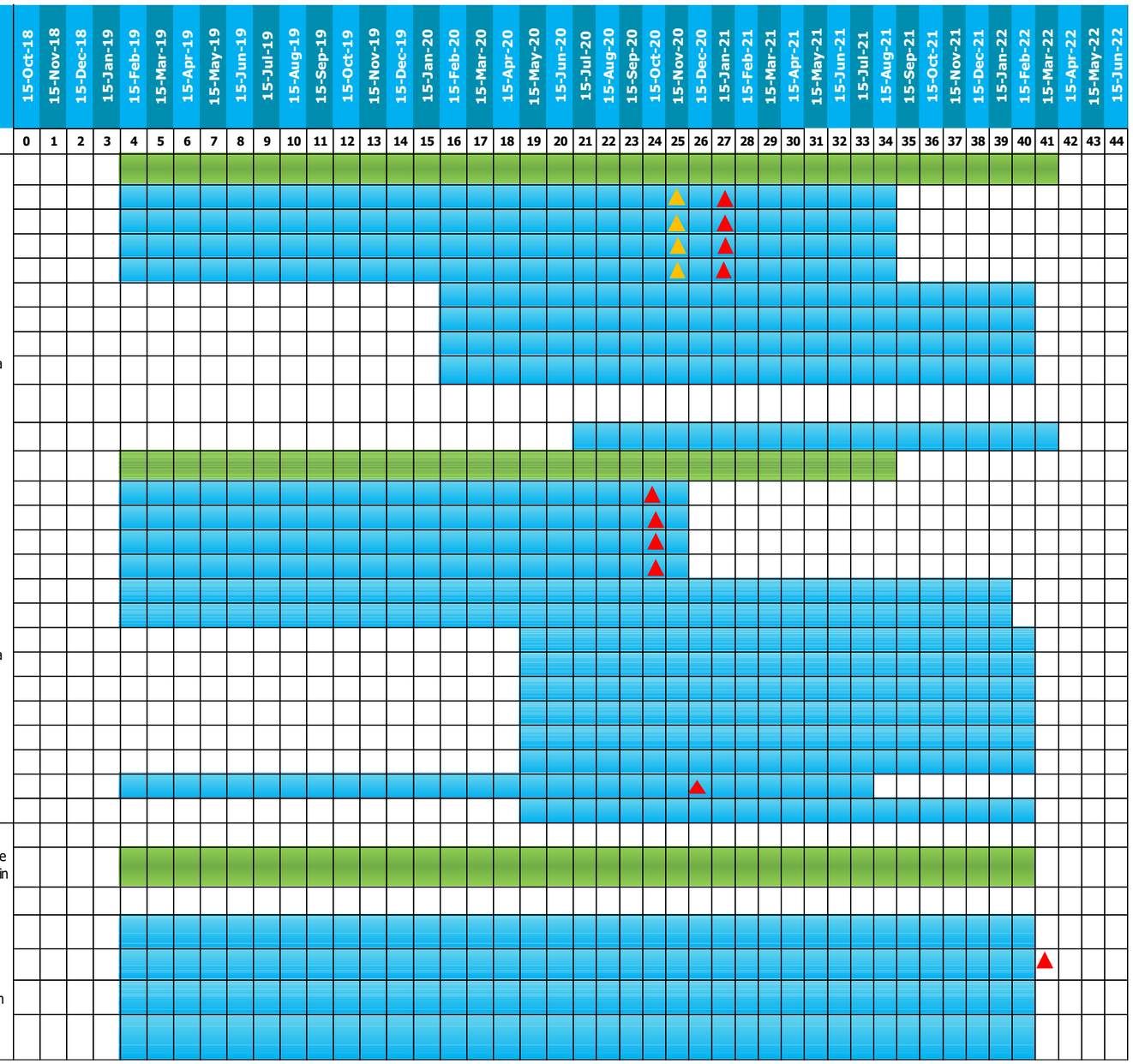


Table 1. 1 (contd) : New Activity Schedule Page 3

No	TOR Reference/ Deliverables Code	TOR Deliverables
D-4A-3	D-4A-3:1,2,3	The model setup developed will be updated under this project with all accompanying technical document with detailed explanation of the methodology and assumptions. A report that describes the pros and cons of the different methodologies to prevent water-logging within the polder and sedimentation of tidal river system including polder-subsidence. The report will include meta-data on the models used and measurements, recommendations for polder design including drainage and long term management plan, and recommendations for pilot area/ polder to implement the ideas, such as but not limited to location, methods and measurements. Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder.
D-4B	D-4B:1,2,3	**Subsidence** Geospatial datasets of total subsidence at present and for 25, 50 and 100 years from now, including full metadata and stored in Database of BWDB and Estimate the annual rate of subsidence. Detailed Technical Report with description and explanation of geospatial analysis of the total subsidence in the four regions of the polder area of the coastal zone at present and for 25, 50 and 100 years from present, including description of the causes of subsidence, full metadata and stored in Databse of BWDB. Report on the total subsidence in specific polders (designated by BWDB) in 25, 50 and 100 years from now when no sediment is supplied to the polder, including the amount of sediment needed to counteract this subsidence.
D-4C	D-4C:1,2	**Meteorology** Technical Report describing current trends and future scenarios in rainfall in the polder area of coastal zone for four coastal regions (including estimation of rainfall distribution over the year) and cyclone frequency and intensity for the next 25, 50 amd 100 years from now, including meta-data of the datasets used for the trend analyses and store and archived in Database of BWDB. The Research Team shall include a description of the statistical and downscaling methods used for reproducibility reasons. Geospatial Dataset and archived in Database of BWDB.
D-4D	D-4D:1,2,3 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.

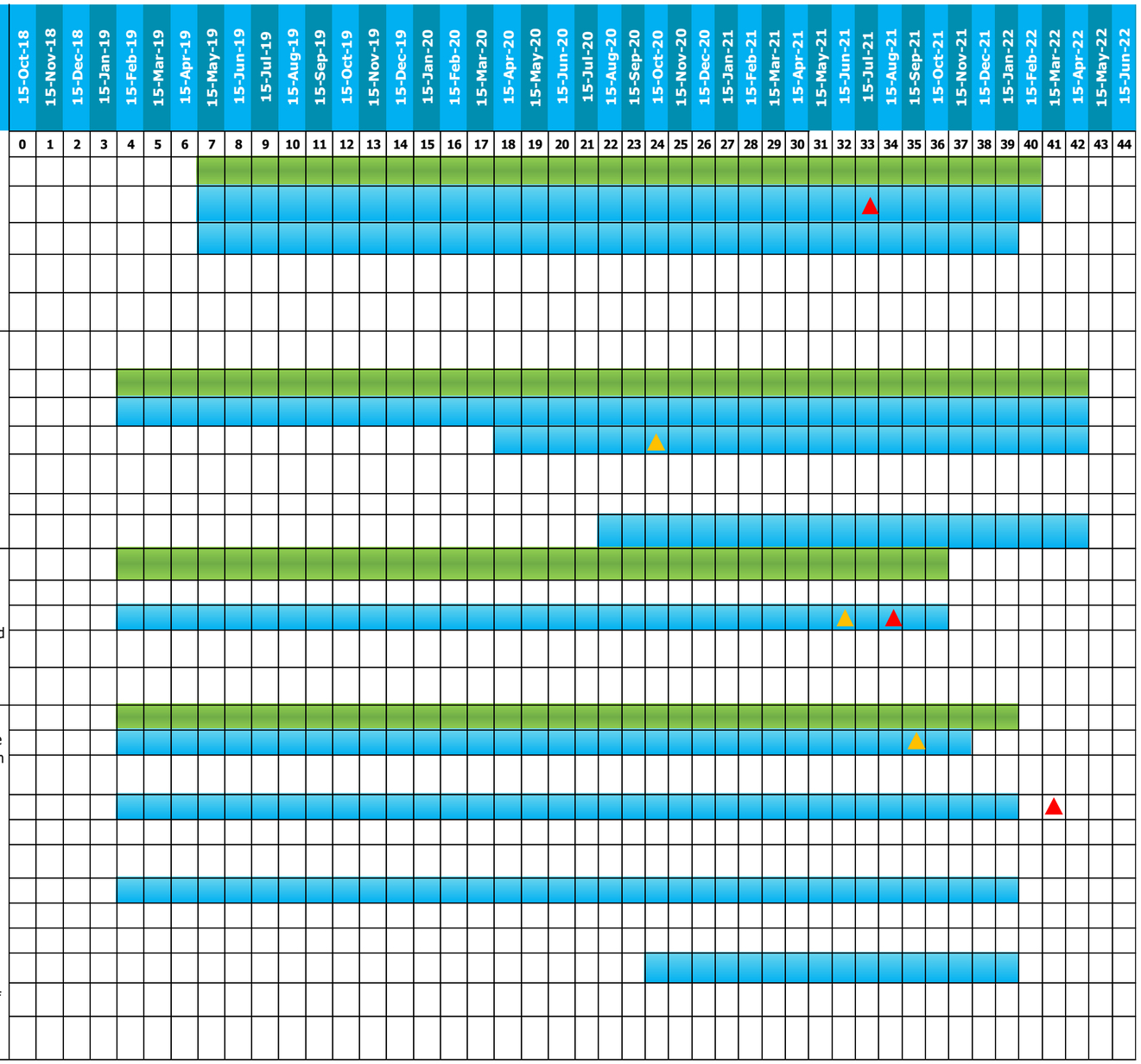
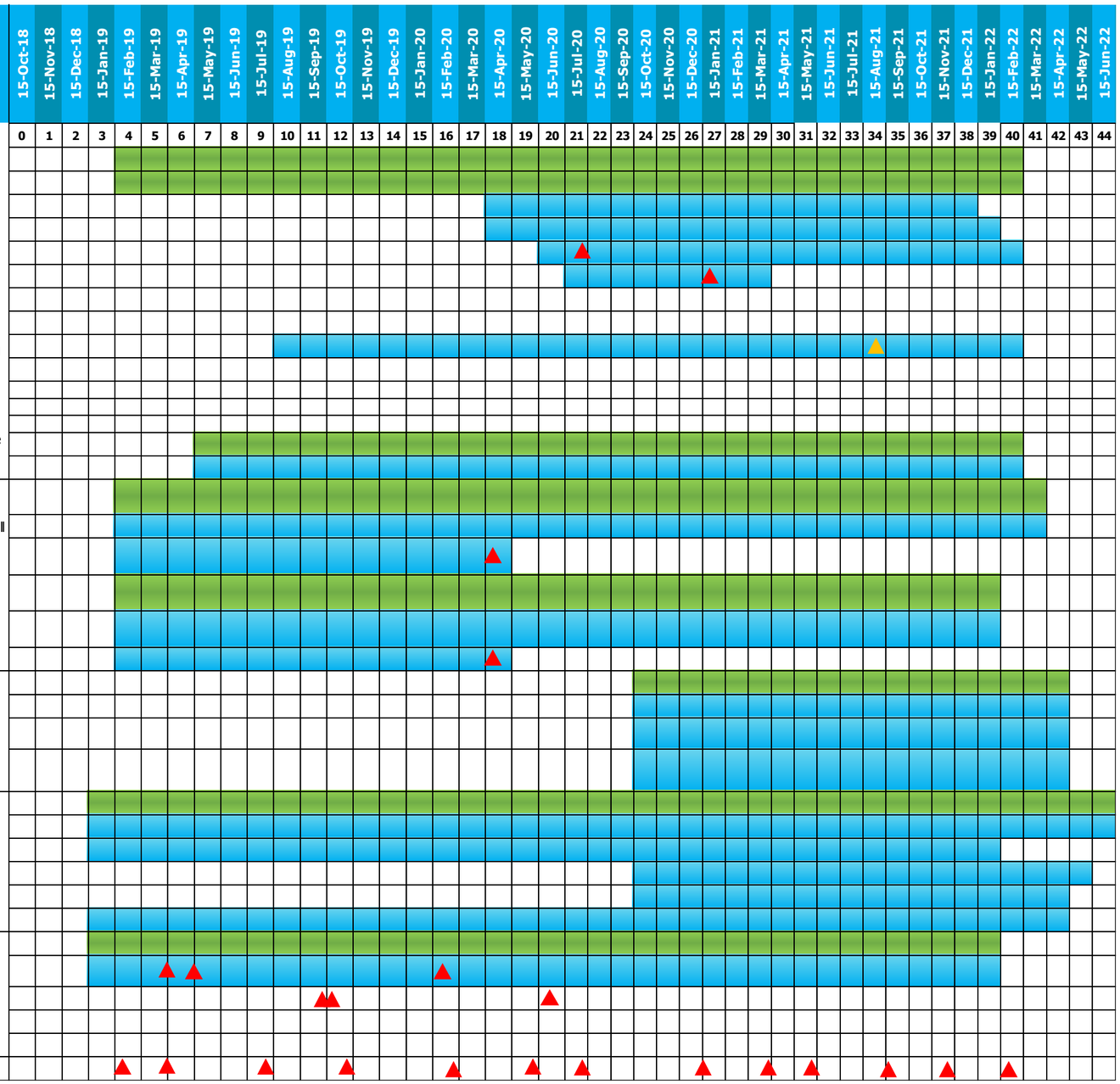


Table 1. 1 (contd) : New Activity Schedule Page 4

No	TOR Reference/ Deliverables Code	TOR Deliverables
D-5		
D-5A		
	D-5A:1	
	D-5A:1	Technical Report on Long Term Polder Improvement measures and Polder Development Plan
	D-5A:1	
	D-5A:2	Design of polder improvement measures of 17 polders under CEIP-I with consideration of existing improvements. Draft report focusing on initial 4 Polders to be optimised. Final report, 17 polders
	D-5A:3	Report for each of the 3-5 polders with a description of ; Present situation, boundary conditions (scenarios), Matching with polder options, Including management plan, Costs and benefits. Draft report focusing on initial 4 Polders to be optimised. Final Report, 17 Polders.
D-5B		Report describing the Interdependencies and relations between the processes and parameters, consequences for the boundary conditions and recommendations for future action plan/ research
D-6		**Updating of design paramerters and specificaitons for construction works and management paractices**
	D-6.1	Report with updated set of design parameters and specifications for construction/ reconstruction of the polders as well as associated appurtenant structures. Detailed delivery plan to be developed druing the inception phase.
D-6.2 & D-6.3	D-6.2 & D-6.3	
		Report on Management plans for the polders including review approaches of polder management and performance monitoirng mechanism
		Detailed delivery plan to be developed during the inception phase
D-7		**Investment Plan for Entire CEIP**
	D-7:1	An investment plan describing a phaased polder improvement roadmap and required budget
	D-7:2	An investment plan for long term management of the polders, including the expansion of monitoring
	D-7:3	An execution plan including financing and fundraising strategies and plan and technical collaboration plan
D-8		**Action Plan for Capacity Building**
		On the job technical training in country
		Report on: results of the on the job training, list of participants
		International Workshop
		Teach the teacher, Teaching at the universities
		Overseas Study tour
D-9.1		**Outreach Program**
	D-9.1:1	Workshops
	D-9.1:2	Workshop Report (Stakeholder's workshop at Barisal and Khulna & Mid-term workshop at Dhaka)
D-9.2		**Communication Strategy**
		Storage of all datasets of BWDB and Communication materials
QPR		



Draft submission of report Submission of revised report

1.2 Revised List of Non-Modelling Milestones and Deliverables)

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

Overview of Deliverables		As per Consultant				
No	**ToR Deliverables**	**Program Item**	**Status**	**Deadline as per Signed Contract**	**Date of Submission to PIU**	**Proposed Deadline (2nd Contract Amendment to June)**
D-1	**Inception**					
	Inception Workshop	Inception Workshop	Accepted	4-Jan-19	9-Jan-19	
	Inception Report (Workplan etc)	Inception Report (Workplan etc)	Accepted	4-Jan-19	30-Jan-19	
D-2	**Detailed Literature Review and its Summary and Lessons Learnt**					
	Literature Inventory & Interim Review 1	Literature Inventory & Interim Review 1	Submitted	4-Feb-19	24-Jun-19	
	Literature Inventory & Interim Review 2	Literature Inventory & Interim Review 2	Submitted	4-Oct-20	15-Jan-20	
	Literature Review & Lessons Learnt	Literature Review & Lessons Learnt	Submitted	4-Oct-20	16-Mar-22	
D-3	**Development of Input Datasets for Modelling the physical processes**					
	Soft and hard copies of map of the location of all the current field measurement stations, by tape, stored in Database of BWDB, Map showing the location of primary BM with values	Data Report, Inventory & Quality Checks (Includes field Data collection and monitoring programmes)	Submitted	4-Jul-19	29-Sep-19	
	Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB					
	Completed and validated dataset including meta-data, stored in Database of BWDB	Database Design Report	Submitted	4-Jul-19	11-Sep-19	
	GIS based National Coastal Polder Database/ Management Information System/ Database	GIS Based Maps	Submitted	4-Jul-19	25-Sep-19	
		GIS Based Database/ MIS system/ Sharepoint	Pending	4-Jul-19		30-Jun-22
	Boundary conditions and data for calibration and validation of models	Supply of Model Boundary Data	Submitted	4-Jul-19	25-Sep-19	
	Monitoring results on sedimentation rate in rivers and floodplain	Monitoring Results on Sedimentation rate in rivers	Submitted	4-Jul-19	Draft version submitted on Dec 7, 2020	
	Annual and seasonal sediment load of major rivers and to Bay of Bengal	Annual & Seasonal Sediment load of Major rivers & to Bay of Bengal	Pending	4-Aug-19	21-Mar-22	30-Apr-22
	Technical memorandum describing the validation and completion procedures that have been udes by the consultant for all type of data; for reproducibility purposes and to be stored in Database of BWDB	Technical Report of Data analysis & Validation	Submitted	4-Aug-19	24-Feb-21	
	Memorandum with recommendations to improve the data collection, processing, validation and dissemination within the GoB	Technical Report on improving Data collection	Pending	4-Aug-19	28-Mar-22	30-Apr-22
D-5A	**Finalization of approach for reconstruction of the Polder at different coastal zones including their phasing and construction program**					
	Technical Report on Long Term Polder Improvement measures and Polder Development Plan	Draft	Submitted	4-Apr-21	6-Aug-19	
		Final	Submitted		20-Mar-21	
	Design of polder improvement measures of 17 polders under CEIP-I with consideration of existing improvements with a description of ; opportunities for livelihood, spatial planning, water management and operation, subsidence, raising of low lying area and future climate change scenarios.	Draft	Submitted	4-Apr-21	18-Jan-21	
		Final	Pending			Submitted 1-11-2021
	Report for each of the 3-5 polders with a description of; · Present situation · Boundary conditions (scenarios) · Establish design, including management plan · Costs and benefits · Matching with polder options	Draft	Submitted	4-Jul-20	7-Sep-21	
		Final	Pending			31-Mar-22
D-5B	**Coherence and Overall picture of Delta**					
	Report describing the Interdependencies and relations between the processes and parameters, consequences for the boundary conditions and recommendations for future action plan/ research	Coherence with respect to Overall Delta	Pending	4-Apr-21		30-Apr-22
		~~Environmental Assessment of Proposed Interventions~~	Pending			
D-6.1	**Updating of design parameters and specifications for construction works**					
	Report with updated set of design parameters and specifications for construction/ reconstruction of the polders as well as associated appurtenant structures	Updated Design Parameters & Specifications	Pending	4-Apr-21		31-Mar-22
	Detailed delivery plan to be developed during the inception phase for D-6.1	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.2	**Review of approaches for management of polders with emphasis on active participation o**					
	Report on Management plans for the polders	Polder Management Plan	Pending	4-Apr-21		31-Jan-21
	Detailed delivery plan to be developed during the inception phase for D-6.2	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.3	**Setting up a performance monitoring Mechanism**					
	Report on participatory monitoring mechanism with goals and targets	Performance Monitoring Mechanisms	Pending	4-Apr-21		Proposed for inclusion in D-6.2, Polder management plan
	Detailed delivery plan to be developed during the inception phase for D-6.3	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	

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

Overview of Deliverables		As per Consultant			
No	**ToR Deliverables**	**Program Item**	**Status**	**Deadline as per Signed Contract**	**Date of Submission to PIU**
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	
	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	
	Report on: results of the on the job training, list of participants	Training Report with list of trainees	Pending	Bi Annually	
	International Workshop	International Workshop	Pending	4-Jul-20	
	Teach the teacher, Teaching at the universities	Curriculum Development	Pending	4-Apr-21	
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	
	Communication materials such as brochures, animations etc.	Communication materials such as brochures, animations etc.	Pending	4-Oct-20	
Q	**QPR**				
	QPR-1	QPR-1	Submitted		30-Jan-19
	QPR-2	QPR-2	Submitted		20-Aug-19
	QPR-3	QPR-3	Submitted		20-Aug-19
	QPR-4	QPR-4	Submitted		7-Nov-19
	QPR-5	QPR-5	Submitted		2-Mar-20
	QPR-6	QPR-6	Submitted		10-Jun-20
	QPR-7	QPR-7	Submitted		6-Sep-20
	QPR-8	QPR-8	Submitted		20-Jan-21
	QPR-9	QPR-9	Submitted		21-Mar-21
	QPR-10	QPR-10	Submitted		23-May-21
	QPR-11	QPR-11	Submitted		18-Aug-21
	QPR-12	QPR-12	Submitted		30-Nov-21
	QPR-13	QPR-13	Submitted		13-Feb-22

1.3 Revised List of Modelling Milestones and Deliverables

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

DELIVERABLES RELATED TO MODELLING ACTIVITIES							
TOR Reference	**TOR Deliverables**	**Scale**	**Model**	**Status**	**Delivery Dates as per signed Contract**	**Date of Submission**	**Proposed Deadline (2nd contract Amendment to June 2022)**
Macro-scale Modelliing							
D-4A-1: 1	The software newly developed under this project with all source code and accompanying technical document with detailed explanation of the methodology and assumptions			Pending	4-Apr-21		
D-4A-1: 2, 3	Geospatial datasets of main sources and deposits of sediment at present, including full meta-data a restored and archived in Database of BWDB Geospatial datasets of main sources and deposits of sediment for 100 years from present, including full meta-data are published and archived in Database of BWDB.	**Macro**	GBM Basin Model	Submitted	D-4A-1: 2 (Jan 20) D-4A-1: 3 (Oct 20)	19-Nov-20	
		Macro	Macro scale River Model	Submitted		19-Nov-20	
		Macro	Macro scale River Model	Submitted		19-Nov-20	
		Macro	GBM Basin Model Applications	Submitted		2-Mar-22	
		Macro	Macro scale River Model Applications	Submitted		2-Mar-22	
		Macro	Macro scale River Model Applications	Submitted		2-Mar-22	
		Macro	Sediment Budget Analyses	Submitted		2-Mar-22	
D-4A-1:-4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Jan 21)		May-22
Long Term Morphology Modelling							
D-4A-2: 1	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions.	**Meso**	Pussur Sibsa	Submitted	4-Oct-19	6-Jan-21	
		Meso	Baleswar-Bishkhali Model	Submitted		6-Jan-21	
		Meso	Lower Meghna	Submitted		2-Dec-20	
		Meso	Sangu	Submitted		6-Jan-21	
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)		May-22
		Meso	Baleswar-Bishkhali Model	Pending			
		Meso	Lower Meghna	Pending			
		Meso	Sangu	Pending			
D-4A-2: 4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Oct 20)		May-22
Bank Erosion on Meso Scale							
D-4A-2: 1, 2	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions. Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Submitted	4-Oct-19	30-Oct-20	
		Meso	Sibsa	Submitted		30-Oct-20	
		Meso	Baleswar	Submitted		submitted on-line	
		Meso	Bishkali	Submitted		8-Oct-20	
		Meso	Lower Meghna	Pending			May-22
		Meso	Sangu	Pending			
D-4A-2: 3	Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should incldue full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Pending	D-4A-2: 2 (Apr 20) D-4A-2: 3 (Jul 20)		
		Meso	Sibsa	Pending			
		Meso	Baleswar	Pending			
		Meso	Bishkali	Pending			
		Meso	Lower Meghna	Pending			
		Meso	Sangu	Pending			
		Meso	Pussur-Sibsa fine sediment model- ext	Submitted		4-Dec-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)		May-22
Drainage Model							
D-4A-3: 1, 2, 3	The model setup developed will be updated under this project with all accompanying technical document with detailed explanation of the methodology and assumptions. A report that describes the pros and cons of the different methodologies to prevent water-logging within the polder and sedimentation of tidal river system including polder-subsidence. The report will include meta-data on the models used and measurements, recommendations for polder design including drainage and long term management plan, and recommendations for pilot area/ polder to implement the ideas, such as but not limited to location, methods and measurements. Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder.	**Micro**	Pilot TRM Model for Polders 24 etc	Submitted	4-Oct-20	18-Jul-21	
		Micro	5 or more polder models	Pending			May-22
D-4A-3: 4	Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder						

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

DELIVERABLES RELATED TO MODELLING ACTIVITIES							
TOR Reference	**TOR Deliverables**	**Scale**	**Model**	**Status**	**Delivery Dates as per signed Contract**	**Date of Submission**	**Proposed Deadline (2nd contract Amendment to June 2022)**
SUBSIDENCE							
D-4B: 1, 2,3	Geospatial datasets of total subsidence at present and for 25, 50 and 100 years from now, including full metadata and stored in Database of BWDB and Estimate the annual rate of subsidence. Detailed Technical Report with description and explanation of geospatial analysis of the total subsidence in the four regions of the polder area of the coastal zone at present and for 25, 50 and 100 years from present, including description of the causes of subsidence, full metadata and stored in Databse of BWDB. Report on the total subsidence in specific polders (designated by BWDB) in 25, 50 and 100 years from now when no sediment is supplied to the polder, including the amount of sediment needed to counteract this subsidence.		Field Campaigns (several)	Submitted	D-4B: 1, 2 (Oct 20) D-4B: 3 (Report: Draft - July 20, Final - Oct 20)	.	
			Subsidence Geospatial Datasets	Submitted		30-Oct-20	
				Pending			May-22
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)	26-Jun-21	
CLIMATE CHANGE EFFECTS							
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	Submitted		15/3/2022	
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			
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			May-22
Other special purpose models							
D-4D: 1, 2, 3, 4, 5	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now. Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges	**Bay of Bengal**	Storm Surge Model	Pending			Apr-22
		Bay of Bengal	Storm Surge Model	Pending			Apr-22
		Bay of Bengal	Wave Propagation Model	Pending			Apr-22
		Bay of Bengal	Salinity Model	Submitted		13/2/2022	

1.4 List of Deliverables Submitted

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

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

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

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

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
52	QPR-13	02/06/2022	Q13	QPR-13	QPR
53	The Effect of Climate Change on Water Levels, Salinity Intrusion and Storm Surges Interim Report on Salinity Modelling Current Situation (Updated report)	02/13/2022	D-4D	Climate change effects	Component-4
54	Macro Scale Morphology-Current situation & Future scenarios	02/22/2022	D-4A-1:2,3	Macro scale river model application	Component-4
55	Groundwater Resources Assessment and Impact of Climate change in Coastal area	03/15/2022	D-4D	Groundwater Salinity	Component-4
56	Literature Review and Lessons Learnt	03/16/2022	D-2:1,2,3	Literature Review & Lessons Learnt	Component-2

2 DATA ACQUISITION

2.1 Collecting Existing Data

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

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

2.2 Field Surveys carried out by IWM

2.2.1 Mobilization

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

2.2.2 Summary of Field Survey Activities

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

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

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

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

Table 2.2: Progress of the discharge observation

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

Table 2.3: Progress of suspended sediment sampling for total concentration

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

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 14th quarter (January 2022 to March 2022) 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 13th Quarter	Progress (%) 14th 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)	95	-	95
2.3	Agricultural Land use (Robi, Kharif-1 & Kharif-2)	85	5	90
2.4	Other Data Collection (shapefile & tabular)	95	2	97
2.5	Other Data Processing (shapefile & tabular)	95	2	97

Sl No	Task & Activities	Progress (%) Up to 13th Quarter	Progress (%) 14th Quarter	Overall Progress (%)
3	**GIS Mapping**			
3.1	Polder Maps & Processing	85	0	85
4	**Database Design & Development**			
4.1	Database Design Development	100	-	100
4.2	Database Design Report	100	-	100
4.3	Database Implement	93	0	93
5	**Web GIS Application Development**			
5.1	IGDCZ Prototype Development	100	-	100
5.2	Full Version Development	95	0	95
5.3	GIS Core Modules	95	0	95
5.4	Dashboard Development	93	0	93
5.5	Metadata Preparation	60	10	70
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	93	0	93
5.11	Data Validation and Check	95	0	95
5.12	Software & Hardware Procurement	0		
5.13	Installation of SW and HW at BDWB Data Centre	-	-	-
5.14	Migration of Database and Application to BWDB Servers	-	-	-
5.15	Fully operational commissioning	-	-	-
5.16	Preparation of User Instruction Manual	-	-	-
6	**Reports**			
6.1	Database Design Report	submitted	-	-
6.2	Validation and Compilation Report (1st version)	submitted	-	100
6.3	IGDCZ Implementation Report (1st version)	submitted	-	100

Sl No	Task & Activities	Progress (%) Up to 13th Quarter	Progress (%) 14th Quarter	Overall Progress (%)
7	**Training & Technology Transfer**	3 days training		
8	**On-job Training**	30	0	30
9	**Feedback and update (ongoing)**	comments were addressed		

3.2 Data Collection and Data Processing

In this quarter, remaining hydro-meteorological time series data were collected from the principal agencies (BWDB and BMD). The collected data were processed and validated with the unexpected values present and subsequently excluded those error. Data verification were concentrated on the following data issues:

- Identification of outlier of data
- Exclusion of Null values
- Data type mismatch
- Incomplete data
- Errors in data time attribute
- Redundancy or duplication of data

After successful verification and conducting proper data validation methods and techniques, the errors were removed and subsequently uploaded into the IGDCZ database.

3.3 Metadata Preparation

The task of metadata preparation is ongoing and a significant progress have been made in this regard. There are 14 metadata elements were used based on Dublin Core Metadata Initiative (DCMI: https://www.dublincore.org/) and ISO standards. The metadata elements and their definitions are given in the following Table

Table 3.2: Metadata Elements

Sl No.	Elements	Definition	Descriptions
1	Name of Data layer/Title	A name given to the resource.	Typically, a Title will be a name by which the resource is formally known
2	Data Type/Type	The nature or genre of the resource.	To describe the file format, physical medium, or dimensions of the resource, use the Format element.
3	Subject	The topic of the resource.	Typically, the subject will be represented using keywords, key phrases, or classification codes. Recommended best practice is to use a controlled vocabulary.
4	Description/Abstract	An account of the resource.	Description may include but is not limited to: an abstract, a table of contents, a graphical representation, or a free-text account of the resource
4.1	Purpose	Sub-Term of Description	
5	Coverage	The spatial or temporal topic of the resource, the spatial applicability of the resource, or the jurisdiction under which the resource is relevant	Spatial topic and spatial applicability may be a named place or a location specified by its geographic coordinates. Temporal topic may be a named period, date, or date range. A jurisdiction may be a named administrative entity or a geographic place to which the resource applies. Recommended best practice is to use a controlled vocabulary such as the Thesaurus of Geographic Names [TGN]. Where appropriate, named places or time periods can be used in preference to numeric identifiers such as sets of coordinates or date ranges.
5.1	Time period of content	Sub-Term of Coverage	
6	Date/Publication date	A point or period of time associated with an event in the lifecycle of the resource.	Date may be used to express temporal information at any level of granularity.
7	Originator/Creator	An entity primarily responsible for making the resource	Examples of a Creator include a person, an organization, or a service. Typically, the name of a Creator should be used to indicate the entity
8	Contributor	An entity responsible for making contributions to the resource.	Examples of a Contributor include a person, an organization, or a service. Typically, the name of a Contributor should be used to indicate the entity.
9	Publisher	An entity responsible for making the resource available.	Examples of a Publisher include a person, an organization, or a service. Typically, the name of a Publisher should be used to indicate the entity.
10	Source	A related resource from which the described resource is derived.	The described resource may be derived from the related resource in whole or in part. Recommended best practice is to identify the related resource by means of a string conforming to a formal identification system.

Sl No.	Elements	Definition	Descriptions
11	Relation	A related resource.	Recommended best practice is to identify the related resource by means of a string conforming to a formal identification system.
12	Language	A language of the resource.	Recommended best practice is to use a controlled vocabulary such as RFC 4646 [RFC4646].
13	Rights	Information about rights held in and over the resource	Typically, rights information includes a statement about various property rights associated with the resource, including intellectual property rights.
14	Identifier	An unambiguous reference to the resource within a given context.	Recommended best practice is to identify the resource by means of a string conforming to a formal identification system.
15	Format	The file format, physical medium, or dimensions of the resource.	Examples of dimensions include size and duration. Recommended best practice is to use a controlled vocabulary such as the list of Internet Media Types [MIME].

3.4 Web Application Development

- **Full version development**

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

3.4.1 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.

3.5 Workplan

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

Work Plan shows the workplan with status of different tasks and activities.

Workplan of IGDCZ Development

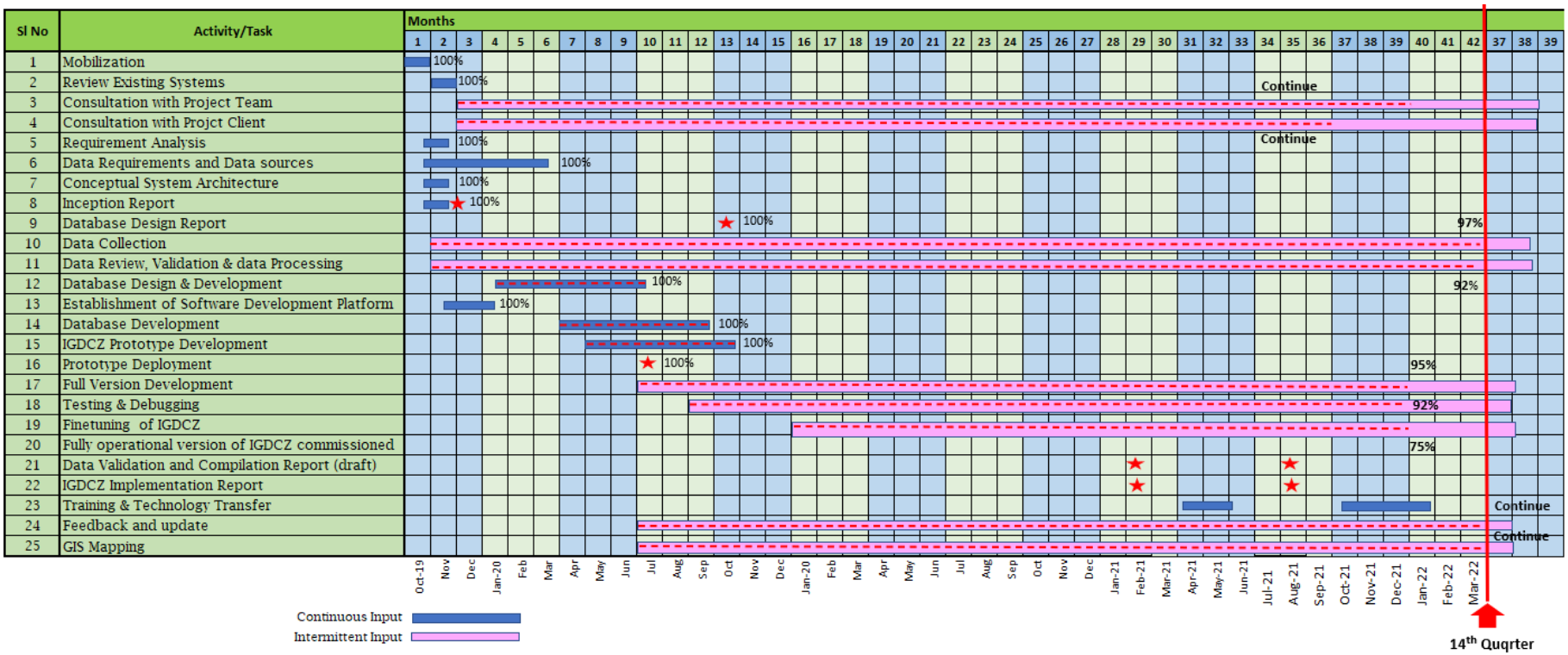


Figure 3.1: Workplan

3.6 Plan for the Next Quarter

Table 3.3: Plan activities for next quarter

Sl No	Task & Activities	Progress (%) Upto 14th Quarter	Plan Progress (%) for Next Quarter
1	**Inception Phase**		
1.1	Review Existing Systems	100	-
1.2	Consultation with Project Team	continue	
1.3	Consultation with Project Client	continue	
1.4	Requirement Analysis	100	-
1.5	Data Requirements and Data sources	100	-
1.6	Conceptual System Architecture	100	-
1.7	Inception Report	100	-
2	**Data Collection and Processing**		
2.1	Coastal Bank Erosion (Satellite Image)	100	-
2.2	Land use Classification (Satellite Image)	95	5
2.3	Agricultural Land use (Robi, Kharif-1 & Kharif-2)	85	15
2.4	Data Collection (shapefile & tabular)	97	3
2.5	Data Processing (shapefile & tabular)	97	3
3	**GIS Mapping**		
3.1	Polder Mappings & Processing	85	5
4	**Database Design & Development**		
4.1	Database Design Development	100	-
4.2	Database Design Report	100	-
4.3	Database Implement	93	5
5	**Web GIS Application Development**		
5.1	IGDCZ Prototype Development	100	-
5.2	Full Version Development	90	5
5.3	GIS Core Module	93	5

Sl No	Task & Activities	Progress (%) Upto 14th Quarter	Plan Progress (%) for Next Quarter
5.4	Dashboard Development	93	0
5.5	Metadata Preparation	60	20
5.6	Metadata Interface Development	70	10
5.7	User Administrative Module	90	5
5.8	Document Archiving	100	-
5.9	Tutorial (help tutorial)	100	-
5.10	Testing & debugging	92	3
5.11	Data Validation and Check	92	5
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
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	**On-Job Training**	30	70
9	**Feedback and update (ongoing)**	comments were addressed	-

4 MATHEMATICAL MODELLING

4.1 Storm Surge Modelling

In the present Long-Term Research and Monitoring Project (LTRM), the storm surge model has been developed using the MIKE 21 FM system with an optimized flexible mesh that has reduced the runtime of the storm surge model simulations. In the new grid system, important river banklines and shorelines have been defined very carefully on the basis of resent satellite images and water depths have been updated with most recent available bathymetry data.

During the 14th (Jan-Feb-Mar 2022) quarter, a draft report comprising the present and future conditions has been prepared and reviews on it is in progress for the finalisation and submission.

The following sub-sections summarise the draft report with the title “Storm Surge Modelling-Present and Future Conditions”

4.2 Improvements of the Bay of Bengal Storm Surge Model

This report describes the development of an improved Bay of Bengal storm surge model, the data basis for this development, calibration and validation of the developed model and application of the model for estimating the effects of cyclones on storm surges during present and future conditions impacted by climate change.

4.3 Data Collection and Climate Change Projection

Bathymetry data

The bathymetry of the Bay of Bengal (BoB) hydrodynamic model has been developed under different studies including the Long-Term Research and Monitoring Program over the recent years. The bathymetry of Pussur-Shibsha River network, Baleswar, Lower Meghna and Sangu River systems has been surveyed under the Long-Term Research and Monitoring Program and most of the major river system’s bathymetry has been updated with recent cross sections data. Offshore bathymetry data has been collected from the digital navigational sea charts, C-Map from DHI.

Water Level data

Water level measurements have been carried out at seven locations under the Long-Term Research and Monitoring project for calibration of the updated Bay of Bengal (BoB) hydrodynamic model. The locations are presented in Figure 4.1.

Discharge data

Discharge measurement is available from 12 locations within the coastal area of Bangladesh: These data has been used for calibration of the updated Bay of Bengal storm surge model (Figure 4.2).

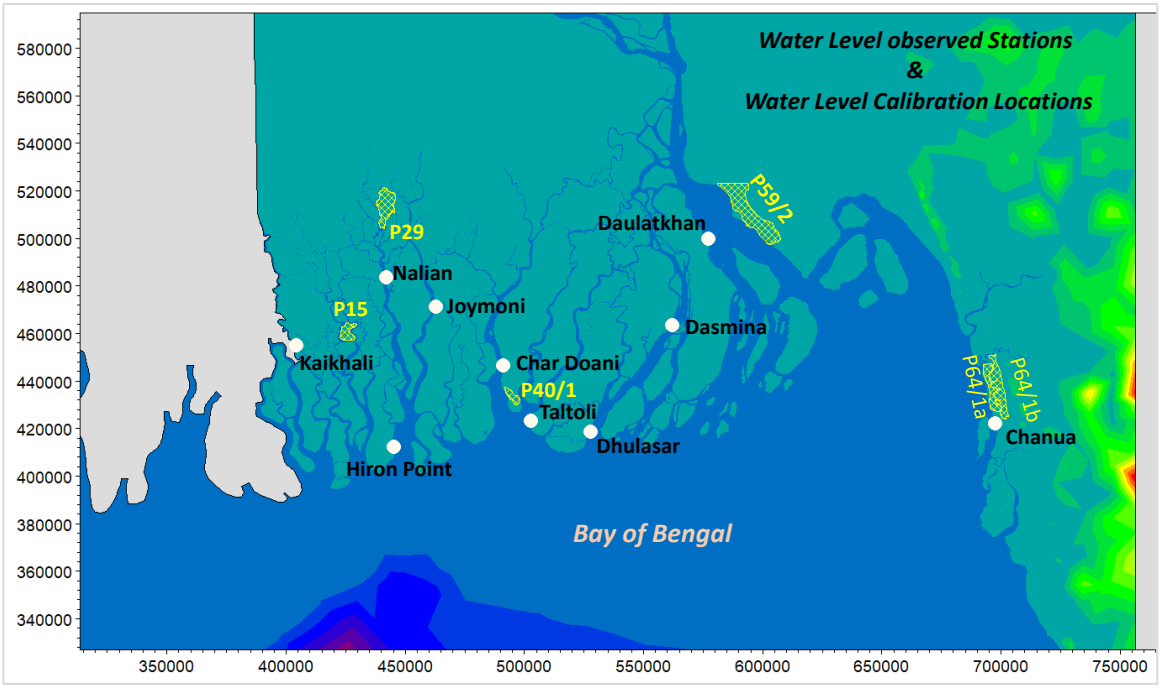


Figure 4.1: Water level observation locations

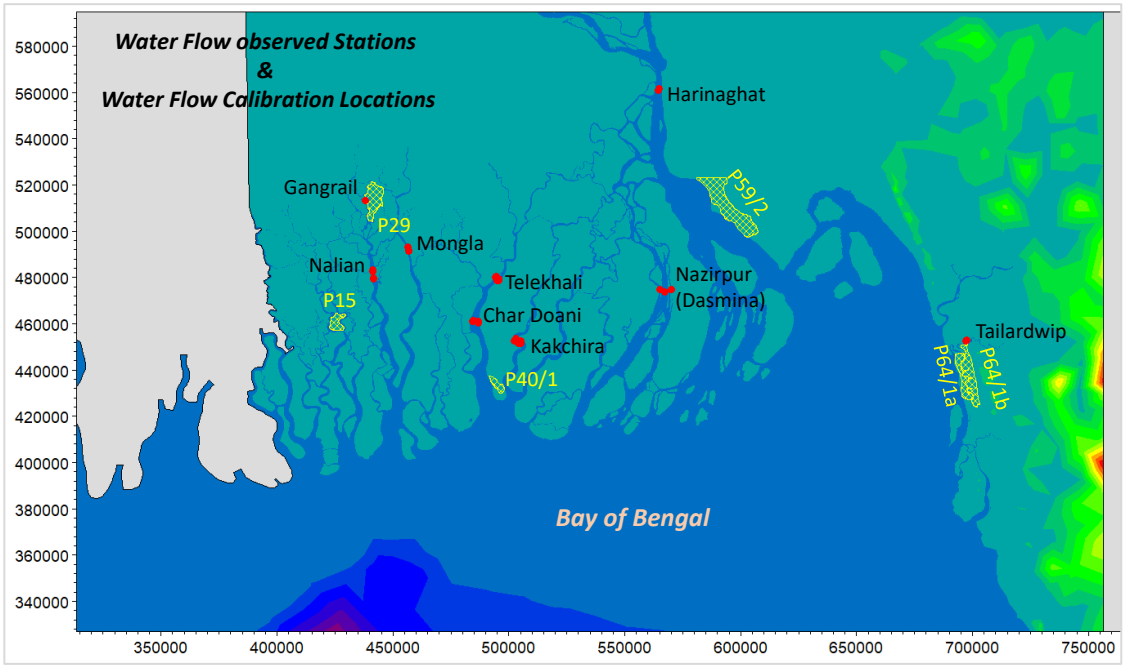


Figure 4.2: Water flow observation and calibration locations

Offshore boundary conditions

Tidal data from DHI's Global Tide Model has been used to generate the offshore (downstream) boundary condition of the updated Bay of Bengal storm surge model.

The tidal data refer to mean sea level and data has been converted to the model datum, mPWD by adding 46cm

Upstream boundary conditions

The calibrated and validated South-West Regional Model (developed by IWM) has been used to generate discharges at the open upstream open boundaries of the updated Bay of Bay of Bengal storm surge model.

Meteorological data

The meteorological data for the storm surge model consists of:

- Wind and pressure maps – used for non-cyclone model simulations
- Cyclone track data

For model calibration and validation simulations of non-cyclone periods maps of wind and air pressure data from the Climate Forecast System Reanalysis (CFSR) atmospheric model, which is established by National Centers for Environmental Prediction, USA (NCEP) was used.

Historical Cyclones

42 tropical cyclones (classified from Cyclonic Storm Surge to Severe Cyclonic Storm Surge) hit the Bay of Bengal Coast from the 9-10 October 1960 cyclone to the 26 May 2021 cyclone (cyclone Yaas).

Among them 24 severe cyclones (Figure 4.3) had directly landfall at the Bangladesh coast (south-west, south-central, south-east, and eastern coastal zones). 3 of these cyclones are defined as Cyclonic Storms (CS) 18 cyclones are defined as Severe Cyclonic Storms (SCS CS) and 3 cyclones are defined as Severe Cyclonic Storms with a core of Hurricane winds (SCSH CS).

For modelling of periods impacted by cyclones, maps of cyclone wind and air pressure were generated using a Cyclone Wind Model (CYWIND), which is part of DHI's MIKEZero software package. The primarily input to the applied cyclone parametric model by Holland consist of historical cyclone data like cyclone track, radius to maximum wind speed, maximum wind speed and central and neutral pressure.

Track data for Cyclones 1 to 19 in below table was collected from the Bangladesh Meteorological Department as part of CEIP (2013) and CEIP-1 (2018) and used in these projects. Track data for Cyclones 20 to 24 are available from Bloemendaal, N. et al. (2019) collected by the Joint Typhoon Warning Center (JTWC).

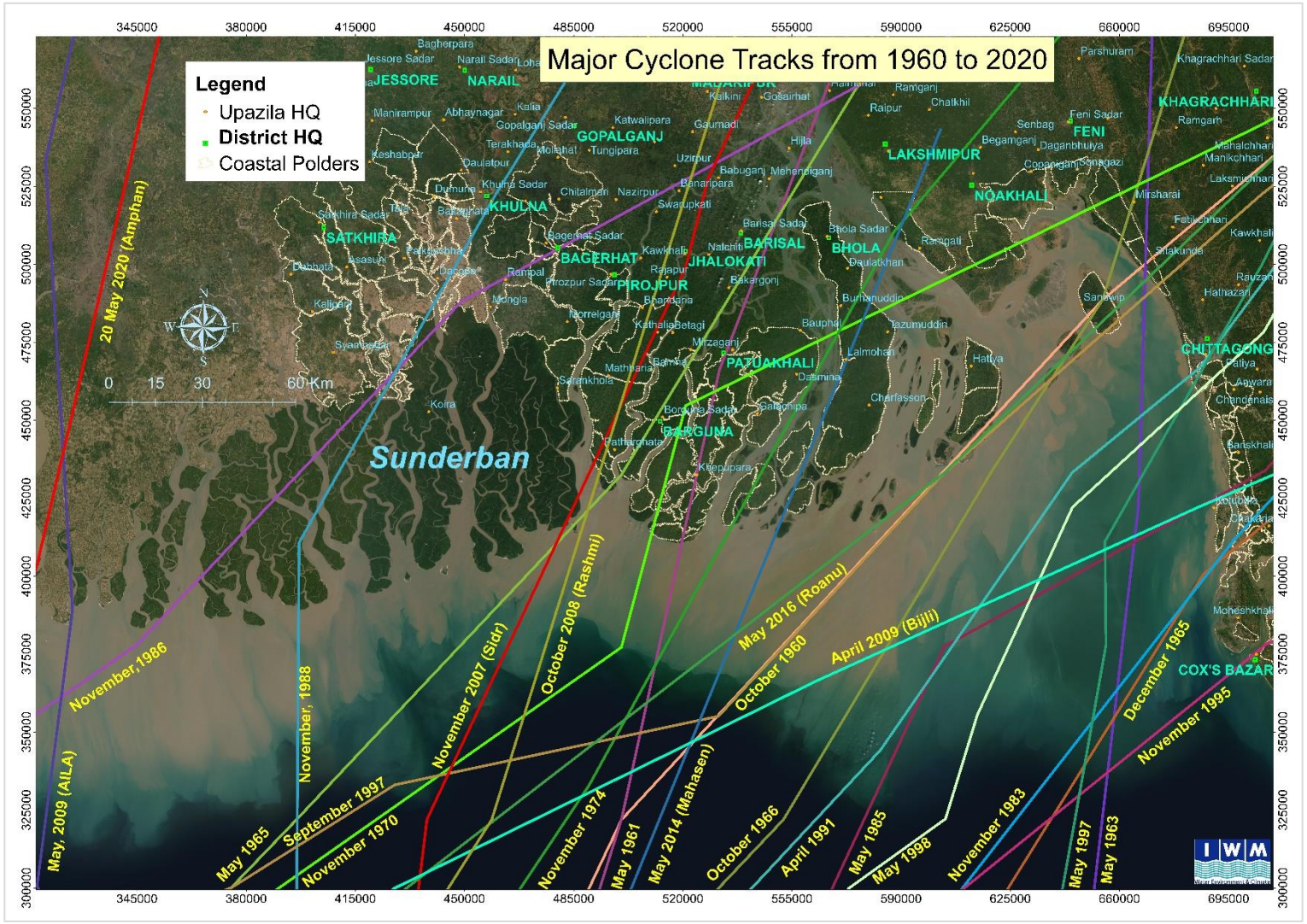


Figure 4.3: Historical severe cyclone tracks in the Bay of Bengal covering the Bangladesh Coast since 1960 to May 2021

4.4 Climate Change Projection

For modelling of future storm surges the impact of climate changes must be considered in the BoB storm surge modelling.

The effect of climate change has been included in the BoB storm surge model through inclusion of climate change projections up to year 2100 of the following parameters.

- Sea level rise
- Cyclonic wind speed
- Land Subsidence

Upstream discharge boundary conditions of the BoB model have not been considered because most of the severe cyclones are formed during the pre-monsoon and post-monsoon periods when the upstream river flow is small compared to the tidal flows.

4.5 Bay of Bengal Storm Surge Model Setup

4.5.1 Development of the Bay of Bengal Model

IWM has developed and maintained the two-dimensional Bay of Bengal (BoB) storm surge model since 1991 using DHI's software MIKE 21 HD (Hydrodynamic Module).

The first version of the model (the so-called classic version using a rectangular model calculation grid) was applied in the Cyclone Protection Project (CPP, 1991) and was further developed as a part of the Cyclone Shelter Preparatory Study (CSPS, 1998). The model was further updated as part of the 2nd Coastal Embankment Rehabilitation Project (2nd CERP, 2000). In the Cyclone Shelter Preparatory study and 2nd CERP study, the model was applied for the simulation of cyclones and cyclone related storm surges for several past major cyclones to generate the high-risk zoning map for the planning and management of cyclone shelters. This updated storm surge model was applied under the CDMP (Comprehensive Disaster Management Program) study in 2008-2009 and the World Bank study in 2009. Again, the model was further updated with additional bathymetric data in 2011-2012 under the CEIP first phase study.

In the CEIP-1 (2015), the existing Bay of Bengal Model was further updated and upgraded to using the software MIKE 21 FM HD using a so-called Flexible Mesh. This upgrade included conversion of the earlier structured computational (classical) grid to a flexible mesh allowing for a better representation of the river, coastal and estuarine system.

The developed MIKE 21 FM model grid uses triangular and quadrangular mesh cells to improve the boundary description and increase grid resolution e.g. around Islands, along the coastline, along interior rivers as well as in other areas of interest. The updated model bathymetry also included incorporation of more and recent bathymetric data into the surge model.

4.6 Improved Bathymetry and Calculation Grid

As part of the present LTRM Project, the existing Bay of Bengal model grid has been widely updated by inclusion of new areas of quadrangular cells and adding recent bathymetry data to

the bathymetry. This update has improved the bathymetry description and at the same time resulted in lower execution time of model simulations as compared to the earlier model setup.

The main improvements are described in the main report on storm surge modelling under the subsections:

- Calculation Grid improvements
- Inclusion of river cross-section depth data
- Inclusion of Polder and Land Levels

4.7 Incorporation of Coastal Polders

The effect of coastal polders has been implemented in the Bay of Bengal surge model using a similar procedure as applied in CEIP-1 (2018).

Because the horizontal dimension (width) of the polder dikes is much smaller than the cell sizes used in the computational grid, all coastal polders have been included in the storm surge model as so-called dike structures using sub grid modelling.

Figure 4.4 shows examples of coastal polders included in the model as coastal dikes.

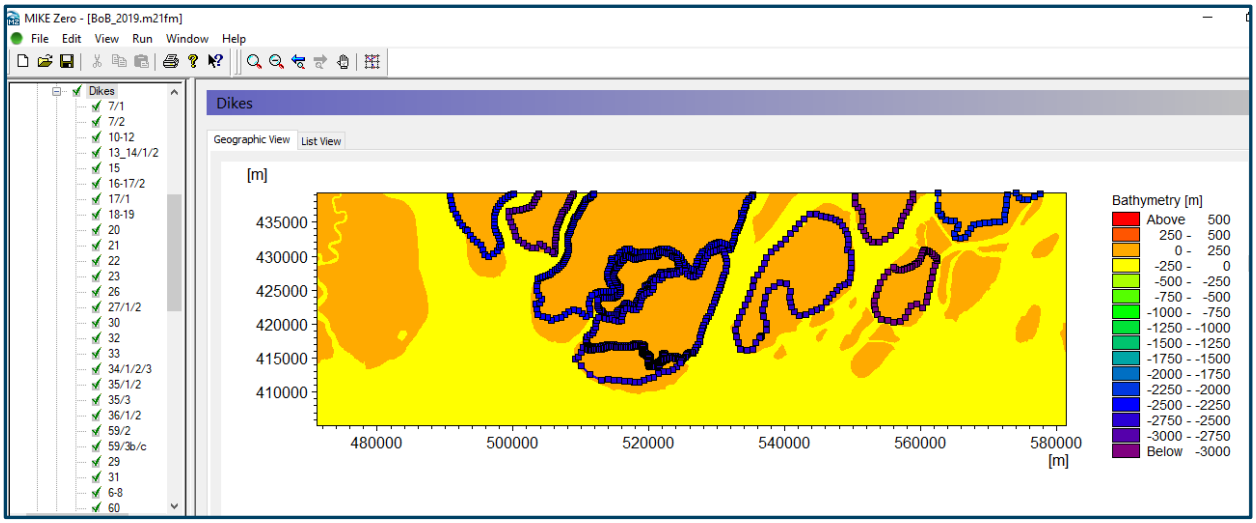


Figure 4.4: Inclusion of coastal polders as a dike structure in the storm surge model

4.8 Open Boundary conditions

There are twenty-seven open boundaries in the updated Bay of Bengal hydrodynamic model, see Figure 4.5. Twenty-six open boundaries are located upstream of the river delta, and one is located offshore in the Bay of Bengal at 16° latitude between Vishakhapatnam and Gwa Bay.

One upstream boundary is located in the north of the Upper Meghna River at Bhairab Bazar, and another is in the Padma River at Baruria.

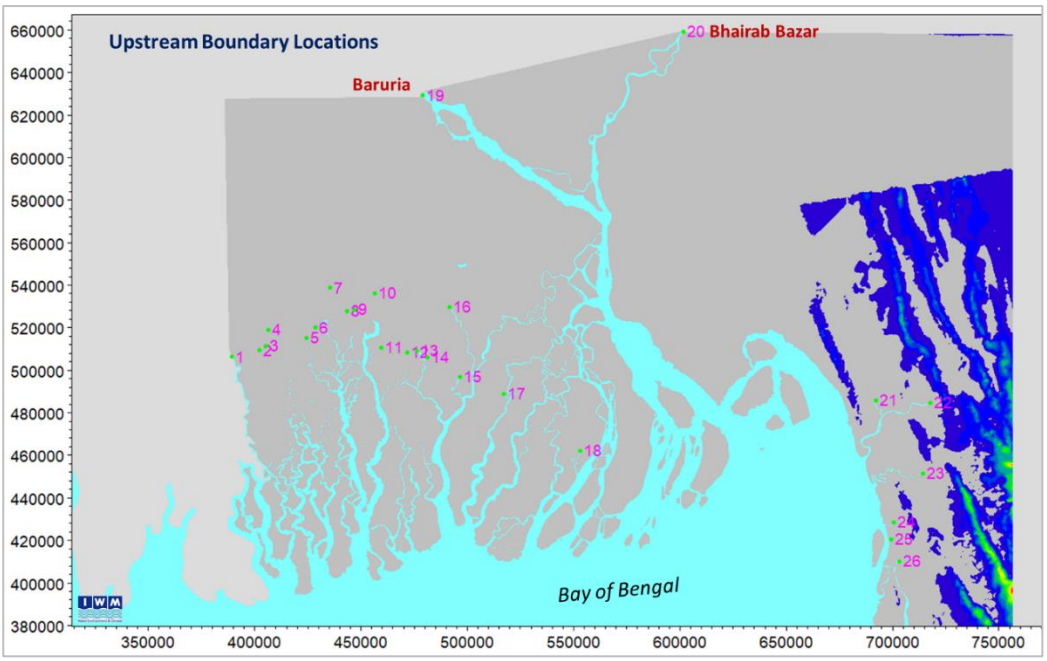


Figure 4.5: Open upstream boundaries in the Bay of Bengal model

The upstream boundary at Baruria is showing non-tidal characteristics and here the discharge is specified as boundary condition through a rating curve (relation between water level and discharge).

At the Bhairab Bazar in the Upper Meghna River tidal effects are observed. Here BWDB is maintaining a water level gauge that provides observed water levels a 3-hours interval. However, to secure model reliability, time series of tidal discharge generated from the available North-Central Region Model (NCRM) are used as the open boundary condition at this location.

At the remaining 24 upstream open boundaries discharge data generated from calibrated and validated regional models (South-West and Eastern Hilly Regional Model) is applied as boundary conditions. Both regional models are available at IWM.

The downstream (offshore) boundary condition consists of astronomical tidal water levels along the open boundary. The tidal data is generated from the Global Tide Model which is part of the DHI MIKE Zero software.

4.9 Other Model Parameters

Other relevant model parameters determined as part of the model calibration are

- Flood & Dry
- Bed Resistance
- Eddy Viscosity
- Wind Forcing

4.10 Bay of Bengal Storm Surge Model Calibration and Validation

The upgraded Bay of Bengal storm surge model has been calibrated against tidal water levels, observed water levels, and observed discharges. The model has been simulated for the period 15th February 2019 to 13th October 2019. This period covers both monsoon and non-monsoon conditions.

The upgraded Bay of Bengal storm surge model has been validated against observed water levels and observed discharges using the model setup and parameters determined through the model calibration. The model was simulated for the year 2015 including the monsoon period (June to September). During this period observations of water levels and discharges were collected at the peripheral river systems of the 17 polders investigated as part of the CEIP-1 project.

4.11 Cyclone Modelling

The modelling of impact from severe cyclones on storm surges follows the methodology used in CEIP, 2013 and CEIP-1, 2018 to ensure consistency with the CEIP-1 results. The methodology is described in the main report on Storm Surge Modelling.

4.12 Summary and Conclusions

River cross section, water level and discharge measurement were carried out at the very beginning of Long-Term Research and Monitoring Program. Major river cross sections like Pussur, Shibsa, Baleswar, Lower Meghna, Sangu were carried out under this project and rest of the rivers like Bishkhali, Buriswar-Payra, Tentulia and Karnaphuli River cross sections were measured in 2018. Water level and water flow measurements were carried out at 10 locations and 12 locations respectively.

Rivers Bankline, char islands, flow paths were digitized using Google Earth image for the year 2019. Using the year 2019 bankline positions, the existing Bay of Bengal was upgraded and updated by different resolutions of grid systems. Both triangular and quadrangular elements were generated to ensure a correct geometry of the channels and estuary. Later, this upgraded and updated Bay of Bengal Model calibrated for the year 2019 and validated for the year 2015 with observed water level and discharges.

Climate change scenario has been developed reviewing sea level rise and cyclonic wind speed. 20cm water level added at the downstream for developing the sea level rise and 8% cyclonic wind speed added with base wind information for generating the wind climate for 2050.

The calibrated and validated Bay of Bengal Model used for the development of cyclonic Storm Surge Model. The cyclones model also calibrated with the observed cyclonic wind data before using the cyclones model into the storm surge models. Cyclonic Storm Surge Models were developed for 19 severe cyclones (cyclone period 1960-2009). There were several cyclones hit after 2009 but could not considered them into the analysis. Among them, few cyclones were tropical cyclones, few cyclones were severe but landfall at Indian coast and Myanmar coast and one cyclone (cyclone Roanu) was classified as severe cyclone but could not consider due to lack of cyclone wind field information.

Number of simulations were generated considering the low tide, high tide and original tidal condition at landfall. In this regard, 54 numbers of simulations were developed for 19

severe cyclones as two cyclones landfall at high tide and one cyclone landfall at low tide condition.

141 number locations were selected covering the whole Bangladesh coast for analysing the storm surge level at base condition (without climate change) and with climate change (2050). 54 numbers of surge level were extracted for each location from the calibrated cyclonic storm surge model results and prepared for statistical analysis. The statistical frequency analysis was carried out to determine the storm surge level for different return periods at the selected 141 locations. Exponential statistical distribution method was selected as a suitable statistical method

5 POLDER DEVELOPMENT PLAN

5.1 Progress in January, February and March 2022

This Chapter covers progress of Work from January, February and March 2022 under Component 5.A in the Terms of Reference. During the reporting period work has focused on Deliverable 5A-3 **"Conceptual Design for 5 Polders"** and Deliverable 5A-1 **"Long Term Polder Development Plan"**.

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

A selection of 5 polders was made out of the 139 coastal polders that will serve as a pilot program for a conceptual design for future polder development. These polders are 15, 29, 40/1, 59/2 and 64/1a+b.

5.2.1 Polder 15

Polder 15 is situated in the high salinity zone of Satkhira in the South-west coastal region. It is therefore an example of a high salinity polder type. In the future this is not likely to change much, considering sea level rise and subsequent increasing salt intrusion. Only if the Ganges Barrage would be constructed there could become more freshwater available. But this is considered only a long-term option. Therefore, aquaculture seems the most viable option for economic development. However, a more diverse cropping pattern (polyculture, rice - shrimp etc.) is needed for a sustainable and more equitable development.

The water management in Polder 15 is not only about drainage, but also on providing the optimal mix of fresh and salt water to diversify aquaculture production. It therefore is recommended to develop a water and salt balance model that enables to provide advice on the optimal water management of the polder.

Drinking water supply in Polder 15 is a critical issue because of high salinity levels of surface and groundwater. This will probably become worse due to sea level rise. Therefore, investments are needed to ensure all inhabitants to safe and affordable drinking water. A combination of rainwater harvesting and Pond Sand Filters should be complemented with Reverse Osmosis desalination plants as a targeted government intervention.

Cyclone risk remains high and therefore warrants the upgrading of the coastal embankments. Besides significant re-sectioning of the entire embankment also some bank and slope protection works are needed. Even so, the mortality risk remains significant and would require additional disaster management measures, such as an increase in the number of cyclone shelters and last mile early warning (e.g. through SMS).

5.2.2 Polder 29

Polder 29 is an example of a polder with intermediate salinity conditions. It also suffers from some waterlogging problems due to the siltation of khals and reduced drainage potential to some of the adjacent rivers. A catchment wide plan for river restoration, encompassing polders 25, 26, 27, 28 and 29, has been studied and implementation is underway. Middle Bhadra, Joykhali and Upper Salta rivers have been excavated already.

In the future this solution may be hampered due to new siltation and increased tidal water levels that further reduce the already limited drainage window. Pumping may be required in the (distant) future. As part of the Blue Gold project already some drainage improvements have been executed, not only on the primary, but also on the secondary and tertiary drainage infrastructure which have proven to

successfully reduce water logging conditions. In the south a relatively new waterlogged area seems to have evolved, which could benefit from TRM.

This polder can become a major agricultural production center with a market close to Khulna, provided that the drainage conditions improve, and salinity levels would decrease. Restoration of the Gorai flow would be highly recommended. A reduction of surface water salinity in its adjoining river system would in the dry season promote surface water irrigation and enhance the production and food security of the polder. Also several in-polder management strategies are available to manage salt, such as subsurface field drainage, groundwater management (lowering of salty groundwater tables), and the management of the canals and ponds to maximize the export of salt from the polder and minimize its import. The increased rain in some climate change scenarios might lead to more waterlogging problems, with adverse impacts on crop production. But field drainage for salt management is also likely to be effective for waterlogging management.

Parts of Polder 29 suffer from insufficient drinking water supply because of high groundwater salinity. This will probably become worse due to sea level rise. Therefore, investments are needed to ensure all inhabitants to safe and affordable drinking water. A combination of rainwater harvesting and Pond Sand Filters should be complemented with Reverse Osmosis desalination plants as a targeted government intervention.

The economic risk of cyclone storm surges is not very high as current embankment has a safety level between 1 in 10 and 1 in 25 years. Even so, the risk will rise considerably due to climate change and would therefore call for embankment improvement in the future. This however, would not prevent mortality risk to rise significantly and will require additional disaster management measures. Approx. 20 additional cyclone shelters are recommended. There are local bank erosion problems (near Chandgar) that require revetments based on geobags and possibly dredging sediments from recently accreted land on the opposite side of the river and to dump this along the bank at Chandgar.

5.2.3 Polder 59/2

Polder 59/2 is a freshwater polder due to the nearby Meghna river. At the same time this river produces the biggest problem of this polder, which is riverbank erosion. Besides bank protection over a long distance, the other potentially effective measure would be to dredge the channel bars and mouth bars and dispose the sediment close to the eroding banks, thus changing the thalweg of the river away from the bank. The feasibility of this measure should be carefully studied.

Waterlogging is a serious problem. The performance is partly dominated by the khal infrastructure: the length per regulator is relatively long (6.6 km) and surface area per km khal is high (162 ha). Thanks to the relatively high elevation the drainage window currently is 23 hours but would reduce to 17 hours per day due to sea level rise and 15 cm subsidence. But malfunctioning regulators cause water flowing inside the polders and silted khals also cause waterlogging.

Both mortality risk and economic risk due to cyclonic storm surges are high, which are significantly reduced by upgraded embankments. However, future conditions (2050) would double the economic risk and increase the mortality risk with one order of magnitude. Therefore, additional disaster management measures are required. Although currently sufficient, in 2050 50 new shelters are considered necessary.

5.2.4 Polder 40/1

Polder 40/1 is an example of a moderately freshwater polder with rice cropping during the Kharif season and pulses in the Rabi season. It is situated on the southern-most tip of the coastal area and is therefore a bit isolated (distance to Barguna is 23 km). The foreshore is very wide and long, where mangrove forest was planted. Economic development opportunities are limited, due to the remoteness of the polder and the relatively low population density. Even so, agricultural production could be promoted by the use of surface water irrigation with low cost pumps.

The current mangrove area will likely expand on the long term and could become an asset for developing eco-tourism and will help protecting the embankments from wave attack.

Waterlogging is practically absent and should not cause problems in the future. Part of the explanation is a relatively short khal length per regulator (3.1 km) and a relatively good drainage capacity at the polder outlets. Even with sea level rise there is probably enough drainage window in 2050 for sufficient drainage capacity.

The economic risk of cyclone storm surge is relatively low, which makes costly embankments economically difficult. Mortality would increase in 2050, even with 1/25 year safety embankments, which would warrant additional disaster management measures. However, no new shelters are needed since the capacity is already quite high.

5.2.5 Polders 64/1a and 64/1b

Polders 64/1a and 64/1b have good connections to the city of Chittagong. Designed primary drainage conditions (number and size of regulators and khals) is good. With 50 regulators and a relatively short khal length per regulator (2.3 km) the drainage infrastructure seems more than sufficient for now and in the future, although the drainage window would reduce from 23 to 19 hours per day. Local waterlogging exists however due to silted up khals which require continuous maintenance. Relative high surface water salinity levels are a constraint for irrigation in the dry season.

Due to its location on the eastern part of the Bay of Bengal, the polder has one of the highest cyclone risks. Current embankments reduce this risk to a certain extent, but an upgrade would significantly reduce the economic risk. The mortality risk, however, will remain extremely high, even with a new embankment. Therefore, and because of population growth, an additional 18 cyclone shelters in 2050 would be needed.

There is ongoing work to strengthen the sea dike with slope protection (CC blocks). Large parts of the current embankment are in a rather poor state and need repair/improvement. Considering the exposure of the coast to potentially large storm surges (more than 6 m high) and the likely future increase in cyclone risk, it would be rational to strengthen and heighten the embankments along the sea coast.

5.3 Risk Assessment

For the second batch of polders to be analyzed, we made use of the selection of polders for CEIP-2. During the reporting period the SFINCS model was used to estimate inundation for different return periods and currently the FIAT model is used for estimating the damages. Table 5.1

Table and Table 5.2 show the results of the FIAT calculations for economic risk in USD/year, people affected with inundation per year and mortality rate per year. From these calculation risk profiles for the polders will be developed, serving to propose investments that will take into consideration also other economic characteristics as was done for the 5 polders.

Table 5.1: Risk for selected polders in 2020

Polder	Location	2020					
		current embankment			new embankment (1/50)		
		economic risk	people affected /year	mortality /year	economic risk	people affected /year	mortality /year
10-12	SW	$ 3,041,489	2882	21	$ 1,696,425	1780	18
13-14_2	SW	$ 4,094,092	3833	30	$ 1,414,563	1486	24
28_1	SW	$ 1,764,825	1614	7	$ 519,367	574	5
28_2	SW	$ 1,450,831	1413	2	$ 355,039	410	1
31	SW	$ 1,375,235	1231	8	$ 473,365	495	6
31 (Part)	SW	$ 121,088	110	0	$ 31,255	31	0
35_1		$ 10,803,350	4452	97	$ 3,146,178	1622	43
39_1A	S	$ 3,665,966	3474	79	$ 1,130,344	1135	54
4	SW	$ 2,101,810	1930	9	$ 716,044	738	7
41_6A	S	$ 192,245	141	0	$ 125,444	113	0
41_7	S	$ 485,214	312	0	$ 392,105	280	0
41_7A	S	$ 501,878	304	0	$ 393,135	267	0
43_2A	S	$ 663,062	477	15	$ 253,268	247	5
43_2E	S	$ 448,708	383	13	$ 134,084	146	4
45	S	$ 698,672	712	40	$ 176,436	173	32
47_1	S	$ 478,938	474	21	$ 137,753	138	17
5	SW	$ 9,581,056	8355	34	$ 4,048,756	4063	25
50_51	S	$ 788,013	728	119	$ 174,027	163	86
55_2E	S	$ 1,342,607	932	17	$ 599,139	527	4
7_1	SW	$ 1,113,973	1177	14	$ 290,798	293	9
7_2	SW	$ 4,268,698	4141	18	$ 1,314,136	1355	11
Average		$ 2,332,464	1861	26	$ 834,365	764	17

Table 5.2: Risk for selected polders in 2050 with sea level rise and subsidence

Polder	Location	CC and subsidence 2050					
		current embankment			new embankment (1/25)		
		economic risk	people affected /year	mortality /year	economic risk	people affected /year	mortality /year
10-12	SW	$ 7,161,349	6950	99	$ 3,720,805	3826	90
13-14_2	SW	$ 7,051,031	6853	99	$ 2,949,122	3025	84
28_1	SW	$ 2,909,428	2884	19	$ 1,059,499	1153	12
28_2	SW	$ 2,236,173	2291	4	$ 719,318	836	2
31	SW	$ 1,922,006	1962	14	$ 939,280	982	12
31 (Part)	SW	$ 201,694	192	0	$ 68,780	65	1
35_1		$ 15,930,710	7162	180	$ 6,278,103	3223	103
39_1A	S	$ 6,391,178	6088	801	$ 2,359,945	2328	730
4	SW	$ 4,171,686	4134	51	$ 1,598,343	1648	38
41_6A	S	$ 430,784	333	0	$ 273,037	268	1
41_7	S	$ 1,169,408	873	1	$ 908,990	783	1
41_7A	S	$ 1,135,896	767	1	$ 871,443	682	1
43_2A	S	$ 1,186,904	990	26	$ 536,951	548	11
43_2E	S	$ 743,012	697	22	$ 286,732	316	8
45	S	$ 1,098,714	1101	262	$ 354,682	345	217
47_1	S	$ 788,991	784	107	$ 288,236	286	95
5	SW	$ 15,679,128	13949	73	$ 8,220,231	8268	61
50_51	S	$ 981,791	932	86	$ 346,810	326	76
55_2E	S	$ 2,827,321	2333	29	$ 1,555,345	1497	12
7_1	SW	$ 1,657,302	1719	22	$ 573,500	583	16
7_2	SW	$ 8,473,952	8616	113	$ 3,088,218	3161	80
Average		$ 4,007,069	3410	96	$ 1,761,780	1626	79

The results of the base risk assessment for the polders have provided useful insights in the cyclone storm surge risk. Figure shows the average risk profile for 27 polders. From this figure we can see:

1. New embankments would reduce the economic risk by roughly 2/3rd and mortality risk by roughly 1/3rd.

2. Climate change and subsidence would significantly increase the economic and mortality risk in 2050. Mortality risk would quadruple to an average annual casualty rate of almost 300 per year.

3. New embankments would reduce the economic risk in 2050 by half. However, mortality risk is still at a very high level.

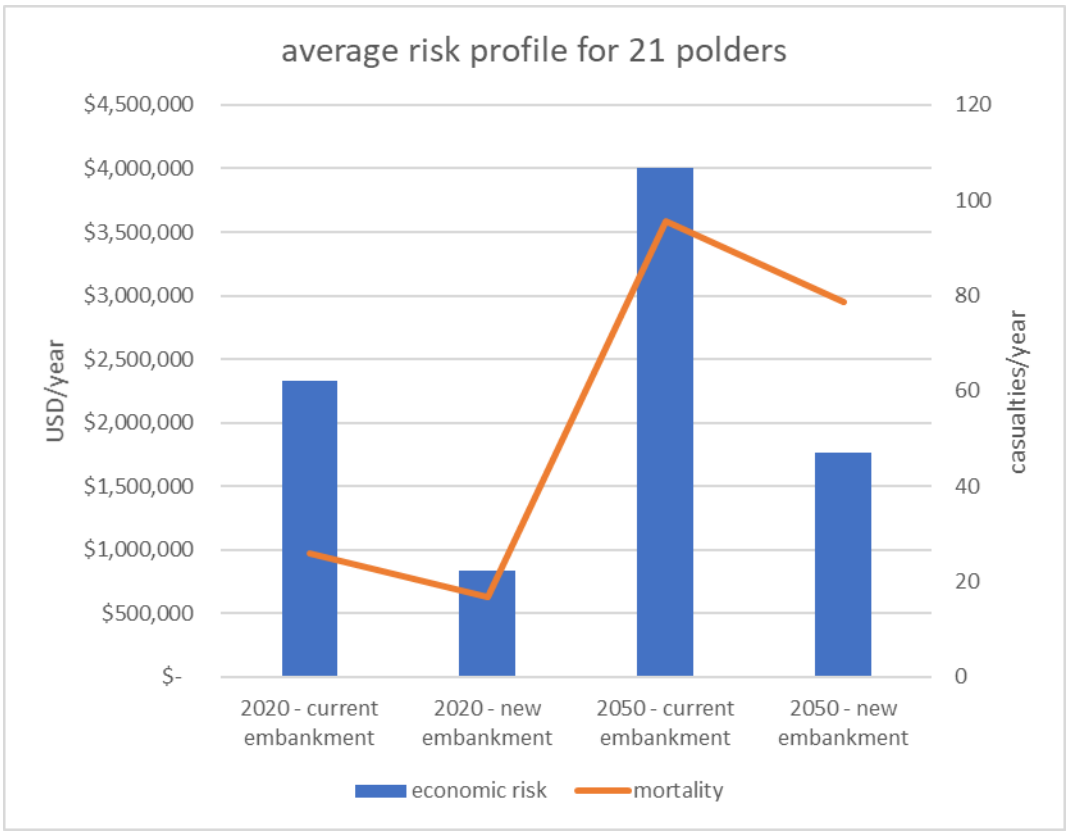


Figure 5.1: Average risk profiles for 21 polders

There are roughly two type of economic risk profiles: for some polders the bulk of the damage occurs only at the less frequent storms (1/50 to 1/100 years). Current embankments already have a safety level of 1/10 to 1/25 years. New embankments would reduce the risk only a little. An example of Polder 41/7 is shown in Figure 5.2. Current economic risk is 485,000 USD/year, which would become 392,000 USD with new embankments. For this polder investments in embankments would have limited economic benefits, and investments would better be targeted at other aspects like improved drainage, additional cyclone shelters, etc.

Other polders have a different risk profile: much damage occurs already at the 1/25 year storms, which means that new embankments can considerably reduce the total risk. For instance, Polder 39/1A shows an almost linear curve from zero damage in the 1/10 year storm to already 44 million USD damage in a 1/25 years storm (Figure 5.2). New embankments would reduce the risk from 3.6 million USD/year to 1.1 million USD/year. For this polder priority investments would be in improved embankments, as the current risk profile for storm surge illustrates.

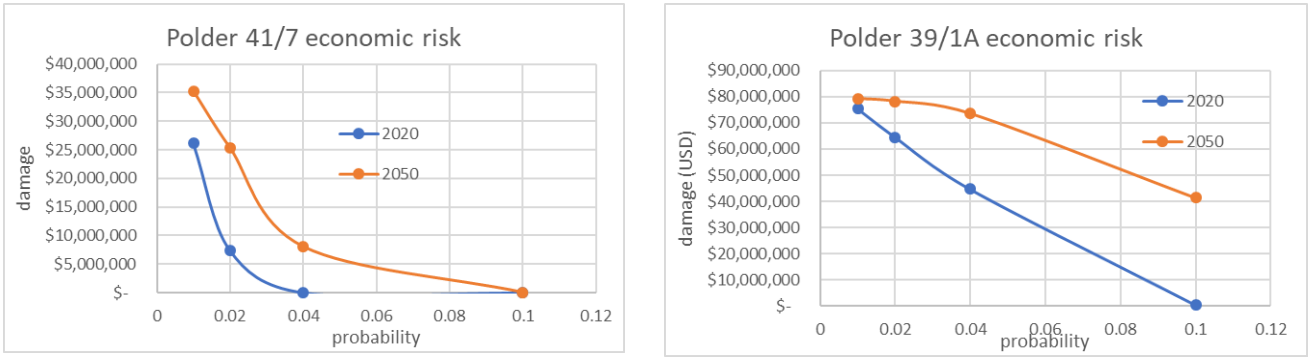


Figure 5.2: Polder 41/7 and Polder 39/1A economic risk profiles

For most polders the mortality rates occur specifically at or above 1/50 year return period (Figure 5.3). This means that raising the embankments to a level of 1/50 year safety does not reduce the mortality risk significantly. For all polders mortality rates with new embankments in 2050 will raise considerably, often even higher than the current rates without embankment. Additional cyclone shelter might prove better in reducing mortality rates than would higher embankments, and at a much lower cost.

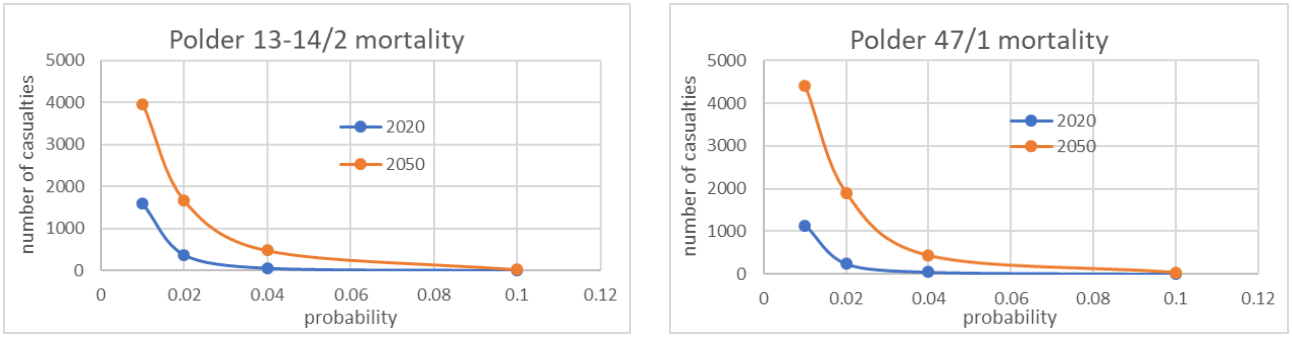


Figure 5.3: Mortality risk profile for two polders

5.4 Deliverable 5A-1 “Long Term Polder Development Plan”

5.4.1 Report

A start has made to draft the report on the Long-Term Polder Development Plan. The main outline of the report is as follows:

1. **Introduction**
2. **Planning context and rationale**
   - 2.1. Polder concept and challenges
   - 2.2. Are polders sustainable?
   - 2.3. Spatial boundaries
   - 2.4. Planning horizon and phasing
3. **Planning approach**
   - 3.1. Vision and planning guidelines
   - 3.2. Improvement measures for agriculture and water management
   - 3.3. Risk reduction measures
   - 3.4. Land reclamation

3.5. Stakeholder consultations

4. Impacts of changing boundary conditions on polders

4.1. Water levels
4.2. Riverbank erosion
4.3. Infilling of channels
4.4. Salt intrusion
4.5. Subsidence
4.6. Macro-scale interventions

5. Long term Polder Development Plan

5.1. Zone-wise development opportunities
5.2. Spatial Plan
5.3. Phasing

6. Conclusions

5.4.2 Vision

As part of the planning approach we developed a vision for the polders in coastal Bangladesh. This vision is to set a point on the horizon that provides a direction for current planning measures and interventions. It should not be regarded as a Master Plan set in stone. This is impossible for two reasons. First, it is difficult to predict with sufficient accuracy how the country and boundary conditions will be in say, 30 to 50 years. Secondly, any polder development can only partly be determined by (government) interventions. Much is also dependent on local actions and activities by the people living in the polders, who base their livelihood on their own opinion how to deal with their immediate surroundings. Be it physical conditions (such as the availability of fresh water), local and regional markets, transport or general economic conditions. It is important that sufficient flexibility is maintained in the solutions, in order to be able to anticipate on the uncertain future.

Hence, this vision describes how a more sustainable and safer coastal Bangladesh could look like, written on the basis of our current understanding of the physical and socioeconomic situation and the likely scenarios for climate change and global and national developments. This vision is partly based on the lessons learned from earlier projects, such as Blue Gold and CEIP-1 as well as from the conceptual designs that were developed for the 5 pilot polders (15, 29, 40/1, 59/2 and 64/1a+b).

The following challenges are considered essential for developing such vision:

- Water management issues inside polders (drainage, subsidence, irrigation)
- Embankment conditions (heights and stability)
- External water-related conditions of estuaries, main and peripheral rivers (notably salinity and water levels)
- Economic development (agriculture, aquaculture, port and industrial development such as near Mongla and Payra Port)

All of these will be extensively described in the report. The storyline of the vision would be like this:

In 30 to 50 years the coastal zone comprises of a mosaic of polders, some of which are highly developed into modern urbanized areas linked to low carbon emitting industrial zones and ports, others with high value aqua- and/or agricultural production regions enabling food security and prosperity of farmers. Some polders provide tourism hot spots from where excursions can be made to biodiverse coastal ecosystems such as mangrove forests, beaches and estuaries. All polders provide optimal safety against cyclonic storms through embankments, cyclone shelters, all-weather road infrastructure and state-of-the-art early warning broadcasting.

Water management is well-organized through functioning Water Management Organizations that operate and maintain the polder drainage channels and regulators, in cooperation with the LGED and BWDB. Model supported decisions are discussed with the users and acted upon by them.

For the longer term, up to the year 2100, coastal Bangladesh will face huge challenges due to climate change, continuing sea level rise and increasing storminess. This inevitably would imply a new round of measures to ensure the safety and prosperity of the polders. A mixture of interventions come into the picture, ranging from further embankment improvements, storm surge barriers across several estuaries, TRM to enable polders to rise with the sea level, pumped drainage, land fill for housing and settlements and active mangrove afforestation to create buffers, to gradually relocating residential and industrial centres to safer areas. These are major interventions that will have huge social and economic costs and require thorough studies. At this moment this requires no decisions yet, but developments on the short term should be avoided that would create a lock-in situation that hampers future adaptation to changed climate conditions.

5.4.3 Scales and zones

The Plan will consist of three spatial levels: i) 4 geographical zones (Figure 5.4), ii) catchments or groups of hydrologically related polders; iii) individual polders.

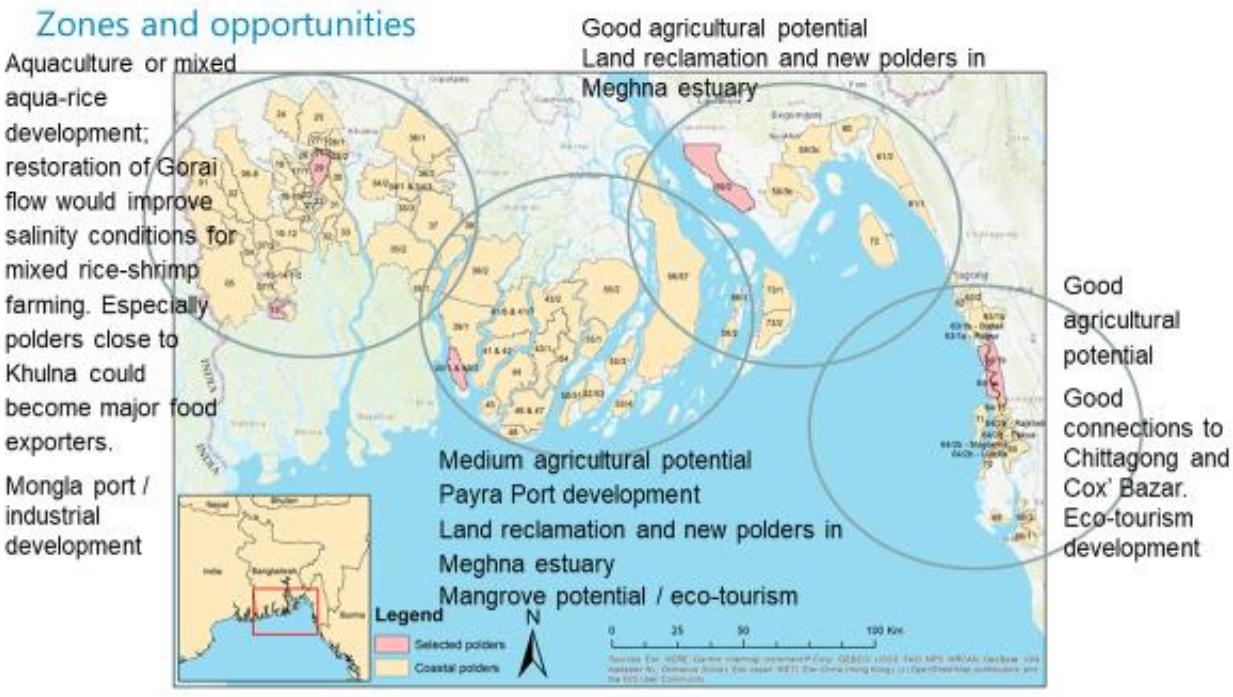


Figure 5.4: Zones and opportunities per zone.

5.5 Activities Next Quarter

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

- Risk assessment for remaining polders
- Drafting Polder Management Report
- Discussing principal design sketches for embankments with local team and BWDB
- Stakeholder workshops discussing the Long-Term Polder Development Plan
- Finalizing polder development and investment plan.

6 CAPACITY BUILDING

6.1 Basic Theory on Improved technique on field survey and Data Processing

A Training Programme on "Basic Theory on Improved technique on field survey and Data Processing" was conducted by Joint Venture of DHI and Deltares in partnership with IWM under "Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone" Consultancy Service of Coastal Embankment Improvement Project, Phase-1 (CEIP-1). This was carried out as a part of Improved technique on field survey and measurement in accordance with the terms of reference (ToR) of the said project. The 4 (four) days training programme was conducted from 31 January 2022 to 03 February 2022 and addressed the overview of discharge observation along with bathymetry concept and hands on training data processing.

The objective of the training is to build capacity within BWDB in conducting discharge observation, bathymetry survey and data processing using the improved techniques with ADCP, Win River-II software, echosounder, GPS and Hydro-Pro software. In addition, this training also addressed on hand on exercise on processing and analysing the data to support planning, design and implementation of potential project.

6.2 Training Activities

The training program was scheduled in consultation with expatriate consultants and PMU CEIP-1, BWDB and was arranged at Pani Bhaban, 72 Green Road, Panthapath, Dhaka. The activities of the training programme is given in Table 6.1.

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

Day	Time	Topic (s)
Day-1 31/01/2022 Monday	10:00-11:00 hour	Inauguration Session
	11:00-11:30 hour	Tea Break
	11:30-13:00 hour	Outlines on Benchmark, Datum, Global Positioning System, Types of GPS, Basics of GPS and DGPS, Advantage of GPS Based Survey
	13:00 –14:00 hour	Launch and Prayer Break
	14:00 -16:00 hour	Co-ordinate systems, Ellipsoid, Projection, Creation of co-ordinate system, Co-ordinate conversion by different tools.
Day-2 01/02/2022 Tuesday	10:00-11:00 hour	Bathymetric Survey; Preliminary works: Co-ordinate system display setting, Configuring vessel.
	11:00-11:30 hour	Tea Break
	11:30- 13:00 hrs	Configuration of Equipment, Generation of Run line, Configuration of Event.
	13:00-14:00 hrs	Launch and Prayer Break
	14:00 – 16:00 hrs	Exercise with Hydro Pro Software
Day-3 02/02/2022 Wednesday	10:00-11:00 hour	Water Level Observation, Selection of Gauge location, Installation of Gauge, Recording of Data and ADCP Basics.
	11:00-11:30 hour	Tea Break
	11:30- 13:00 hrs	Use of pressure sensor for water Level Observation, Barometric Sensor, Processing of Water Level Data, Discharge Observation method by ADCP, Field data collection by Win River-II Software
	13:00-14:00 hrs	Launch and Prayer Break
	14:00 – 16:00 hrs	Data Processing Exercise on Water Level and on Discharge observation by Win River-II Software
Day-4 03/02/2022 Thursday	10:00-11:00 hour	Processing of Bathymetric Data by Hydro Pro Software and Discharge data by Win River-II Software (continues)
	11:00-11:30 hour	Tea Break
	11:30- 13:00 hrs	Continue previous session
	13:00-14:00 hrs	Launch and Prayer Break
	14:00 – 16:00 hrs	Training Evaluation Exercise work, Evaluation of training, Concluding Session

6.3 List of Participants

To make the training program successful and effective, 4 experienced resources personnel of IWM were engaged who carried out the roles of trainer. The list of IWM resources personnel and list of participants from BWDB are given in Table 6.2 and Table 6.3.

Table 6.2: List of IWM participants

Sl. No.	Name of Professional	Designation
1	Md Amirul Islam	Director, Survey and Data Division
2	Pankaj Kumar Maitra	Senior Survey Expert
3	Md. Tofail Islam	Junior Survey Expert
4	Abeer Quddus	Junior Survey Expert

Table 6.3: List of BWDB participants

S.L	Name	Designation	Mobile No & E-mail ID
1.	Mohammad Samiul Hoque	Executive Engineer, PMU, CEIP-1, BWDB, Dhaka	Mobile:+8801726-233262 ee2pmuceip1@gmail.com
2.	Shahriar Sarkar	Sub-Divisional Engineer, PMU, CEIP-1, BWDB, Dhaka	Mobile:+8801954479232 shahriaranik@gmail.com
3.	Md. Manjurul Hoque	Sub-Divisional Engineer, Hydrology Sub-division, BWDB, Chattogram	Mobile:+8801712258596 manjuhoq65@gmail.com
4.	Sirazhum Monera Asha	Assistant Engineer, Central GIS Directorate, BWDB, Dhaka	Mobile:+8801783921572 aasha074@gmail.com
5.	Md. Salim Shahed	Assistant Engineer, Central GIS Directorate, BWDB, Dhaka	Mobile:+8801741453634 salimshahed25@gmail.com
6.	Md. Masudur Rahman	Assistant Engineer, Hydrology Sub-division, BWDB, Barishal	Mobile:+8801711459868 masud68.bwdb@gmail.com
7.	Tanveer Hasan Rasel	Sub-Assistant Engineer, Hydrology Section, BWDB, Mymensingh.	Mobile:+8801985579268 tanveer749509@gmail.com
8.	Khalid Hasan	Sub-Assistant Engineer, Hydrology Section, BWDB, Bhairob.	Mobile:+8801726569700 khalid404498@gmail.com
9.	Hrishikesh Bhowmik	Surveyor, B.Baria Hydrology Section, BWDB, Cumilla	Mobile:+8801740850828 hrishikeshbhowmik98@gmail.com
10.	Md. Mabud Hossain	Sub-Assistant Engineer, Hydrology Section, BWDB, Sylhet.	Mobile:+8801757532743 mabud507@gmail.com
11.	Sheikh Mahbubur Rahman	Sub-Assistant Engineer, Hydrology Section, BWDB, Faridpur.	Mobile:+8801746188500 mahbub951556@gmail.com
12.	Md. Tajul Islam	Sub-Assistant Engineer, Hydrology Sub-division, BWDB, Barishal	Mobile:+8801712842998 tajulce93@gmail.com
13.	Tapaus Chandra Pal	Surveyor, Hydrology Section, BWDB, Faridpur.	Mobile:+8801765900071 tapauspal96@gmail.com
14.	Badrul Alam	Sub-Assistant Engineer, Hydrology Section, BWDB, Manikganj	Mobile:+8801718121908 Badrul.alam.ce@gmail.com
15.	Md. Mahfuzer Hassan	Sub-Assistant Engineer, CEIP-1, BWDB, Dhaka	Mobile:+8801715213673 mahfuzer38@gmail.com

6.4 Remarks

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

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

Photo-1: Discussion on Bathymetric Survey

Photo-2: Discussion on discharge measurement using ADCP

Photo-3: Participants and trainers

Photo-4: Concluding Session