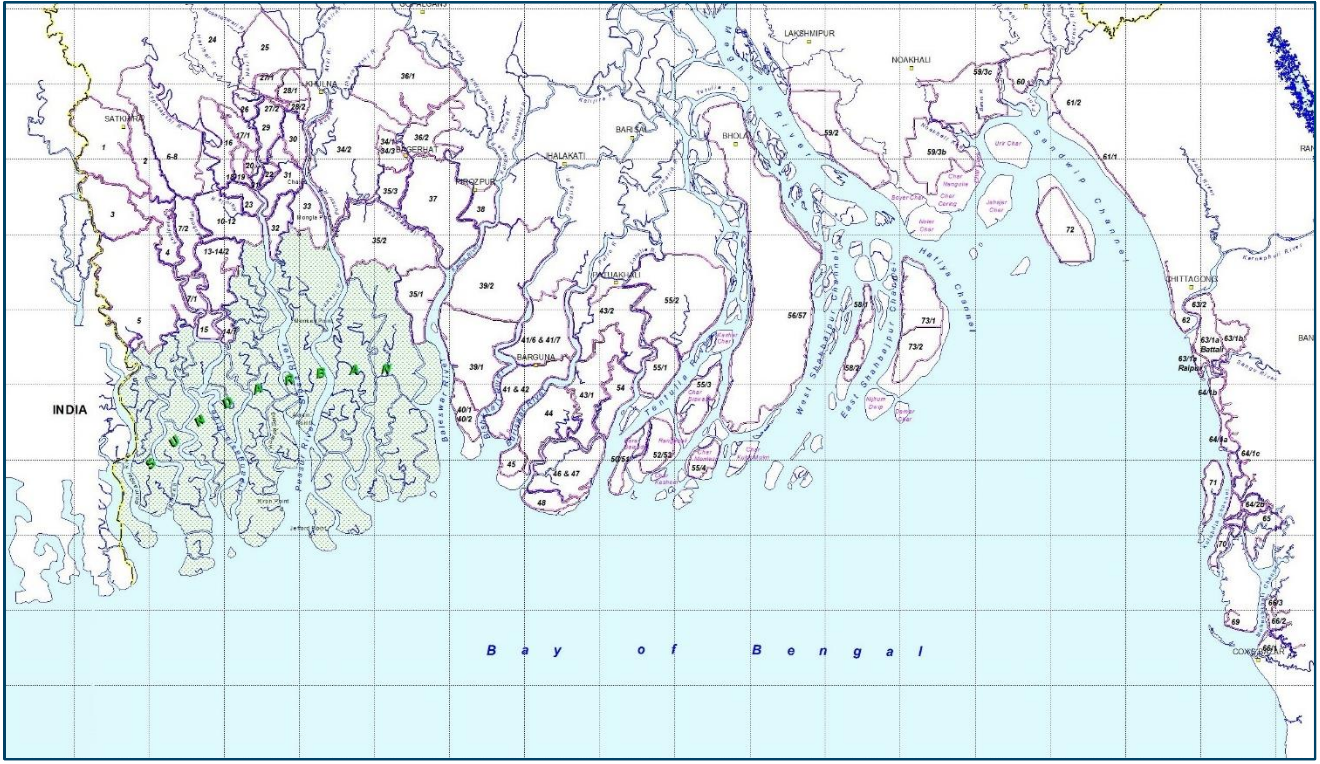
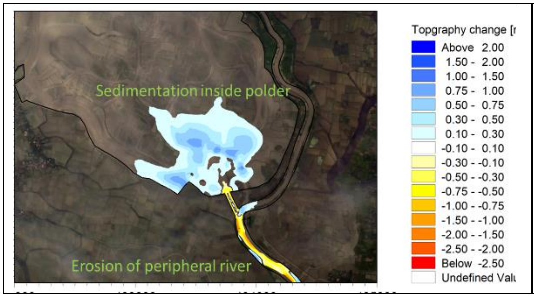
Ministry of Water Resources

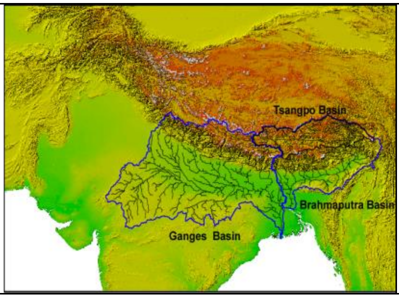
Bangladesh Water Development Board

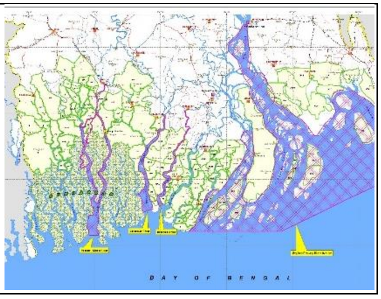
Coastal Embankment Improvement Project, Phase-I (CEIP-I)

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









QUARTERLY PROGRESS REPORT-11

August 2021

Ministry of Water Resources

Bangladesh Water Development Board

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August 2021

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/0821/123 18 August 2021

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

Attn: Mr. Syed Hasan Imam, Project Director

Dear Mr Imam,

Subject: Submission of Quarterly Progress Report-11

It is our pleasure to submit herewith three copies of the Quarterly Progress Report-11. This is the 11th Quarterly Progress Report describing the progress made between 1st April 2021 to 30 June 2021. We regret that the submission of the report has been very slightly delayed due to interruption of travel and our intra-project communications by the COVID-19 crisis.

The amount of progress made during this quarter has been less than optimal on all fronts because of restrictions on staff travel because of COVID-19 lockdowns which have been accommodated within the extended schedule and other adjustments re-negotiated with you in recent months, which resulted in an extension of the project duration by 10 months to enable all the expected project outputs to be realised without additional cost.

This report comprises 7 chapters, including the first three chapters that describe progress in development of input datasets for modelling including coastal database. Chapter4 deals with progress in determining climate Change Scenarios, and Chapter 5 introduces the work on the Polder Development Plan. Chapter 6 deals with Updating of Design Parameters and Chapter 7 deals with Capacity Building. While work has continued in the development and applications of many models, a separate chapter is not devoted to this subject. Instead, several modelling reports submitted to you on this subject are listed in Table 1.4.

Thanking you,

Yours sincerely,

Dr Ranjit Galappatti
Team Leader

Copies: Engineer A K M Waheduddin Chowdhury, Director General, BWDB
Engr. Md. Mizanur Rahman, ADG (Planning), BWDB
Dr Kim Wium Olesen, Project Manager, DHI
Dr Alessio Giardino, Deltares Project Manager
Mr Zahirul Haque Khan, Deputy Team Leader
Mr AKM Bodruddoza, Procurement Specialist
Swarna Kazi, Sr. Disaster Risk Management Specialist, World Bank

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ACRONYMS AND ABBREVIATIONS

ADCP- Acoustic Doppler Current Profiler

BDP2100- Bangladesh Delta Plan 2100

BIWTA- Bangladesh Inland Water Transport Authority

BMD- Bangladesh Meteorological Department

BoB - Bay of Bengal

BWDB- Bangladesh Water Development Board

CBA- Coast Benefit Analysis

CCP- Chittagong Coastal Plain

CDMP-Comprehensive Disaster Management Program

CDSP- Char Development Settlement Project

CEA- Cost Effectiveness Analysis

CEGIS- Centre for Environmental and Geographic Information Services

CEIP- Coastal Embankment Improvement Project

CEP- Coastal Embankment Project

CERP-Coastal Embankment Rehabilitation Project

CPA- Chittagong Port Authority

CPP-Cyclone Protection Project

CSPS-Cyclone Shelter Preparatory Study

DDM- Department of Disaster Management

DEM- Digital Elevation Model

DOE- Department of Environment

EDP- Estuary Development Program

FAP- Flood Action Plan

FM- Flexible Mesh

GBM- Ganges Brahmaputra Meghna

GCM- General Circulation Model

GIS- Geographical Information System

GNSS- Global Navigation Satellite System

GPS- Global Positioning System

GTPE- Ganges Tidal Plain East

GTPW- Ganges Tidal Plain West

HD- Hydrodynamic

IGDCZ- Interactive Geo-Database for Coastal Zone

InSAR- Interferometric Synthetic Aperture Radar

IPCC- Intergovernmental Panel for Climate Change

IPSWAM- Integrated Planning for Sustainable Water Management

IWM- Institute of Water Modelling

LCC- Life Cycle Costs

LGED- Local Government Engineering Department

LGI- local Government Institute

LRP- Land Reclamation Project

MCA- Multi Criteria Analysis

MES- Meghna Estuary Study

MoWR- Ministry of Water Resources

MPA- Mongla Port Authority

NAM - Nedbor Afstromnings Model

PPMM- Participatory Polder Management Model

RCP- Representative Concentration Pathways

RSET-MH- Rod surface elevation table – marker horizon

RTK- Real-Time Kinematic

SET-MH- Surface Elevation Tables – Marker Horizons

SLR- Sea Level Rise

SOB- Survey of Bangladesh

SSC- Suspended Sediment Concentration

SWRM- South West Region Model

TBM- Temporary Bench Mark

ToR- Terms of Reference

WARPO- Water Resources Planning Organization L - Water Level

1 INTRODUCTION

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

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

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

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

This report (QPR-11) covers the progress of work in the period 1st April 2021 to 31st June 2021. The constraints imposed by the travel bans which prevented the field inputs (in Bangladesh) by International Staff was the subject of several rounds of protracted negotiations between the Consultant and the Client – has made some progress in the face of growing global uncertainty.

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 10 months and the deliverables and the related man-power inputs to be re-arranged and re-scheduled as necessary.

Table 1.1 shows the new, re-negotiated schedule of activities. The original workplan (not shown here) was published in the Inception Report published in December 2018. This new work plan shows an extension of the project duration until January 2022.

These negotiations proceeded throughout the previous quarter and have reached a conclusion with the signing of a revised contract on 26 April 2021.

The project duration has now been extended till the end of year 2021. The work programme has been modified to accommodate the travel restrictions imposed by the COVID-19 crisis. This programme involves some staffing and budget changes currently under discussion. Section 1.2 and section 1.3 describe the current adjusted work schedules and the corresponding lists of deliverables.

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
		1	Inception Report (Workplan etc
D-2	D-2		**Literature Review & Lessons Learnt**
		1	Literature Inventory & Interim Review 1
		2	Literature Inventory & Interim Review 2
		3	Literature Review & Lessons Learnt
D-3			**Development of Input datasets for modelling the physical processes**
	D-3:1,2	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	1,2	2) Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB
	D-3.3	1,2	Completed and validated dataset including meta-data, stored in Database of BWDB (Database design report)
	D-3:4	4	GIS based National Coastal Polder Database/ Management Information System/ Database (GIS based map)
	D-3:4	4	GIS based National Coastal Polder Database/ Management Information System/ Database
	D-3:5	5	Boundary conditions and data for calibration and validation of models
	D-3:6	6	Monitoring results on sedimentation rate in rivers and floodplain
	D-3:7	7	Annual and seasonal sediment load of major rivers and to Bay of Bengal
	D-3:8	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	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	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	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	3,4	
			Technical reports (one report for 4A-1 Final Report on Morphological Trend)

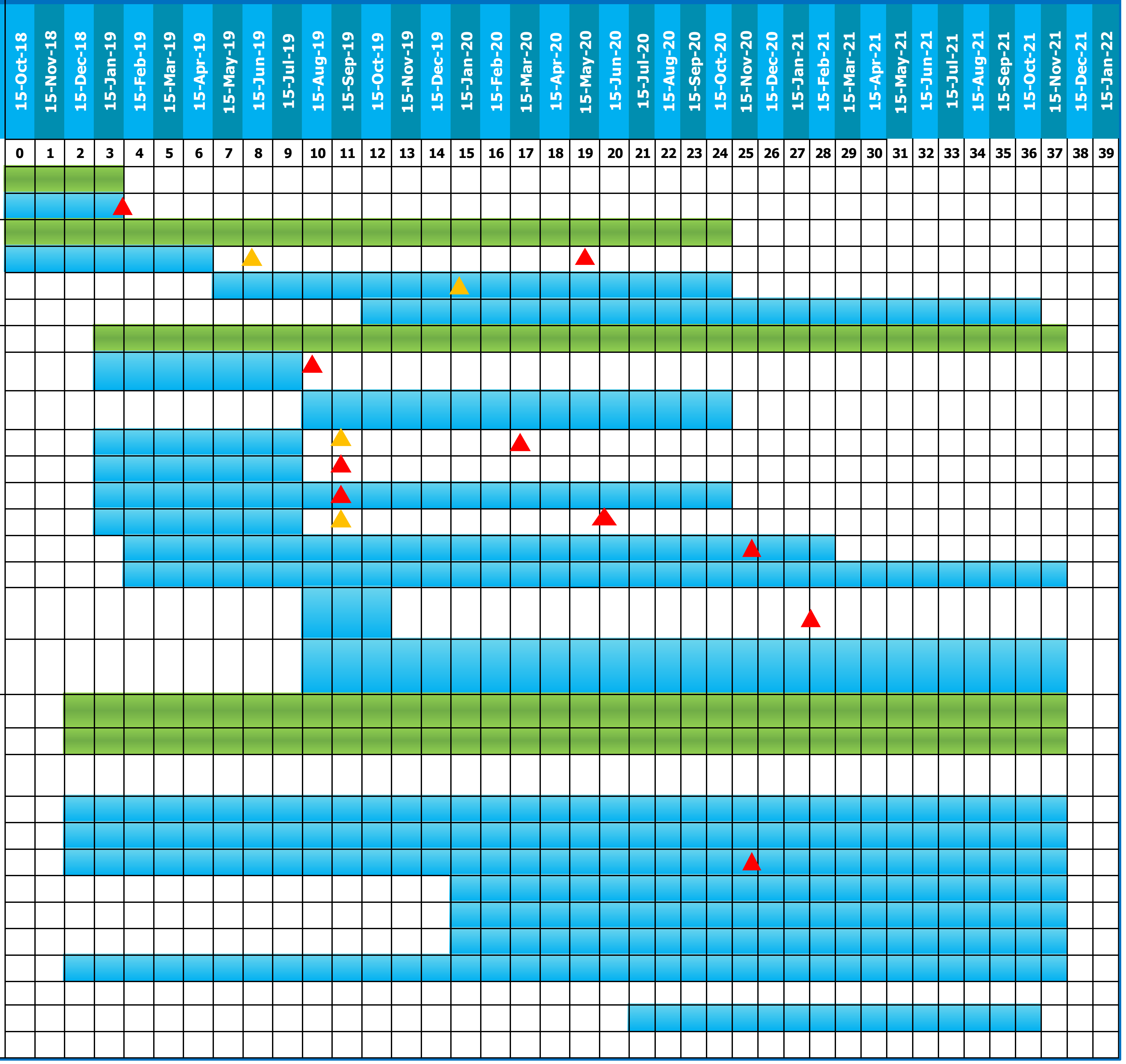


Table 1.1 (contd) : New Activity Schedule Page 2

No	TOR Reference/ Deliverables Code		TOR Deliverables	15-Oct-18	15-Nov-18	15-Dec-18	15-Jan-19	15-Feb-19	15-Mar-19	15-Apr-19	15-May-19	15-Jun-19	15-Jul-19	15-Aug-19	15-Sep-19	15-Oct-19	15-Nov-19	15-Dec-19	15-Jan-20	15-Feb-20	15-Mar-20	15-Apr-20	15-May-20	15-Jun-20	15-Jul-20	15-Aug-20	15-Sep-20	15-Oct-20	15-Nov-20	15-Dec-20	15-Jan-21	15-Feb-21	15-Mar-21	15-Apr-21	15-May-21	15-Jun-21	15-Jul-21	15-Aug-21	15-Sep-21	15-Oct-21	15-Nov-21	15-Dec-21	15-Jan-22
				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
D-4A-2			**Morphology on a meso scale**					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩			
	D-4A-2:1	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-2:2,3	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 inclde full meta-data and be stored and archived in Database of BWDB																	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦			
	D-4A-2:4	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	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	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 inclde full meta-data and be stored and archived in Database of BWDB																				🟦	🟦	🟦	🟦	🟦	🟦	🟦▲	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦					
	D-4A-2:4	**4**	Technical report (one report for 4A-1 and 4A-2)																				🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦					
			Other special purpose models																																								
D-4D-3								🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩					
	D-4D-3:1,2,3,4	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					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦					

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

No	TOR Reference/ Deliverables Code		TOR Deliverables	15-Oct-18	15-Nov-18	15-Dec-18	15-Jan-19	15-Feb-19	15-Mar-19	15-Apr-19	15-May-19	15-Jun-19	15-Jul-19	15-Aug-19	15-Sep-19	15-Oct-19	15-Nov-19	15-Dec-19	15-Jan-20	15-Feb-20	15-Mar-20	15-Apr-20	15-May-20	15-Jun-20	15-Jul-20	15-Aug-20	15-Sep-20	15-Oct-20	15-Nov-20	15-Dec-20	15-Jan-21	15-Feb-21	15-Mar-21	15-Apr-21	15-May-21	15-Jun-21	15-Jul-21	15-Aug-21	15-Sep-21	15-Oct-21	15-Nov-21	15-Dec-21	15-Jan-22
				0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
D-4A-3											🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩				
	D-4A-3:1,2,3	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.																																								
			Subsidence																																								
D-4B			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.					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩					
	D-4B:1,2,3	1,2,3	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			**Meteorology**					🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩			
	D-4C:1,2	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.					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	▲	🟦	🟦	🟦	🟦			
D-4D			**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.					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
	D-4D:1,2,3	1,2,3	Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now.					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
	D-4D:4,5	4,5	Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges.					🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
	D-4D:6	6	Technical Report with description and explanation of the geospatial datasets of surface and ground water salinity, and the tidal salinity and water level curves, including description of relevant seasonal variations, used models, indication of more and less likely scenarios and full metadata. The Research Team shall also discuss the effect of at least two relevant options of redistribution of river water in the South West delta on salt intrusion.																									🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		

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

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

▲ Draft submission of report ▲ Submission of revised report

1.2 Revised List of Non-Modelling Milestones and Deliverables)

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

Overview of Deliverables		As per Consultant				
No	**ToR Deliverables**	**Program Item**	**Status**	**Deadline as per Signed Contract**	**Date of Submission to PIU**	**Proposed Deadline (2nd Contract Ammendment)**
D-1	**Inception**					
	Inception Workshop	Inception Workshop	Accepted	4-Jan-19	9-Jan-19	
	Inception Report (Workplan etc)	Inception Report (Workplan etc)	Accepted	4-Jan-19	30-Jan-19	
D-2	**Detailed Literature Review and its Summary and Lessons Learnt**					
	Literature Inventory & Interim Review 1	Literature Inventory & Interim Review 1	Submitted	4-Feb-19	24-Jun-19	Revised report 31 aug-21
	Literature Inventory & Interim Review 2	Literature Inventory & Interim Review 2	Pending	4-Oct-20		31-oct-2021
	Literature Review & Lessons Learnt	Literature Review & Lessons Learnt	Pending	4-Oct-20		31-Dec-21
D-3	**Development of Input Datasets for Modelling the physical processes**					
	Soft and hard copies of map of the location of all the current field measurement stations, by tape, stored in Database of BWDB, Map showing the location of primary BM with values	Data Report, Inventory & Quality Checks (Includes field Data collection and monitoring programmes)	Submitted	4-Jul-19	29-Sep-19	
	Raw datasets of all type of data. Including meta-data. Stored in Database of BWDB					
	Completed and validated dataset including meta-data, stored in Database of BWDB	Database Design Report	Submitted	4-Jul-19	11-Sep-19	
	GIS based National Coastal Polder Database/ Management Information System/ Database	GIS Based Maps	Submitted	4-Jul-19	25-Sep-19	
		GIS Based Database/ MIS system/ Sharepoint	Pending	4-Jul-19		30-Sep-21
	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	Accepted	4-Jul-19	Revised Version Submitted on June 21, 2021	30-Nov-20
	Annual and seasonal sediment load of major rivers and to Bay of Bengal	Annual & Seasonal Sediment load of Major rivers & to Bay of Bengal	Pending	4-Aug-19		30-Nov-21
	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	25-Feb-21	31-Dec-20
	Memorandum with recommendations to improve the data collection, processing, validation and dissemination within the GoB	Technical Report on improving Data collection	Pending	4-Aug-19		30-Nov-21
	Technical Report on Long Term Polder Improvement measures and Polder Development Plan	Draft	Pending	4-Apr-21		31-Dec-21
		Final	Pending			31-Jan-22
	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	15-Jan-21	Submitted 15-01-2021
		Final	Pending			
	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	Draft	Pending	4-Jul-20		31-Oct-21
		Final	Pending			30-Nov-21
D-5B	**Coherence and Overall picture of Delta**					
	Report describing the Interdependencies and relations between the processes and parameters, consequences for the boundary conditions and recommendations for future action plan/ research	Coherence with respect to Overall Delta	Pending	4-Apr-21		28-Feb-22
		~~Environmental Assessment of Proposed Interventions~~	Pending			
D-6.1	**Updating of design parameters and specifications for construction works**					
	Report with updated set of design parameters and specifications for construction/ reconstruction of the polders as well as associated appurtenant structures	Updated Design Parameters & Specifications	Pending	4-Apr-21		30-Dec-21
	Detailed delivery plan to be developed during the inception phase for D-6.1	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.2	**Review of approaches for management of polders with emphasis on active participat**					
	Report on Management plans for the polders	Polder Management Plan	Pending	4-Apr-21		31-Dec-21
	Detailed delivery plan to be developed during the inception phase for D-6.2	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	
D-6.3	**Setting up a performance monitoring Mechanism**					
	Report on participatory monitoring mechanism with goals and targets	Performance Monitoring Mechanisms	Pending	4-Apr-21		30-Nov-21
	Detailed delivery plan to be developed during the inception phase for D-6.3	Detailed Delivery Plan	Submitted	4-Feb-19	11-Apr-20	

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

No	ToR Deliverables	Program Item	Status	Deadline as per Signed Contract	Date of Submission to PIU	Proposed Deadline (2nd Contract Ammendment)
D-7	**Investment plan for the Entire CEIP**					
	An investment plan describing a phaased polder improvement roadmap and required budget	An investment plan describing a phaased polder improvement roadmap and required budget	Pending	4-Apr-21		30-Mar-22
	An investment plan for long term management of the polders, including the expansion of monitoring	An investment plan for long term management of the polders, including the expansion of monitoring	Pending	4-Apr-21		
	An execution plan including financing and fundraising strategies and plan and technical collaboration plan	An execution plan including financing and fundraising strategies and plan and technical collaboration plan	Pending	4-Apr-21		
D-8	**Action Plan for Capacity Building**					
	On the job technical training in country	In-country on-the- job Training	Pending	Continuous		ongoing
	Report on: results of the on the job training, list of participants	Training Report with list of trainees	Pending	Bi Annually		31-Dec-21
	International Workshop	International Workshop	Pending	4-Jul-20		28-Feb-22
	Teach the teacher, Teaching at the universities	Curriculum Development	Pending	4-Apr-21		28-Feb-22
D-9.1	**Outreach Program**					
	Workshops	Workshop 1 - Barishal	Accepted		30-Mar-19	
	Workshops	Workshop 2 - Khulna	Accepted		27-Apr-19	
	Workshops	Workshop 3 - Mid Term Progress Workshop	Accepted		6-Feb-20	
	Workshops	Workshop 4	Pending			
	Workshops	Workshop 5	Pending			
	Workshops	Workshop 6	Pending			
	Workshops	Workshop 7	Pending			
	Workshop Report	Workshop 1 Report - Barishal	Submitted		20-Feb-20	
	Workshop Report	Workshop 2 Report - Khulna	Submitted		20-Feb-20	
	Workshop Report	Workshop 3 Report - Mid Term Progress Workshop	Submitted		8-Jun-20	
	Workshop Report	Workshop 4 Report	Pending			
	Workshop Report	Workshop 5 Report	Pending			
	Workshop Report	Workshop 6 Report	Pending			
	Workshop Report	Workshop 7 Report	Pending			
D-9.2	**Communication Strategy**					
	Storage of all datasets BWDB	Storage of all datasets BWDB	Pending	4-Apr-21		31-Dec-21
	Communication materials such as brochures, animations etc.	Communication materials such as brochures, animations etc.	Pending	4-Oct-20		31-Dec-21
Q	**QPR**					
	QPR-1	QPR-1	Submitted		30-Jan-19	
	QPR-2	QPR-2	Submitted		20-Aug-19	
	QPR-3	QPR-3	Submitted		20-Aug-19	
	QPR-4	QPR-4	Submitted		7-Nov-19	
	QPR-5	QPR-5	Submitted		2-Mar-20	
	QPR-6	QPR-6	Submitted		10-Jun-20	
	QPR-7	QPR-7	Submitted		6-Sep-20	
	QPR-8	QPR-8	Submitted		20-Jan-21	
	QPR-9	QPR-9	Submitted		21-Mar-21	
	QPR-10	QPR-10	Submitted		23-May-21	
	QPR-11	QPR-11				
	QPR-12	QPR-12				
	QPR-13	QPR-13				

1.3 Revised List of Modelling Milestones and Deliverables

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

DELIVERABLES RELATED TO MODELLING ACTIVITIES							
TOR Reference	**TOR Deliverables**	**Scale**	**Model**	**Status**	**Delivery Dates as per signed Contract**	**Delivery Dates (by Consultant)**	**Proposed Deadline (2nd Contract Ammendment)**
D-4A-1: 1	The software newly developed under this project with all source code and accompanying technical document with detailed explanation of the methodology and assumptions			Pending	4-Apr-21	At the end of each model	
D-4A-1: 2, 3	Geospatial datasets of main sources and deposits of sediment at present, including full meta-data a restored and archived in Database of BWDB Geospatial datasets of main sources and deposits of sediment for 100 years from present, including full meta-data are published and archived in Database of BWDB.	**Macro**	GBM Basin Model	Submitted	D-4A-1: 2 (Jan 20) D-4A-1: 3 (Oct 20)	Mar-20	30-Sep-21
		Macro	Macro scale River Model	Submitted		Mar-20	
		Macro	Macro scale River Model	Submitted		Mar-20	
		Macro	GBM Basin Model Applications	Pending		7th Quarter	
		Macro	Macro scale River Model Applications	Pending		7th Quarter	
		Macro	Macro scale River Model Applications	Pending		7th Quarter	
		Macro	Sediment Budget Analyses	Pending		Apr-20	
D-4A-1:-4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Jan 21)	Oct-20	30-Sep-21
Long Term Morphology Modelling							
D-4A-2: 1	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions.	**Meso**	Pussur Sibsa	Submitted	4-Oct-19	Mar-20	
		Meso	Baleswar-Bishkhali Model	Submitted		Mar-20	
		Meso	Lower Meghna	Submitted		Mar-20	
		Meso	Sangu	Submitted		Mar-20	
D-4A-2: 2, 3	Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB. Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should inclde full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur Sibsa	Pending	D-4A-2: 2 (Apr 20) D-4A-2: 3 (Jul 20)	7th Quarter	31-Oct-21
		Meso	Baleswar-Bishkhali Model	Pending		7th Quarter	
		Meso	Lower Meghna	Pending		7th Quarter	
		Meso	Sangu	Pending		7th Quarter	
D-4A-2: 4	Technical report (one report for 4A-1 & 4A-2)			Pending	Draft (Jul 20) Final (Oct 20)	Nov-20	31-Oct-21
Bank Erosion on Meso Scale							
D-4A-2: 1, 2	Report on upgrade and update of present meso scale model including detailed explanation of the methodology and assumptions. Geospatial datasets of erosion and sedimentation in the coastal zone at present for various seasons and circumstances in relevant. These geospatial datasets should include full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Submitted	4-Oct-19	Apr-20	Interim Report: October 2020 Final Report: 15-08-2021
		Meso	Sibsa	Submitted		Apr-20	
		Meso	Baleswar	Pending		Apr-20	
		Meso	Bishkali	Submitted		Apr-20	
		Meso	Lower Meghna	Pending		Apr-20	
		Meso	Sangu	Pending		Apr-20	
D-4A-2: 3	Geospatial datasets of erosion and sedimentation in the coastal zone for possible scenarios 25, 50 and 100 years from now, for various reasons and circumstances if relevant. These geosparial datasets should inclde full meta-data and be stored and archived in Database of BWDB	**Meso**	Pussur	Pending	D-4A-2: 2 (Apr 20) D-4A-2: 3 (Jul 20)	Dec-20	15-Sep-21
		Meso	Sibsa	Pending		Dec-20	
		Meso	Baleswar	Pending		Dec-20	
		Meso	Bishkali	Pending		Dec-20	
		Meso	Lower Meghna	Pending		Dec-20	
		Meso	Sangu	Pending		Dec-20	
		Meso	Pussur-Sibsa fine sediment model- ext	Submitted		Jan-20	
D-4A-2: 4	Technical report (one report for 4A-1 and 4A-2)	**Meso**	**FINAL REPORT ON BANK**	Pending	Draft (Jul 20) Final (Oct 20)	Jan-21	15-Sep-21
D-4A-3: 1, 2, 3	The model setup developed will be updated under this project with all accompanying technical document with detailed explanation of the methodology and assumptions. A report that describes the pros and cons of the different methodologies to prevent water-logging within the polder and sedimentation of tidal river system including polder-subsidence. The report will include meta-data on the models used and measurements, recommendations for polder design including drainage and long term management plan, and recommendations for pilot area/ polder to implement the ideas, such as but not limited to location, methods and measurements. Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder.	**Micro**	Pilot TRM Model for Polders 24 etc	Pending	4-Oct-20	Mar-20	Interim (15-07-2021) & Final (15-09-2021)
		Micro	5 or more polder models	Pending		20-Sep	Current situations/Interim: Polder modelling report 15-08-2021 Final Version: 30-11-2021
D-4A-3: 4	Recommended plan to manage sediment at the downstream stretch of the tidal river and in the polder						

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

TOR Reference	TOR Deliverables	Scale	Model	Status	Delivery Dates as per signed Contract	Delivery Dates (by Consultant)	Proposed Deadline (2nd Contract Ammendment)
SUBSIDENCE							
D-4B: 1, 2,3	Geospatial datasets of total subsidence at present and for 25, 50 and 100 years from now, including full metadata and stored in Database of BWDB and Estimate the annual rate of subsidence. Detailed Technical Report with description and explanation of geospatial analysis of the total subsidence in the four regions of the polder area of the coastal zone at present and for 25, 50 and 100 years from present, including description of the causes of subsidence, full metadata and stored in Databse of BWDB.		Field Campaigns (several)	Pending	D-4B: 1, 2 (Oct 20) D-4B: 3 (Report: Draft - July 20, Final - Oct 20)	Dec-20	30-Sep-21
			Subsidence Geospatial Datasets	Submitted		Oct-20	
				Pending		Oct-20	
METEOROLOGY (these are covered under other modelling and data topics)							
D-4C: 1, 2	Technical Report describing current trends and future scenarios in rainfall in the polder area of coastal zone for four coastal regions (including estimation of rainfall distribution over the year) and cyclone frequency and intensity for the next 25, 50 amd 100 years from now, including meta-data of the datasets used for the trend analyses and store and archived in Database of BWDB. The Research Team shall include a description of the statistical and downscaling methods used for reproducibility reasons. Geospatial Dataset and archived in Database of BWDB.		Technical reports & Database	Submitted	D-4C: 1 (Apr 20) D-4C: 2 (Jul 20)		
CLIMATE CHANGE EFFECTS							
			Climate Change & Preciptation,	Pending		Oct-20	This item is fully covered by D-4C
D-4D: 1, 2, 3	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now.		Salinity intrusion & Groundwater Salinity	Pending		Oct-20	30-Nov-21
D-4D: 4, 5	Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges.		Extreme Storm Surges	Pending		Oct-20	30-Nov-21
D-4D: 6	Technical Report with description and explanation of the geospatial datasets of surface and ground water salinity, and the tidal salinity and water level curves, including description of relevant seasonal variations, used models, indication of more and less likely scenarios and full metadata. The Research Team shall also discuss the effect of at least two relevant options of redistribution of river water in the South West delta on salt intrusion.			Pending		Nov-20	Current situations/Interim: Storm surge and wave modelling 9-08-2021 Salinity Modelling 9-08-2021 Final (Report on CC Effects) 30-11-02021
Other special purpose models							
D-4D: 1, 2, 3, 4, 5	Geospatial datasets of High Water, Low Water and maximum salt intrusion in all river branches for average tide in the wet and dry season at present and at 25, 50 and 100 years from now, including full meta-data stored and archived in database of BWDB. Geospatial datasets of groundwater salinity at 3 relevant levels (in the upper shallow, lower shallow and deeper aquifers, to be deignated by BWDB) at present and at 25, 50 and 100 years from now, including full metadata and stored and archived in Database of BWDB. Tidal and salinity curves for key locations in the coastal zone (about 20, to be designated by BWDB) in the wet and dry season at present, and at 25, 50 and 100 years from now. Exceedance frequency curves for water levels in the same 20 stations at present, and at 25, 50 and 100 years from now. Define extreme water levels in the polder of coastal zone at 25, 50 and 100 years from now, due to cyclonic storm surges	**Bay of Bengal**	Storm Surge Model	Pending		Dec-19	The use of synthetic cyclone events has been abandoned. It has been deemed that use of historical events (and
		Bay of Bengal	Storm Surge Model	Pending		Dec-20	Current situation: 9-08-2021 Future situation: 30-11-2021
		Bay of Bengal	Wave Propagation Model	Pending		Dec-20	
		Bay of Bengal	Salinity Model	Pending		2020 end	

1.4 List of Deliverables Submitted

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

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

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
	coastal model -current scenario (1st submission)				
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

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
34	Review/Improvements on-going work (CEIP-I)	01/17/2021	D-5A:2	Improvement to 17 Polders	Component-5
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

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 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. A team of 12 personnel comprising the IWM Survey Expert, an experienced hydrographic surveyor and land surveyors has been deployed for conducting the planned data collection campaign as per specification.

2.2.2 Summary of Field Survey Activities in the 11th Quarter (ending June 2021)

To support the mathematical modelling study for TRM, cyclone storm surge/ flood hazard in connection with conceptual polder design, the field survey for the 5 selected polders has been completed in February 2021.

In the quarter from April 2021 to June 2021, routine discharge and sediment measurements at Bahadurabad of Brahmaputra River and at Hardinge Bridge of Ganges River are being continued for the better understanding of the sediment rating curve. 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 is planned to continue the measurements over those two locations up to September 2021 during the extended period of the project. In this period, measurements will be done with a more frequency to achieve the target number of measurements which would also be helpful for improving the understanding in the sediment rating curve analysis.

The survey methodology for the 5 polders survey employed by IWM survey teams is described in this Quarterly Report and the methodology for the others survey is described in detail in the Second Quarterly Progress Report.

The progress of discharge and sediment monitoring has been shown in Table 2.2 to Table 2.3.

Survey methodology/progress for the 5 polders:

The survey was started in Feb-2020. However, due to the lockdown under COVID-19, the field work was suspended in 20/03/2020 which has been restarted again in June-2020.

The main feature of the 5 polders survey included cross-section of surrounding embankment and internal drainage canals, detail structure inventory, cross-section of the surrounding rivers/canals, and land level survey. Out of these, the cross sections survey of the surrounding embankment, internal drainage canal and structure inventory have been already completed. The land level survey has been started from November 2020 and completed during this present quarter in February 10, 2021. The progress of the survey for 5 polders has been shown in Table 2.1.

Establishment of Bench Marks:

1. **Bench Mark Fly:**

   The survey work for the all polders has been conducted with reference to available existing Survey of Bangladesh (SOB) bench marks (BM) situated around the polders area. TBMs have been kept by engraving on the permanent structures like regulator and sluices during the survey. Closing errors were checked to maintain the survey accuracy. List of reference Bench Marks are given in the following table.

List of reference Bench Mark

1	BM-1039	The pillar is situated on the Upazilla Research center compound, PS: Dumuria, Dist: Khulna.	2.135	748347	2524502	Polder 29
2	BM-148	The pillar situated on the N/E corner of pond behind the house of Mr. Rumi commisioner east side of Patharghata Hospital road, Vill: Patharghata Hospital road, UP: Patharghata, Dist: Barguna.	2.137	806423	2439568	In Polder 40/1
3	BM-4103	Situated in the Turabgonj High School Compound, PS: Kamalnagar, Dist: Laxmipur	4.314	280961	2524625	In Polder 59/2
4	GPS-214	Situated in the Motirhat High School compound, PS: Komolnagar, Dist: Laxmipur	3.624	272674	2524873	
5	GPS-274	The pillar is situated at west side of Sandwip Para cyclone shelter and east bank of pond, Vill: Sandwip Para, UP: Bashkhali	3.599	383788	2446678	In Polder 64/1A and Polder 64/1B
6	BM-5117	SOB BM pillar no-5117 situated in SE corner of 73no Sora Primary School. Vill: Sora, Up: Gabura, PS: Shyamnagar, Dist: Satkhira	2.044	732187	2459629	In Polder 15

2. **Embankment cross section**:

Cross sections of the existing embankment are taken at 500m intervals. Apart from the Polder 15, a total of 296km embankment cross section survey has been carried out for the other 5 polders. The embankment cross sections of Polder 15 were conducted during 2016 under CEIP-I. However, some part of the embankment in Polder 15 has been damaged significantly due to the recent cyclone Amphan during May 20, 2020. This changed part of the embankment has been revisited through conducting surveys of 44 cross sections to cover the damaged part of the embankment. All cross sections are taken with perpendicular to the alignment of the embankment and has been extended at least 15m beyond the toe in the country side (C/S) and 50 meter in the river side (R/S). At locations of breaches, damages, cross-sections have been taken at closer intervals to represent the correct configuration of the cross-section. Cross section has been carried out by using optical level and handheld GPS.

Figure: Embankment Cross section Survey

3. **Drainage Channel Survey**:

The cross section of the Khal has been carried out at an interval of 500 meter or closer where ever necessary, to represent the correct configuration of the khal. A total of 326 Km drainage channel cross section survey are carried out in the five polders excluding Polder 15. The cross-section survey has been conducted during March 2017 at Polder 15 can be utilized here in this study. Cross section has been extended at 15 m beyond the bankline and spot level to be taken maximum 5 m apart or less as necessary to represent the correct configuration of the cross section. Cross sections of the drainage channel have been conducted by using optical level and hand GPS. The tentative locations of the cross section are made by delineating the alignment of the existing drainage channel.

4. **Structure Inventory:**

The structural dimensions/level, information like operational practice, physical condition of structure, launching apron and drainage channels condition has been recorded during the survey A log-sheet was prepared and followed in the field for recording the necessary information regarding the structure.

Figure. Sluce-10 of P-64/1A

Figure: Asanghar Sluice of P-29

5. Cross section of the surrounding river:

A total of 340 cross-sections of the peripheral river of all 6 polders have been conducted. River section survey was carried out at 500m-1000m interval considering the existence of the drainage regulator and also along the river bend. The cross sections extended up to high bank or up to embankment. The survey has been done by using DGPS & Echo sounder for the channel part while the shallower part and the dry land have been surveyed by using Optical Level.

Figure: Bathymetry Survey at the surrounding river of Polder 29.

6. Topographic Survey:

Spot levels together x, y co-ordinate have been carried out around 50mx50m interval by using optical level and GPS or total station for the drainage model. Spot level are undertaken in the open area mainly and some representative spot levels are also recorded inside the homestead. Initially, it was planned to conduct topography survey along the limited area (30% of the available open area). However, a total of 412 Km^2 has been carried out covering the whole area of 5 polders excluding the polder-15 for interest of this research project. Land level survey conducted during 2017 at Polder-15 under the detail design of CEIP-1 will be utilized for this study. Level data has been processed in Arc View GIS software to produce spot level with reference to MSL vertical datum. The spot levels have been taken along with physical features ID like khals, road, embankment, paddy land etc.

Table 2. 1: Progress/ future plan of 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 Mar-2021	Progress in between Apr -June 2021	Cumulative progress upto June-2021	Remarks
		TOR	Modified				
A	3 main rivers						
1	Bahadurabad, Brahmaputra	18	48	34	8	42	Data collection will be done up to September 2021 as a part of the extended study.
2	Hardinge Bridge, Ganges	18	48	34	8	42	
3	Bhairab Bazar, Upper Meghna	18	48	26	1	27	
Total of A		54	144	94	17	111	
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 season
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 Mar-2021	Progress from Apr-June 2021	Cumulative Progress upto June 2021
A	3 main rivers						
1	Bahadurabad, Brahmaputra	18	48	1056	2407	406	2813
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 11th quarter (April 2021 to June 2021) of the project.

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

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

To achieve the above objectives, a web GIS based Interactive Geodatabase for Coastal Zone (IGDCZ) has been developing under this project. IWM team have been conducting several tasks and activities during this quarter. The summary of work progress of are presented in Table 3.1.

Table 3. 1: Summary of work progress

Sl No	Task & Activities	Progress (%) Up to 10th Quarter	Progress (%) 11th Quarter	Overall Progress (%)
1	**Inception Phase**			
1.1	Review Existing Systems	100	-	100
1.2	Consultation with Project Team	continue		continue
1.3	Consultation with Project Client	continue		continue
1.4	Requirement Analysis	100	-	100
1.5	Data Requirements and Data sources	100	-	100
1.6	Conceptual System Architecture	100	-	100
1.7	Inception Report	100	-	100
2	**Data Collection and Processing**			
2.1	Coastal Bank Erosion (Satellite Image)	100	-	100
2.2	Land use Classification (Satellite Image)	85	0	85
2.3	Other Data Collection (shapefile & tabular)	90	-	90
2.4	Other Data Processing (shapefile & tabular)	85	5	90
3	**GIS Mapping**			

Sl No	Task & Activities	Progress (%) Up to 10th Quarter	Progress (%) 11th Quarter	Overall Progress (%)
3.1	Polder Maps for Data Collection	85	0	85
4	**Database Design & Development**			
4.1	Database Design Development	100	-	100
4.2	Database Design Report	100	-	100
4.3	Database Implement	90	0	90
5	**Web GIS Application Development**			
5.1	IGDCZ Prototype Development	100	-	100
5.2	Full Version Development	93	2	95
5.3	GIS Core Modules	93	2	95
5.4	Dashboard Development	90	3	93
5.5	Metadata Preparation	45	5	50
5.6	Metadata Interface Development	60	10	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	90	2	92
5.11	Data Validation and Check	92	0	92
5.12	Software & Hardware Procurement	-	-	-
5.13	Installation of SW and HW at BDWB Data Centre	-	-	-
5.14	Migration of Database and Application to BWDB Servers	-	-	-
5.15	Fully operational commissioning	-	-	-
5.16	Preparation of User Instruction Manual	-	-	-
6	Reports			
6.1	Database Implementation Report	submitted		
6.2	Validation and Compilation Report (1st version)	submitted		

Sl No	Task & Activities	Progress (%) Up to 10th Quarter	Progress (%) 11th Quarter	Overall Progress (%)
7	**Training & Technology Transfer**	-	3 days training	3 days training
8	**Feedback and update (ongoing)**		12 comments were addressed	

3.2 Training and Technology Transfer

A 3-days training programme was provided to the selected 11 numbers of BWDB engineers from 24 May 2021 to 30 May 2021. The training was provided through a mixed-mode online zoom and physical presence of trainees. The whole training programme has been divided into three parts (i) Overall objectives, purpose and the concept of database, software platform etc. (ii) detailed operations of each module and function of IGDCZ application demonstrated by the trainer and finally, and (iii) The trainees carried out the software operations and filling up an answer sheet based on some operational questions of different interfaces and parameters in the database. The day-wise training schedules are given below:

Day-1 (24 May 2021): Objectives, purpose, and the overall concept of building the database particularly the concept of database, software and hardware platform and Web GIS Application.

Day-2 (25 May 2021): detailed demonstration of IGDCZ user interfaces and modules, implementation of spatial and non-spatial database, detailed operations of IGDCZ functionalities metadata updating and implementation.

Day-3 (30 May 2021): practical exercises performed by the trainees, filling up an answer sheet by operating different interfaces and functionalities and pick the results/findings to the give questions. The trainer assisted them whenever they face any problem.

A detailed training programme and the list of participants are given in the Appendix A1 of this report.

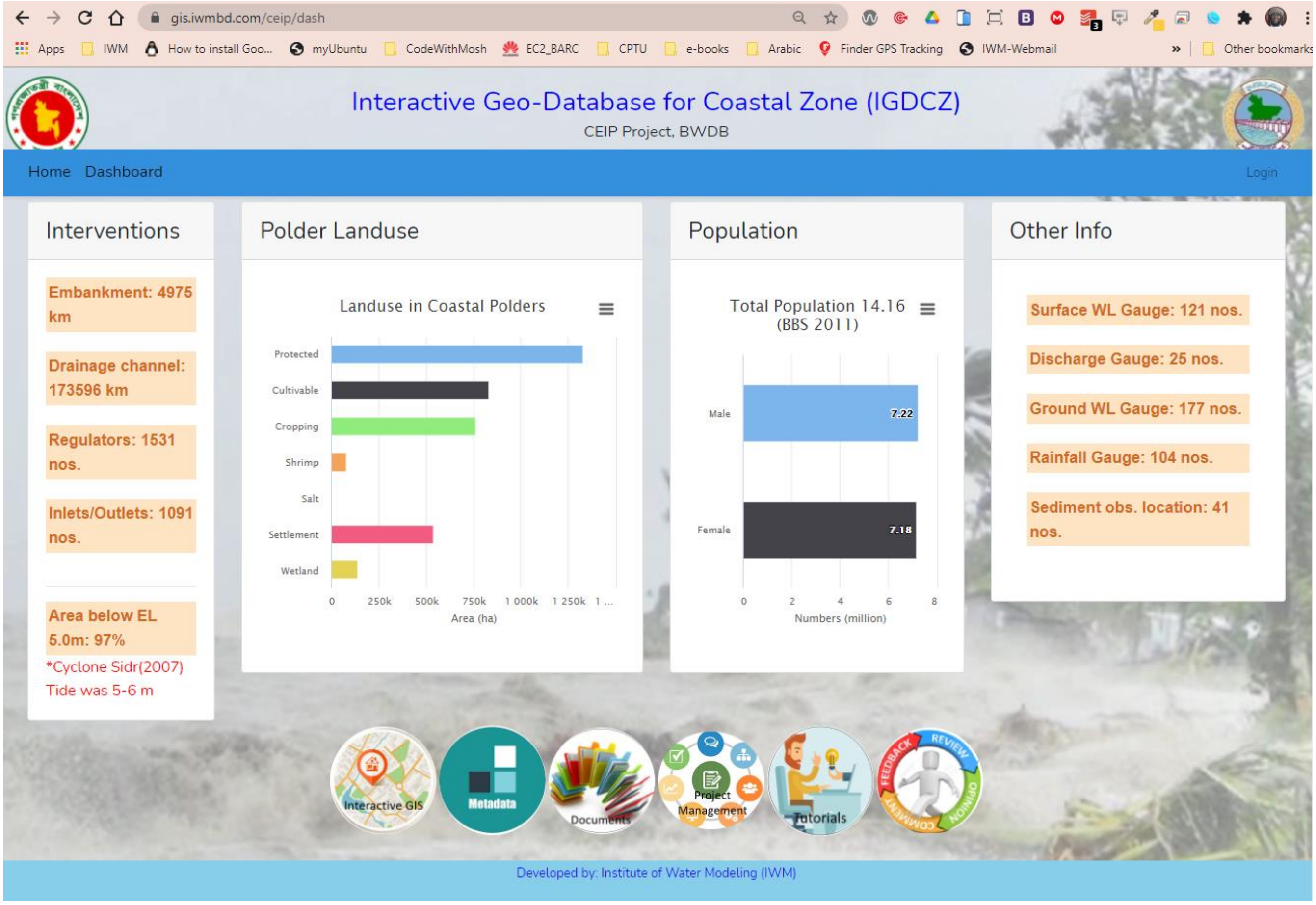
3.3 Web Application Development

- **Full version development**

A significant part of the Full version IGDCZ has been developed and remaining parts are still under development. Current version has been presented several times before the client and expert teams. Comments have been received and being addressed. Access to the full version has been provided to extended numbers of interested and relevant officials and experts endorsed by the Project Director.

- **Dashboard Development**

Dashboard has been improved a lot, it consists of interfaces of the summary information of polder database and the gateway to access different modules of the application. It has been made more user friendly. A snapshot of the Dashboard is presented below in Figure 3.1:



Interactive Geo-Database for Coastal Zone (IGDCZ)

CEIP Project, BWDB

Interventions

Embankment: 4975 km

Drainage channel: 173596 km

Regulators: 1531 nos.

Inlets/Outlets: 1091 nos.

Area below EL 5.0m: 97%

*Cyclone Sidr(2007) Tide was 5-6 m

Polder Landuse

Population

Other Info

Surface WL Gauge: 121 nos.

Discharge Gauge: 25 nos.

Ground WL Gauge: 177 nos.

Rainfall Gauge: 104 nos.

Sediment obs. location: 41 nos.

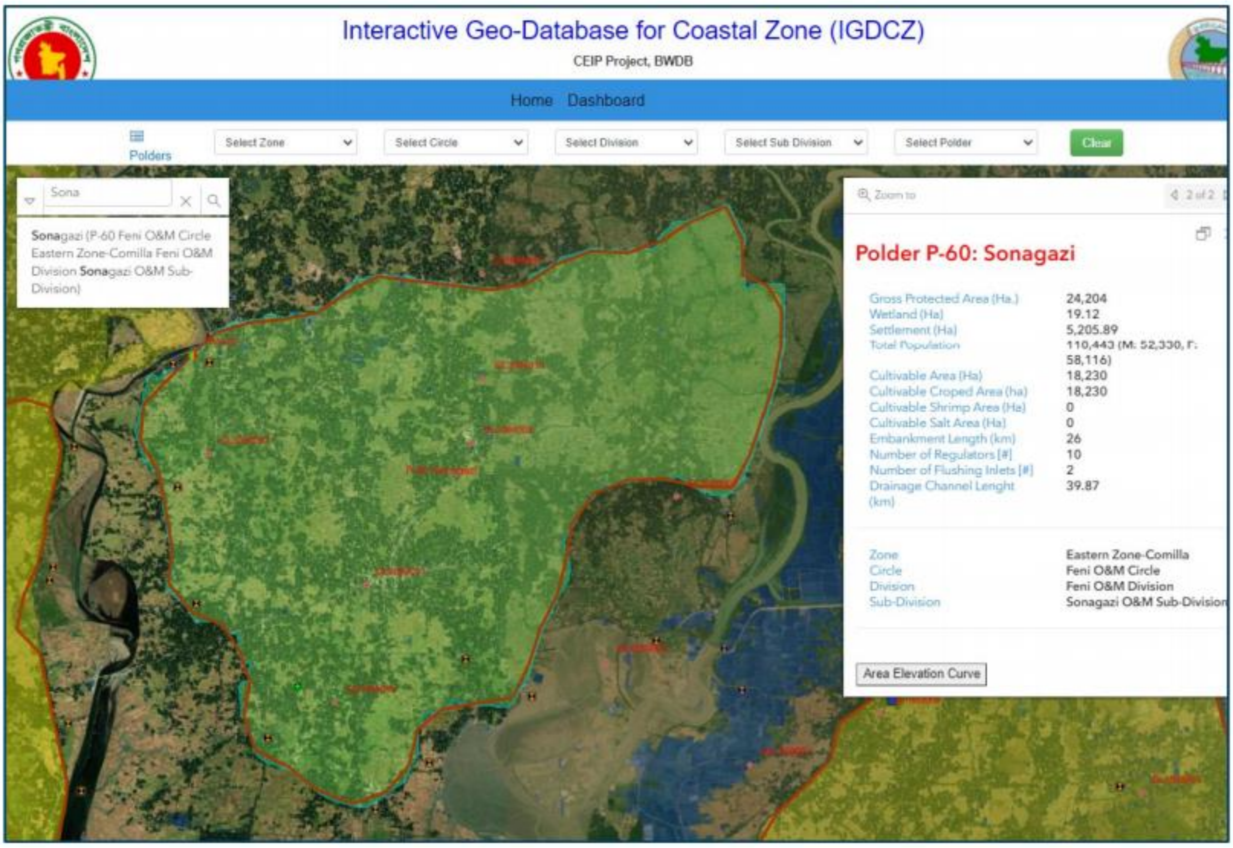
Developed by: Institute of Water Modeling (IWM)

Figure 3. 1: Dashboard of IGDCZ

- **Polder Data Modification**

  A web Interface of Polder Data modification tool has been developed with the core GIS module. User can search a particular polder by selecting a Zone, Circle, Division and Sub-division from Zone, Circle, Division and Sub-division list. Subsequently polder data can be modified on the selected polder attribute table in the database (**Figure 3.2**).

  Also, data polder information can be edited and updated through interactive interfaces. Data entry validation has been applied (**Figure 3.3**).



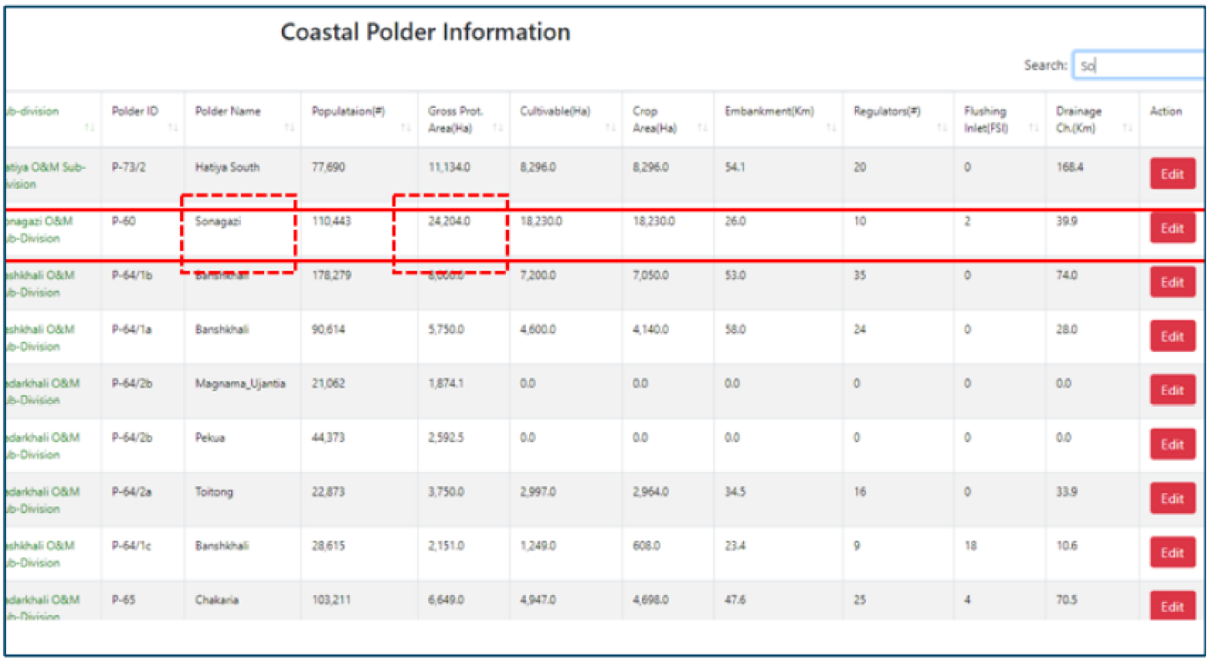
Sonagazi (P-60 Feni O&M Circle Eastern Zone-Comilla Feni O&M Division **Sona**gazi O&M Sub-Division)

Polder P-60: Sonagazi

Gross Protected Area (Ha.)	24,204
Wetland (Ha)	19.12
Settlement (Ha)	5,205.89
Total Population	110,443 (M: 52,330, F: 58,116)
Cultivable Area (Ha)	18,230
Cultivable Croped Area (ha)	18,230
Cultivable Shrimp Area (Ha)	0
Cultivable Salt Area (Ha)	0
Embankment Length (km)	26
Number of Regulators [#]	10
Number of Flushing Inlets [#]	2
Drainage Channel Lenght (km)	39.87

Zone	Eastern Zone-Comilla
Circle	Feni O&M Circle
Division	Feni O&M Division
Sub-Division	Sonagazi O&M Sub-Division

Figure 3.2: Interface of Polder Searching and Information


Coastal Polder Information

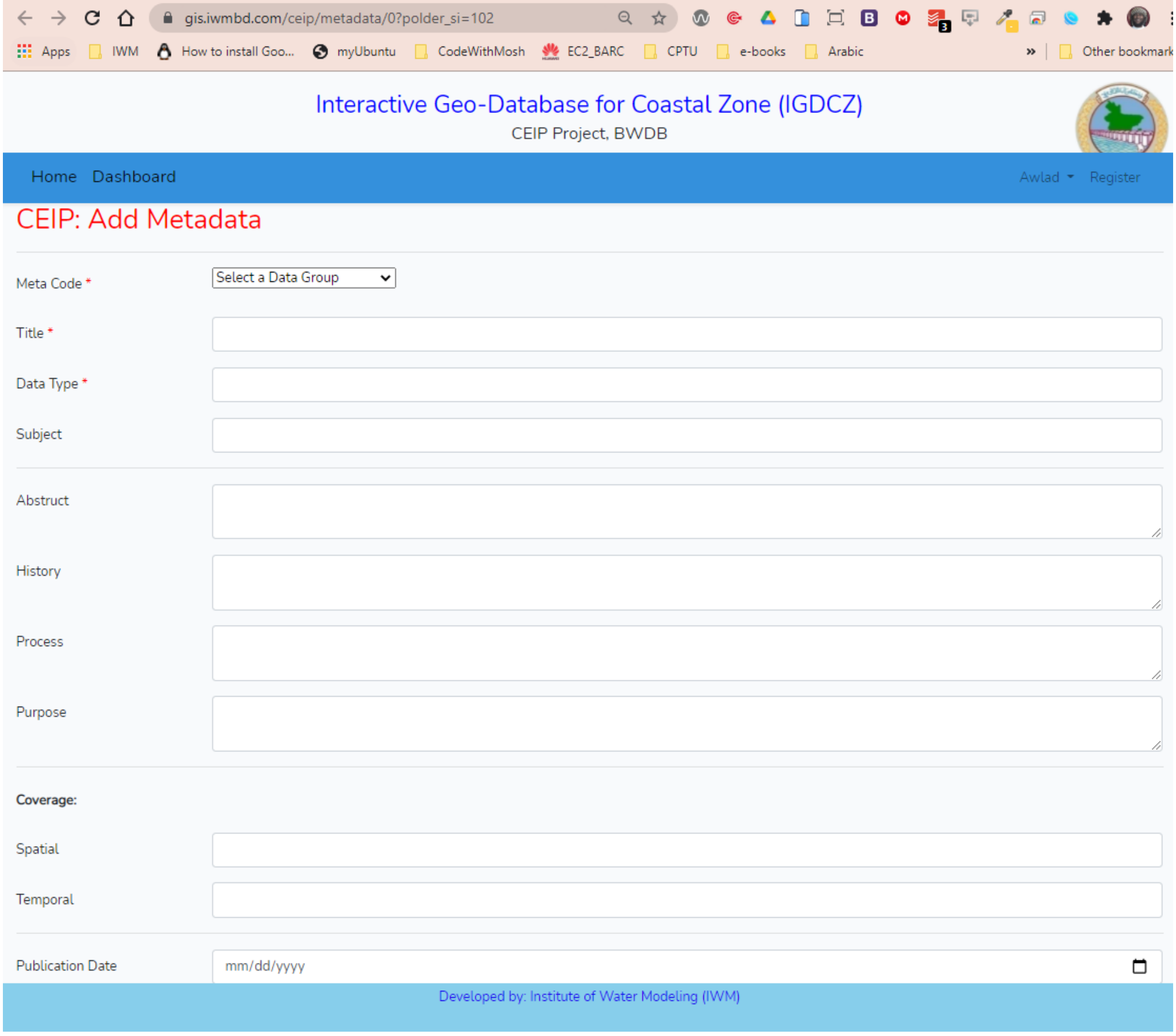
Search: So

ub-division	Polder ID	Polder Name	Populataion(#)	Gross Prot. Area(Ha)	Cultivable(Ha)	Crop Area(Ha)	Embankment(Km)	Regulators(#)	Flushing Inlet(FSI)	Drainage Ch.(Km)	Action
atiya O&M Sub-vision	P-73/2	Hatiya South	77,690	11,134.0	8,296.0	8,296.0	54.1	20	0	168.4	Edit
nagazi O&M b-Division	P-60	Sonagazi	110,443	24,204.0	18,230.0	18,230.0	26.0	10	2	39.9	Edit
shkhali O&M b-Division	P-64/1b	Banshkhali	178,279	8,000.0	7,200.0	7,050.0	53.0	35	0	74.0	Edit
shkhali O&M b-Division	P-64/1a	Banshkhali	90,614	5,750.0	4,600.0	4,140.0	58.0	24	0	28.0	Edit
darkhali O&M b-Division	P-64/2b	Magnama_Ujantia	21,062	1,874.1	0.0	0.0	0.0	0	0	0.0	Edit
darkhali O&M b-Division	P-64/2b	Pekua	44,373	2,592.5	0.0	0.0	0.0	0	0	0.0	Edit
darkhali O&M b-Division	P-64/2a	Toitong	22,873	3,750.0	2,997.0	2,964.0	34.5	16	0	33.9	Edit
shkhali O&M b-Division	P-64/1c	Banshkhali	28,615	2,151.0	1,249.0	608.0	23.4	9	18	10.6	Edit
darkhali O&M b-Division	P-65	Chakaria	103,211	6,649.0	4,947.0	4,698.0	47.6	25	4	70.5	Edit

Figure 3.3: Polder Interface with update option

- **Metadata module**

Metadata module has been started. The data entry form of Metadata is presented below (Figure 3.4).



Interactive Geo-Database for Coastal Zone (IGDCZ)
CEIP Project, BWDB

CEIP: Add Metadata

Meta Code * Select a Data Group
Title *
Data Type *
Subject
Abstruct
History
Process
Purpose

Coverage:

Spatial
Temporal
Publication Date mm/dd/yyyy

Developed by: Institute of Water Modeling (IWM)

Figure 3.4: Interface of Metadata updating

3.3.1 Data Handover to BWDB

As per the request of the Project Director (PD), the IWM consultant has provided 23 numbers of spatial layers (shapefiles) and tabular data as a first batch of data to the CEIP Project office (list is given in the appendix A2). The remaining data layers/datasets will be handed over to BWDB in future.

3.3.2 User Feedback

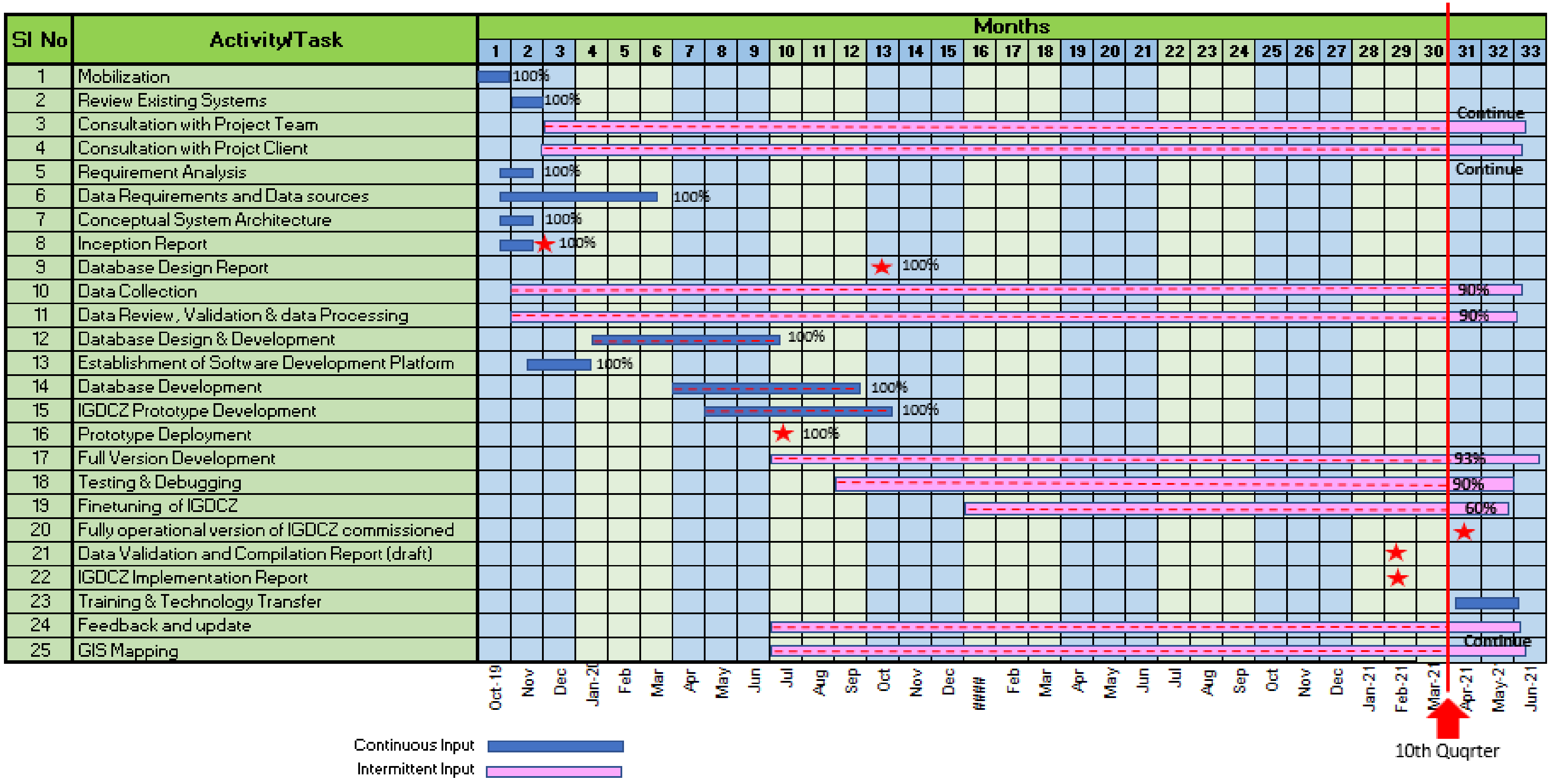
The web GIS based IGDCZ still under developing stage and hosted in development server at IWM. A significant progress has been made during the reported quarter by IWM team, concurrently, online feedback and suggestions received from the potential users of BWDB, World Bank and other stakeholders. Accordingly,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

3.4 Workplan

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

Work Plan (**Figure 3.5**) shows the workplan with current status of different tasks and activities.

Workplan of IGDCZ Development



Sl No	Activity/Task
1	Mobilization
2	Review Existing Systems
3	Consultation with Project Team
4	Consultation with Projct Client
5	Requirement Analysis
6	Data Requirements and Data sources
7	Conceptual System Architecture
8	Inception Report
9	Database Design Report
10	Data Collection
11	Data Review, Validation & data Processing
12	Database Design & Development
13	Establishment of Software Development Platform
14	Database Development
15	IGDCZ Prototype Development
16	Prototype Deployment
17	Full Version Development
18	Testing & Debugging
19	Finetuning of IGDCZ
20	Fully operational version of IGDCZ commissioned
21	Data Validation and Compilation Report (draft)
22	IGDCZ Implementation Report
23	Training & Technology Transfer
24	Feedback and update
25	GIS Mapping

Figure 3. 2: Workplan

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3.5 Plan for the Next Quarter

Table 3.2: Plan activities for next quarter

Sl No	Task & Activities	Progress (%) Upto 11th Quarter	Plan Progress (%) for Next Quarter	Overall Progress (%)
1	**Inception Phase**			
1.1	Review Existing Systems	100	-	100
1.2	Consultation with Project Team	continue		continue
1.3	Consultation with Project Client	continue		continue
1.4	Requirement Analysis	100	-	100
1.5	Data Requirements and Data sources	100	-	100
1.6	Conceptual System Architecture	100	-	100
1.7	Inception Report	100	-	100
2	**Data Collection and Processing**			
2.1	Coastal Bank Erosion (Satellite Image)	100	-	100
2.2	Land use Classification (Satellite Image)	85	15	100
2.3	Data Collection (shapefile & tabular)	90	5	95
2.4	Data Processing (shapefile & tabular)	90	5	95
3	**GIS Mapping**			
3.1	Polder Mappings & Processing	85	5	90
4	**Database Design & Development**			
4.1	Database Design Development	100	-	100
4.2	Database Design Report	100	-	100
4.3	Database Implement	90	5	95
5	**Web GIS Application Development**			
5.1	IGDCZ Prototype Development	100	-	100
5.2	Full Version Development	93	5	98
5.3	GIS Core Module	93	5	98
5.4	Dashboard Development	90	5	95

Sl No	Task & Activities	Progress (%) Upto 11th Quarter	Plan Progress (%) for Next Quarter	Overall Progress (%)
5.5	Metadata Preparation	50	20	70
5.6	Metadata Interface Development	60	20	60
5.7	User Administrative Module	90	5	95
5.8	Document Archiving	100	-	100
5.9	Tutorial (help tutorial)	100	-	100
5.10	Testing & Debugging	90	5	95
5.11	Data Validation and Check	92	5	97
5.12	Software & Hardware Procurement	-	-	-
5.13	Installation of SW and HW at BDWB Data Canter	-	-	-
5.14	Migration of Database and Application to BWDB Servers	-	-	-
5.15	Fully operational commissioning	-	-	-
5.16	Preparation of User Instruction Manual	-	20	20
6	**Reports**			
6.1	Database Implementation Report	Submitted		
6.2	Validation and Compilation Report (1st version)	Submitted		
7	**Training & Technology Transfer**	3 days training		
8	**Feedback and update (ongoing)**	12 comments were addressed		

4 CLIMATE CHANGE SCENARIO

4.1 Introduction

The report on Climate Change Scenario is submitted to the client on 27 June 2021. This chapter includes a very brief summary of the report. For details, main report needs to be followed.

Following the ToR of this project, the report is part of project Component-4D ("Meteorology") which has, as main goal, the definition of current and future trends in **rainfall**, **temperature**, **cyclone frequency** and **intensity** as a result of climate change. In addition, and for completeness, the report includes the assessment of **sea level rise** scenarios based on available data and recent literature. This deliverable provides the input to a number of project components as described in Figure 4.1, including both model- and non-model deliverables. Possible climate scenarios are put forward for the different variables analysed and (whenever possible) until the end of the century. These scenarios are used to assess the response of the physical system, based on numerical modelling, and towards the definition of new conceptual polder designs and the investment plan.

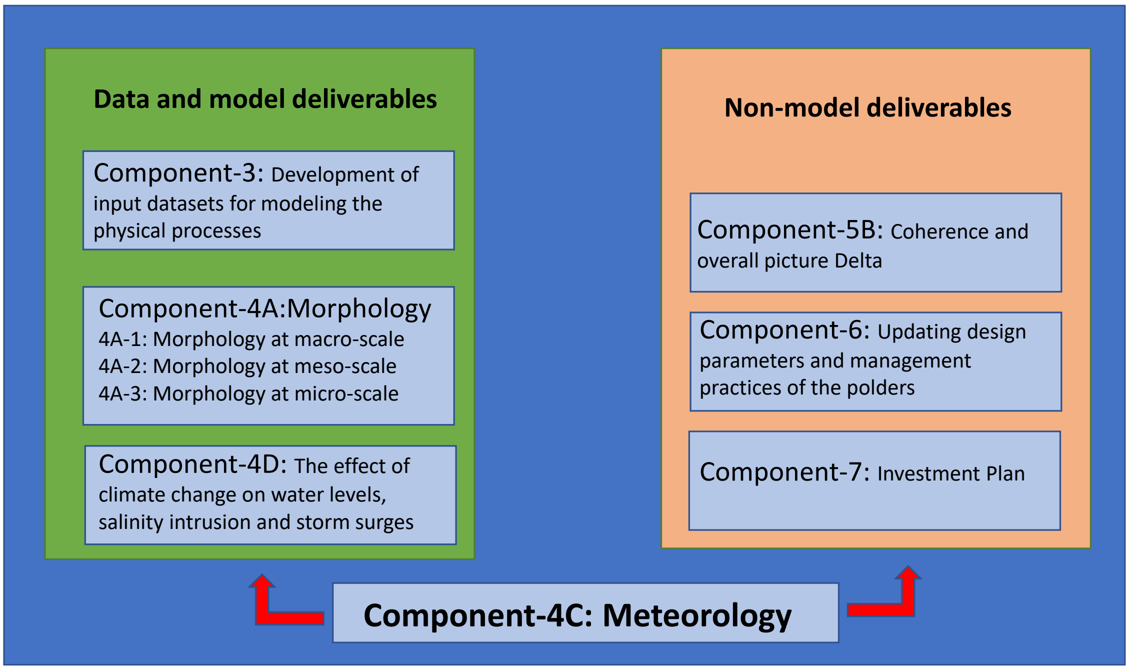


Figure 4.1: Overview of project components to which this report is providing input.

The spatial scale is focused both on the entire coastal region (and even GBM catchment for temperature and precipitation) and with particular emphasis on the five polders which will be analysed more in details as part of Component 5-A (i.e. 15, 29, 40/1 & 40/2, 59/2, 64/1a & 64/1b).

Different climate models provide substantially different projections. This means uncertainties in climate change are substantial and cannot be ignored. It is strongly advised against selecting a single climate scenario as input for model simulations, as such a scenario might be confused with a *prediction* instead of one of many possible *projections*. It is relevant to show stakeholders that there is large uncertainty involved and that it is important to be prepared for a range of scenarios.

Because climate change is highly uncertain and because different applications require focus on different climate characteristics, it is important to consider multiple climate change scenarios.

It is therefore proposed to apply a ‘tipping point approach’ (Kwadijk et al., 2010) in the follow-up phases of the project. This means evaluation is to be made on a number of plausible ‘fixed” scenarios without directly putting a label on it like a year, an emission scenario or a high/low bound’. For example, this can be a scenario like +10% precipitation, +30% precipitation or +2 degrees Celsius. Then analyse on how the various systems (macro-, meso- and microscale) respond to those changes and report on major “tipping points” i.e. where the system starts to behave significantly different from todays’ situation. Subsequently, we can *qualitatively* describe the likelihood of those scenarios in a particular year and emission scenario, based on the available climate projections.

This report is organized as follows: **Chapter 1** provides a general introduction to the report, while **Chapter 2** describes the approach and methodology used for the analysis. The data used for the analysis of the different variables are described as part of **Chapter 3**. **Chapter 4** presents an overview of major results and, finally, **Chapter 5** provides a summary of major conclusions and proposed scenarios for further use in upcoming model and non-model deliverables.

4.2 Approach and Methodology

4.2.1 Rainfall and temperature

The general concept has been:

- Analyse the current climate conditions and quantify its most relevant statistical characteristics.
- Analyse projections from various Global Climate Models (GCMs) and quantify how these relevant characteristics may change over time in the coming decades.
- Quantify projected changes in climate conditions in terms of percentages (precipitation) or absolute differences (temperature).
- Superimpose these projected changes on data from historic records. For rainfall and temperature in Bangladesh, projected changes will be superimposed on available records of the approximately 30 climate stations spread over the country.

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

4.2.2 Sea level rise

To assess relative changes in sea level the following approach was used:

- We first analyse past trends of absolute (ASLR) and relative sea level rise (RSLR) and subsidence based on most recent literature. Note that subsidence will be further analysed based on new data collected under this project as part of Component 4B.
- Then we retrieve regional projection of ASLR based on different future projections and until the end of the century. For our analysis, we will use four coastal regions as basis as done, for example, in the Bangladesh Delta Plan (GED, 2018)[1].

---

[1] The four coastal regions are: South West (Sundarbans), South Central (Ganges tidal flats), South East (Ganges Meghna Flats), Easter Hill (Chittagong Coastal Plain)

- Additionally, we provide future subsidence values available at the same regions, and which can be used to obtain RSLR values.

As different projections are expected to provide very different values, a suggestion of plausible values for further use in the project we will be provided.

4.2.3 Cyclone frequency and intensity

Possible changes in cyclone frequency and intensity will be analysed as follow:

- Look into possible trends based on past data;
- Analysis and compare different future projections;
- Finally, give suggestion of plausible values for further use in the project based on the analysis of past and future trends.

4.3 Data

Climate data consist of time series. There are three types of time series relevant here:

[1] Observed data from gauging stations;

[2] Re-analysis data: estimates of historic time series by a combination of combination of models and observations;

[3] Projected future scenarios from climate models;

[1] and [2] will be used to characterise the current (‘reference’) climate conditions, whereas [3] will be used to characterise projections of future conditions. Results from [2] and [3] will be compared to assess relative changes in climate conditions.

4.4 Results

Results from the analysis are presented in chapter 4 of the report (Climate Change Scenarios) at different spatial scale, depending on the variable analysed:

- For the entire country;
- For the four morphological zones as defined for example in the Bangladesh Delta Plan (Figure 4.2);
- For the five selected polders (i.e. 15, 29, 40/1 & 40/2, 59/2, 64/1a & 64/1b) (Figure 4.3).

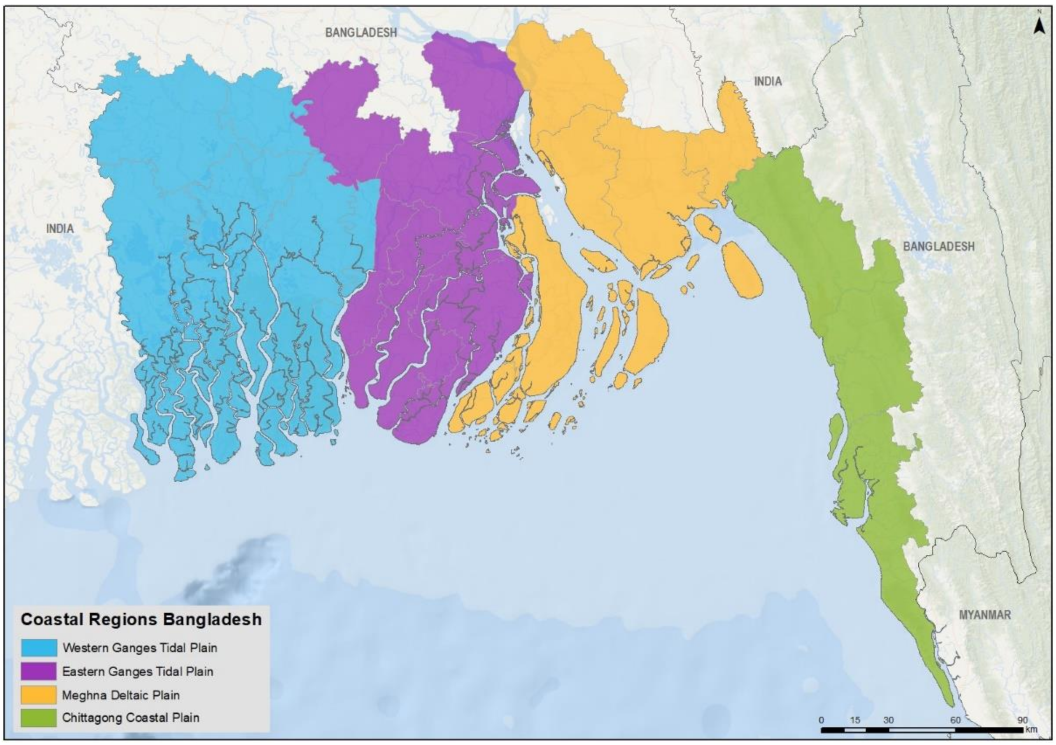


Figure 4.2: Morphological zones of the coastal area of Bangladesh as used in the Delta Plan (GED, 2018).

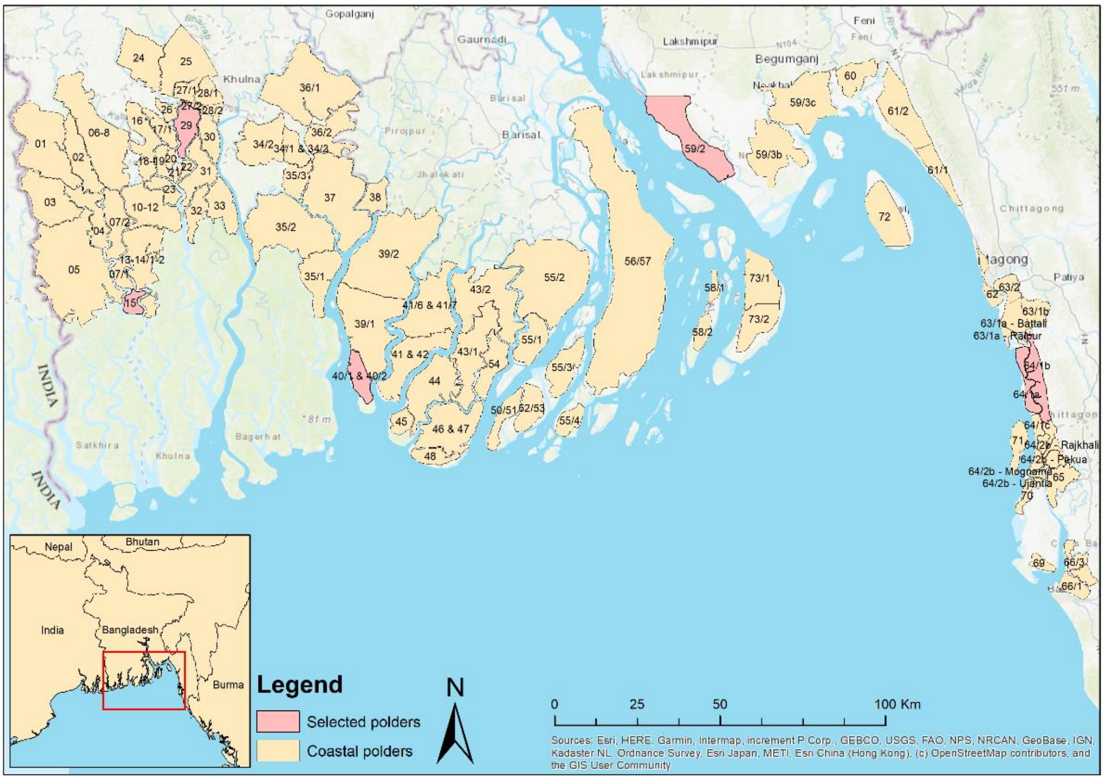


Figure 4.3: Map of the five selected polders.

4.5 Conclusions and proposed climate scenarios

4.5.1 Conclusions

The main conclusions from the study are summarized in the following sub-sections for each different variable analysed. Based on these conclusions, a number of suggestions for possible climate scenarios to be further used in the study are identified.

4.5.2 Precipitation

An analysis of historical precipitation and temperature records, available for the period 1948-2007 for ~30 stations in Bangladesh, revealed a number of statistically significant trends. Several tests indicate that the winter season has an overall negative trend in precipitation, whereas the post-monsoon season and the whole year have an increasing trend. Note that this conclusion is based on the combination of all stations, individual stations sometimes have trends that are opposite of the general trend.

- Measured past precipitation data over Bangladesh indicate a slightly increase in monsoon rainfall, annual and maximum daily rainfall. On the other hand, winter rainfall appeared to decrease overall (drier winters).
- Future projections by most models indicate a tendency over Bangladesh towards an increase in monsoon and annual precipitation but accompanied by drier winters.
- The range in projected changes in annual mean precipitation in Bangladesh is about 15% in 2020 (-5% to +10%), 20% in 2040 (-10% to +10%), 30% in 2060 (-10% to +20%) and 30% in 2080 (-5% to +25%)
- The conclusions for Bangladesh are also valid for the five polders analysed in detail under this project (15, 29, 40 (1&2), 59/2, 64/1a and 64/1b). In particular at these polders an increase in precipitation in the monsoon season after 2050 is observed, and a decrease in precipitation in the winter season.
- Differences in future projections based on our study and as reported in the Delta Plan are observed (Figure 4.4).
- For the GBM basin as a whole, future projections by most models indicate an increase in monsoon precipitation as well, and a decrease in winter precipitation. Projected percentage changes for the Ganges basin are larger than for the Brahmaputra basin.

4.5.3 Temperature

- Measured past temperature data over Bangladesh indicate an overall increase in mean temperature, mostly as a result of an increase in mean and maximum temperature during monsoon and post-monsoon seasons. More variability can be seen during pre-monsoon and winter. Overall, this suggests a trend towards warmer and wetter monsoon and post-monsoon, and towards (slightly) colder and drier winters.
- Future projections for different models are consistent, indicating a temperature increase over the entire GBM basin. Increases are largest in winter and especially in the Himalaya region.
- The RCP 8.5 scenarios is projected to causes bigger temperature increases than the RCP 4.5 scenario.
- Also, for Bangladesh there is consistency among all models towards a clear increase in future temperature in all seasons.

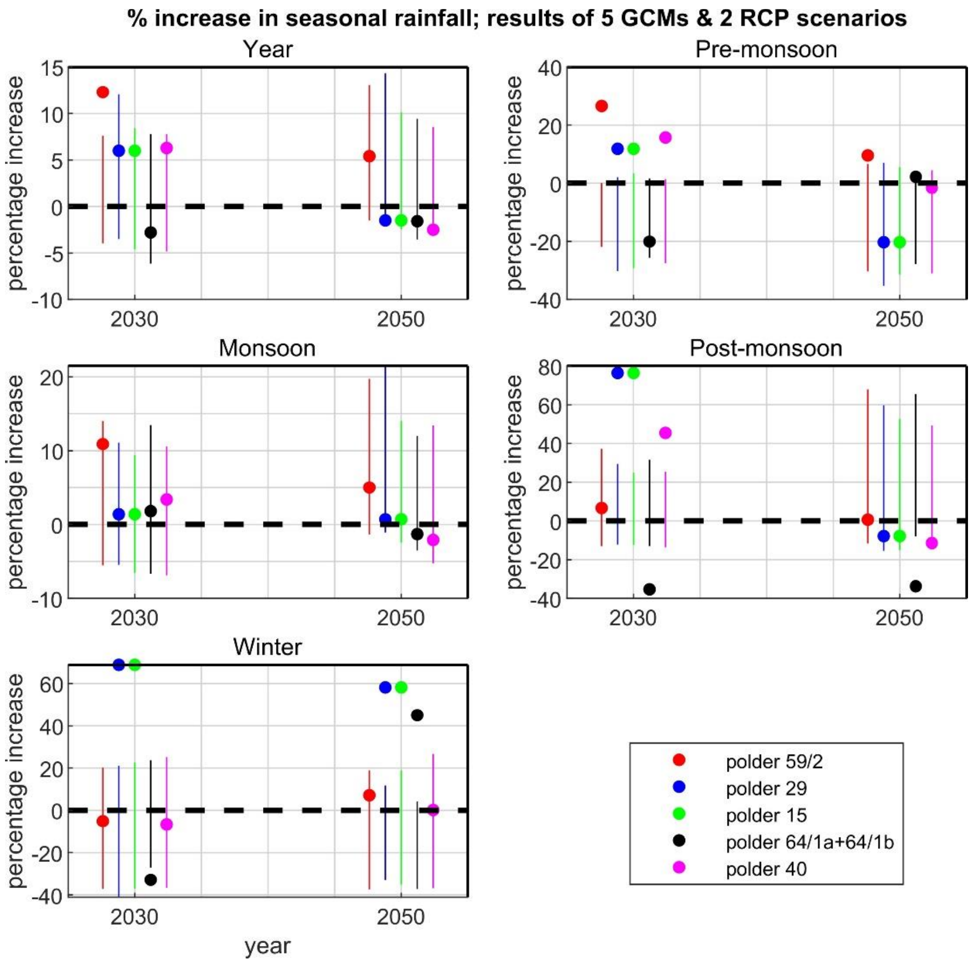


Figure 4.4: Projected percentage change in maximum daily precipitation in the 5 selected polders for 4 different seasons and for the entire year, relative to climate year 1990. Each vertical line represents the range in percentage increase for combinations of RCP-scenarios (2) and climate-models (5). The dots show the projections from the Bangladesh Delta Plan (GED, 2018).

4.5.4 Sea level rise

- Relative sea level rise across the GBM delta can be locally several time larger than global absolute sea level rise as a result of local subsidence (see e.g. Syvitski et al., 2009; Becker et al., 2020, Steckler et al., 2021).

- It is expected that the effect of subsidence will have a similar (or locally even larger) effect than absolute sea level rise in the future, at least in the short- and medium-term (Table 4.1).

- Differences in absolute sea level rise scenarios across the delta are minimal (Table 4.2 and Table 4.3) and can be well approximated by one averaged value. However, local differences in relative sea level rise are important and are related to local differences in subsidence levels. In addition, changes in high water, tidal range and mean water levels within (some of) the river channels and resulting from long-term morphological processes can be locally much larger than the rise in global absolute sea level rise (see Deliverable D4A-2; “Effect of human interventions on tidal and sediment dynamics in the Pussur-Sibsa basin”).

- Regional absolute sea level rise projections following SROCC data (IPCC, 2019; Oppenheimer et al. 2019), indicate mean sea level rise values by 2100 for Bangladesh equal to 0.473 m (95% = 0.661m) according to RCP4.5 and 0.756 m (95% = 1.049m) according to RCP8.5 (Table 4.2 and Table 4.3).

- Recent studies have described physically plausible mechanisms leading to high-end SLR scenarios as a result of accelerated ice mass-loss from Antarctica and Greenland. These processes could lead to a median value increase in mean sea level up to (or beyond) 2 m by 2100. It is advisable to take these high-end values into account in the long-term planning of the polders across the GBM delta.

Table 4.1: Proposed regional absolute sea level scenarios (i.e. 0.25m, 0.5m, 1.0m and 2.0m) and approximate year when the sea level rise may be reached according to RCP4.5 and RCP8.5 scenarios, based on SROCC projections (IPCC, 2019; Oppenheimer et al. 2019). Years are estimated respectively for a 5, 50 and 95 percentile. In addition to the year when the absolute sea level rise will be reached, subsidence values are provided for each coastal region (W=Western Ganges; E=Eastern Ganges; M=Meghna; C=Chittagong) and estimated based on Becker et al. (2020) (i.e. for E, W, and M) and Ostanciaux et al. (2012) for C.

	%	MSL	0.25 m				0.50 m				1.00 m				2.00 m			
RCP 4.5	**5**	**Year**	**2083**				**2147**				**2294**				**2416**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.19	0.55	0.41	0.47	0.34	0.99	0.74	0.85	0.69	2.02	1.50	1.73	0.99	2.88	2.14	2.47
	50	**Year**	**2063**				**2105**				**2195**				**2394**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.14	0.41	0.30	0.35	0.24	0.70	0.52	0.60	0.46	1.33	0.99	1.14	0.93	2.72	2.02	2.33
	95	**Year**	**2046**				**2082**				**2148**				**2288**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.10	0.29	0.21	0.25	0.18	0.54	0.40	0.46	0.34	1.00	0.74	0.86	0.68	1.98	1.47	1.70
RCP 8.5	**5**	**Year**	**2070**				**2098**				**2159**				**2271**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.16	0.46	0.34	0.39	0.22	0.65	0.48	0.56	0.37	1.08	0.80	0.92	0.64	1.86	1.38	1.60
	50	**Year**	**2055**				**2081**				**2119**				**2194**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.12	0.35	0.26	0.30	0.18	0.53	0.40	0.46	0.27	0.80	0.59	0.68	0.45	1.32	0.98	1.13
	95	**Year**	**2042**				**2068**				**2099**				**2151**			
		Zone	W	E	M	C	W	E	M	C	W	E	M	C	W	E	M	C
		VLM	0.09	0.26	0.19	0.22	0.15	0.44	0.33	0.38	0.23	0.66	0.49	0.56	0.35	1.02	0.76	0.88

Table 4.2: Regional and global ASLR projections for the 21st century at the five closest locations along the Bangladesh coast (Figure 4.57) and averaged values of the five locations, according to RCP 4.5 scenario. Mean values are provided in bolds while associated uncertainties (5 and 95%) are included in brackets. Long-term estimates for 2200 and 2300 are only available based on global projections (GMSL).

Time	**Total Sea Level Rise – RCP 4.5 [m] (Rel. to 1986 to 2005)**						
	1	**2**	**3**	**4**	**5**	**MEAN**	**GMSL**
2020	**0.057** [-0.006 to 0.121]	**0.053** [-0.016 to 0.123]	**0.055** [-0.01 to 0.121]	**0.054** [-0.001 to 0.109]	**0.055** [-0.014 to 0.124]	**0.055** [-0.009 to 0.12]	**0.081** [0.057 to 0.104]
2040	**0.135** [0.067 to 0.208]	**0.137** [0.069 to 0.21]	**0.126** [0.078 to 0.179]	**0.129** [0.082 to 0.183]	**0.133** [0.088 to 0.184]	**0.132** [0.077 to 0.193]	**0.172** [0.124 to 0.221]
2050	**0.181** [0.079 to 0.297]	**0.185** [0.081 to 0.301]	**0.164** [0.09 to 0.247]	**0.164** [0.103 to 0.233]	**0.176** [0.104 to 0.255]	**0.174** [0.091 to 0.266]	**0.228** [0.165 to 0.293]
2060	**0.235** [0.115 to 0.373]	**0.234** [0.111 to 0.366]	**0.230** [0.126 to 0.345]	**0.231** [0.137 to 0.34]	**0.240** [0.137 to 0.354]	**0.234** [0.125 to 0.356]	**0.288** [0.206 to 0.373]
2080	**0.351** [0.207 to 0.515]	**0.350** [0.201 to 0.515]	**0.329** [0.211 to 0.466]	**0.336** [0.221 to 0.468]	**0.341** [0.229 to 0.47]	**0.341** [0.214 to 0.487]	**0.417** [0.296 to 0.545]
2100	**0.487** [0.301 to 0.699]	**0.489** [0.303 to 0.702]	**0.458** [0.324 to 0.627]	**0.457** [0.315 to 0.628]	**0.471** [0.323 to 0.648]	**0.473** [0.313 to 0.661]	**0.549** [0.385 to 0.724]
2200	- -						**1.03** [0.710 to 1.380]
2300	- -						**1.53** [1.020 to 2.090]

Table 4.3: Regional and global ASLR projections for the 21st century at the five closest locations along the Bangladesh coast (Error! Reference source not found.**) and averaged values of the five locations, according to RCP 8.5 scenario. Mean values are provided in bolds while associated uncertainties (5 and 95%) are included in brackets. Long-term estimates for 2200 and 2300 are only available based on global projections (GMSL).**

Time	**Total Sea Level Rise – RCP 8.5 [m] (Rel. to 1986 to 2005)**						
	1	**2**	**3**	**4**	**5**	**MEAN**	**GMSL**
2020	**0.059** [0.008 to 0.114]	**0.058** [0.007 to 0.11]	**0.059** [0.004 to 0.115]	**0.064** [0.011 to 0.118]	**0.062** [0.012 to 0.114]	**0.061** [0.008 to 0.114]	**0.085** [0.061 to 0.109]
2040	**0.165** [0.084 to 0.25]	**0.166** [0.088 to 0.251]	**0.153** [0.084 to 0.227]	**0.154** [0.09 to 0.223]	**0.162** [0.096 to 0.233]	**0.160** [0.088 to 0.237]	**0.195** [0.142 to 0.250]
2050	**0.216** [0.117 to 0.325]	**0.213** [0.112 to 0.325]	**0.197** [0.115 to 0.287]	**0.206** [0.135 to 0.284]	**0.209** [0.133 to 0.295]	**0.208** [0.122 to 0.303]	**0.268** [0.196 to 0.343]
2060	**0.295** [0.187 to 0.416]	**0.296** [0.19 to 0.416]	**0.286** [0.19 to 0.398]	**0.296** [0.197 to 0.407]	**0.299** [0.203 to 0.41]	**0.294** [0.193 to 0.409]	**0.353** [0.259 to 0.454]
2080	**0.505** [0.323 to 0.715]	**0.506** [0.326 to 0.711]	**0.475** [0.332 to 0.652]	**0.486** [0.332 to 0.672]	**0.500** [0.344 to 0.681]	**0.494** [0.331 to 0.686]	**0.568** [0.415 to 0.738]
2100	**0.764** [0.506 to 1.081]	**0.764** [0.509 to 1.078]	**0.741** [0.514 to 1.021]	**0.750** [0.521 to 1.028]	**0.760** [0.532 to 1.037]	**0.756** [0.516 to 1.049]	**0.842** [0.609 to 1.105]
2200	- -						**2.080** [1.340 to 2.920]
2300	- -						**3.700** [2.280 to 5.37]

4.5.5 Cyclone frequency and intensity

- Warming of the surface oceans as a result of climate change is likely fuelling more powerful TCs.
- Analysis of historical data from 1972 in the North Indian Ocean and Bay of Bengal indicates that the number of most sever cyclones (cat 4-5) has increased over time. Differently, the total number of cyclones does not show a clear trend over time and may even have decreased in time.
- Future changes in TC frequency and intensity depends on the chosen scenario. The most recent regional projections by Knutson et al. (2019, 2020) are derived assuming a 2°C global mean surface temperature increase. These projections indicate, for the North Indian Ocean, a median change in frequency for all TC equal to about -5%, with an interquartile range equal to -15% / +6%, and with a 5th/95th percentiles equal to about -35% / +30%. When looking at the very intense TC only (cat 4-5), the prediction suggests a mean increase in frequency of about +5% with an interquartile range equal to -15% / +40% and a 10th/90th percentile equal to -70% / +80%.
- Following Knutson et al. (2019, 2020), changes in TC intensity suggest an overall increase of about +4%, with an interquartile range equal to +2% / +6%, and a 10th/90th percentile equal to -1% and +8%.
- Following Knutson et al. (2019, 2020), changes in TC induced precipitation suggest a median increase equal to about +18%, with an interquartile range equal to +14% / +19%, and a 10th/90th percentile equal to +12% and +20%.
- TCs induced precipitations are projected to increase due to enhanced atmospheric moisture associated with anthropogenic global warming.
- According to global CMIP5 climate models, as applied in Knutson et al. (2020) a mean 2°C surface temperature increase will be reached around mid-century, under RCP 8.5 scenario. It is likely that these temperature increase will be largely exceeded by the end of the century. However, the uncertainties are currently too large to provide reliable projections for more extreme scenarios, which could be valid for larger temperature increases.
- The impact of individual TCs will be largely amplified by rising sea levels.

4.6 Proposed scenarios to be applied in upcoming deliverables

Uncertainties in climate change projections are large, depending on the climate model used. For this reason, multiple climate change scenarios have been considered in this report. It is noted that these projections are regularly updated over time. For example, new updated projections will be published in 2022, by the IPCC Sixth Assessment Report (AR6).

In addition, different scenarios are used for different purposes, for example depending on whether the scenario is used for the design of a specific structure or for long-term planning purposes, and also according to the life-time of the structure to be designed. Also, how a specific variable is described in the scenario depends on the specific application (e.g. averaged precipitation values may be relevant to assess fresh water availability, while extreme values may be more relevant for a flood assessment study).

Therefore, in this section we will provide a “generic” and “fixed” set of plausible scenarios based on the information analysed as part of this report and most recent literature, and which can be used for different applications as part of this project and in follow-up deliverables. “Fixed” means that they will not be linked to a specific year, but rather provide a range of plausible values, while the year can be computed based on the climate projections used. This will allow testing how the system may respond to different changes, following a “tipping point approach” (Kwadijk et al., 2010).

4.6.1 Precipitation

Daily mean precipitation

A ‘low’, median’ and ‘high’ scenario of the percentage change in daily mean precipitation (Table 4.4) is proposed for:

- five polders;
- four seasons and the whole year;
- three time horizons.

The numbers represent the percentage change in daily mean precipitation, relative to the year 2020. The low, median and high scenarios correspond to 20-, 50- and 80-percentiles of the changes derived from the various GCM runs.

Table 4.4: Proposed precipitation scenarios for the five selected polders. The numbers represent the percentage change in daily mean precipitation, relative to the year 2020.

	Year:	**2040**			**2070**			**2100**		
	Scenario:	**low**	**median**	**high**	**low**	**median**	**high**	**low**	**median**	**high**
Year	**polder 59/2**	-6.2	-0.1	5.2	-0.5	5.9	15.9	3.0	11.5	21.2
	polder 29	-4.6	0.8	7.8	-0.1	6.5	16.6	5.0	9.8	22.2
	polder 15	-5.2	-0.8	6.6	-0.5	5.2	13.6	2.8	10.0	17.6
	polder 64/1a+64/1b	-4.5	-1.2	4.4	-1.1	5.7	10.3	1.5	7.8	12.8
	polder 40	-6.2	-1.1	5.9	-1.1	5.3	13.4	3.0	10.4	18.2
Pre-monsoon	**polder 59/2**	-17.1	-4.4	3.1	-7.6	6.5	17.7	8.2	17.9	23.8
	polder 29	-15.5	-3.5	8.1	-4.8	8.0	26.8	7.5	24.7	31.6
	polder 15	-12.5	-0.6	5.1	-3.7	8.7	27.7	8.0	22.0	33.2
	polder 64/1a+64/1b	-15.4	-5.4	-1.5	-8.1	2.6	17.9	0.7	7.3	28.7
	polder 40	-12.3	-1.1	4.3	-5.5	8.1	23.3	8.8	24.5	30.0
Monsoon	**polder 59/2**	-3.6	1.7	7.0	1.2	5.1	15.8	8.0	10.4	23.4
	polder 29	-4.0	1.2	8.6	0.5	5.5	16.4	7.1	12.4	25.3
	polder 15	-4.7	0.3	6.9	-0.1	4.0	13.8	6.5	9.2	19.6
	polder 64/1a+64/1b	-2.8	0.0	5.8	-1.8	5.4	11.2	0.4	9.0	13.0
	polder 40	-4.6	0.7	6.6	-0.6	4.0	14.3	5.0	9.0	18.9
Post-monsoon	**polder 59/2**	-21.2	0.3	17.7	-12.1	4.9	26.6	-13.6	4.6	30.1
	polder 29	-22.9	1.5	19.7	-12.3	5.4	27.7	-17.4	4.7	30.8
	polder 15	-23.0	1.2	18.5	-13.2	5.2	27.3	-16.2	5.2	30.7
	polder 64/1a+64/1b	-16.2	-0.4	10.5	-14.0	6.2	24.2	-10.6	7.1	24.8
	polder 40	-22.5	-1.3	19.6	-11.3	4.8	25.9	-12.5	5.9	30.9
Winter	**polder 59/2**	-9.6	14.1	39.4	-40.1	8.0	49.6	-67.6	-15.8	15.9
	polder 29	-8.1	8.1	43.1	-37.4	5.2	37.3	-55.8	-7.1	13.1
	polder 15	-8.9	8.8	40.5	-40.5	2.8	34.9	-57.9	-11.2	12.7
	polder 64/1a+64/1b	-11.5	6.3	24.2	-36.3	-10.0	47.2	-56.3	-14.8	15.8
	polder 40	-9.8	13.2	42.6	-43.9	4.0	39.9	-66.1	-13.9	12.6

Annual maximum daily precipitation

For rainfall-induced flood studies, the annual maximum daily precipitation (Table 4.5) is a better indicator. A ‘low’, median’ and ‘high’ scenario of the percentage change in annual maximum daily precipitation are proposed for:

- five polders;
- the whole year;
- three time horizons.

The difference with ***Daily mean precipitation*** is that no scenarios are derived for the various seasons, only for the whole year. The numbers represent the percentage change in annual maximum daily precipitation, relative to the year 2020. The low, median and high scenarios correspond to 20-, 50- and 80-percentiles of the changes derived from the various GCM runs.

Table 4.5: Proposed precipitation scenarios for the five selected polders. The numbers represent the percentage change in annual maximum daily precipitation, relative to the year 2020.

	Year:	**2040**			**2070**			**2100**		
	Scenario:	**low**	**median**	**high**	**low**	**median**	**high**	**low**	**median**	**high**
Year	**polder 59/2**	-9.2	-1.1	10.2	-0.3	10.6	28.3	7.8	19.0	37.4
	polder 29	-2.1	1.5	13.8	-1.5	7.5	25.1	2.8	10.7	26.6
	polder 15	-2.8	2.6	14.1	-0.5	8.2	23.0	6.0	18.1	26.8
	polder 64/1a+64/1b	-7.9	0.3	7.3	-0.8	10.4	23.2	5.1	13.6	26.7
	polder 40	-7.1	0.8	12.2	-3.6	7.6	23.0	3.4	14.3	28.2

4.6.2 Temperature

A ‘low’, median’ and ‘high’ scenario of the change in daily mean temperature (Table 4.6) are proposed for:

- five polders;
- four seasons and the whole year;
- three time horizons.

The numbers represent the change in daily mean temperature in degrees, relative to the year 2020. The low, median and high scenarios correspond to 20-, 50- and 80-percentiles of changes derived from the various GCM runs.

Table 4.6: Proposed temperature scenarios for the five selected polders. The numbers represent the change in daily mean temperature in degrees, relative to the year 2020.

	Year:	2040			2070			2100		
	Scenario:	low	median	high	low	median	high	low	median	high
Year	**polder 59/2**	0.6	0.7	1.0	1.1	1.5	2.3	1.3	2.2	3.6
	polder 29	0.6	0.7	1.0	1.0	1.4	2.2	1.3	2.2	3.5
	polder 15	0.6	0.7	0.9	1.0	1.4	2.1	1.2	2.1	3.3
	polder 64/1a+64/1b	0.5	0.7	1.0	1.0	1.5	2.2	1.3	2.2	3.5
	polder 40	0.6	0.7	0.9	1.0	1.4	2.1	1.2	2.1	3.3
Pre-monsoon	**polder 59/2**	0.5	0.7	1.1	1.0	1.5	2.4	1.5	2.2	3.8
	polder 29	0.5	0.7	1.2	0.9	1.6	2.4	1.4	2.2	3.7
	polder 15	0.5	0.6	1.0	0.9	1.5	2.2	1.3	2.1	3.4
	polder 64/1a+64/1b	0.5	0.7	1.1	1.0	1.4	2.4	1.3	2.1	3.7
	polder 40	0.5	0.6	1.1	0.9	1.5	2.1	1.3	2.1	3.3
Monsoon	**polder 59/2**	0.4	0.6	0.8	0.7	1.2	1.9	1.0	1.8	3.1
	polder 29	0.4	0.6	0.8	0.7	1.3	1.9	0.9	1.8	3.1
	polder 15	0.4	0.6	0.8	0.7	1.2	1.8	0.9	1.8	2.9
	polder 64/1a+64/1b	0.4	0.6	0.8	0.7	1.2	1.9	0.9	1.8	3.0
	polder 40	0.4	0.6	0.8	0.7	1.2	1.8	1.0	1.7	2.9
Post-monsoon	**polder 59/2**	0.6	0.9	1.0	1.1	1.7	2.1	1.3	2.5	3.2
	polder 29	0.6	0.9	1.0	1.1	1.7	2.1	1.3	2.5	3.2
	polder 15	0.6	0.8	1.0	1.0	1.7	2.0	1.2	2.4	3.1
	polder 64/1a+64/1b	0.6	0.8	0.9	1.1	1.6	2.0	1.3	2.4	3.2
	polder 40	0.6	0.8	1.0	1.1	1.6	2.0	1.2	2.4	3.1
Winter	**polder 59/2**	0.7	0.8	1.1	1.3	1.7	2.5	1.6	2.5	3.8
	polder 29	0.7	0.8	1.1	1.3	1.6	2.4	1.5	2.4	3.6
	polder 15	0.7	0.8	1.0	1.3	1.5	2.3	1.4	2.3	3.5
	polder 64/1a+64/1b	0.7	0.8	1.1	1.3	1.6	2.4	1.5	2.3	3.8
	polder 40	0.6	0.7	1.0	1.3	1.5	2.3	1.4	2.3	3.5

4.6.3 Sea level rise

For sea level rise, we suggest using a set of four different ASLR scenarios (0.25m, 0.5m, 1.0m and 2.0 m) as described in Table 4.1, depending on the application. The table indicates when the ASLR scenario may be reached, based on SROCC projections (IPCC, 2019; Oppenheimer et al. 2019), according to RCP 4.5 and RCP 8.5 scenarios, and for three different percentile values (5%, median and 95%). Note that as regional projections are only available up to 2100, values beyond this year are based on global projections (Table 4.2 and Table 4.3). The table also indicates the estimated subsidence value for each of the four coastal regions and which, depending on the application, should be added to the ASLR in order to get a total RSLR. For Western Ganges (W), Eastern Ganges (E) and Meghna (M) maximum subsidence values are based on Becker et al. (2020) (Table 4.7), while for Chittagong values are derived based on Ostanciaux et al. (2012) and equal to 6 mm/year, as these are not available from Becker at al. (2020). Note that new subsidence estimates, based on new data collected as part of this project, are also being derived and they will be described as part of Component-4B. Preliminary estimates suggest that subsidence values may be up to ≈15 mm/year in areas of active sedimentation, while values expected for buildings and embankments are lower, and up to ≈ 8 mm/y (Steckler et al., 2021). The differences in reported values between Becker et al. (2020) and Steckler et al. (2021) are most likely related to the different measurement techniques used to collect these measurements.

While ASLR values of 0.25 m and 0.5 m will be relevant for applications with time-scale of decades, as indicated by the exceedance years in Table 4.1, ASLR values of 1.0 and 2.0 m, will be relevant for long-term planning purposes (i.e. 100 years and beyond) or to assess the long-term morphological responses of the GBM delta system to SLR (e.g. deliverable D4A-1).

Design conditions of embankment crest levels during CEIP-I were derived assuming a RSLR of 50 cm with reference to the current situation and which would account for absolute sea level rise, regional subsidence and effect of sediment deposition from upstream rivers (see e.g. IWM & Royal Haskoning, 2018). This value was used for example in CEIP-I as input in the storm surge and wave modelling, across the Bay of Bengal, which was then used to derive the design conditions. Note that the effect of sediment deposition from upstream rivers has an opposite effect than subsidence and could even offset subsidence in case of sufficient sediment input and homogeneous redistribution across the delta. In addition, embankment design in CEIP-I included an additional allowance for initial subsidence at the embankment equal to 30 cm, to account for initial compaction, consolidation and other local effects after construction.

When comparing a RSLR value of 50 cm with the exceeding years as presented in Table 4.1, one can see that a 50 cm value may be sufficient to derive design conditions for a planning scenario of about 20-30 years, depending on the emission scenario and specific subsidence rate. However, design conditions for a longer timeframe (e.g. 50 years) should take into account higher RSLR and up to ≈ 90-100 cm.

Table 4.7: Relative sea level rise estimated based on water level gauges for the period 1968-2012, absolute sea level rise estimated based on satellite altimetry data for the period 1993-2012 and expected max subsidence for the period 1993-2012. The P-values in brackets provide an indication of how statistically significant trends are (see Appendix A) (adapted from Becker et al., 2020).

Region	Relative sea level rise 1968-2012 (mm/y)	Absolute sea level rise 1993-2012 (mm/y)	Expected max subsidence 1993-2012 (mm/y)
Western Ganges Tidal Plain	2.7 ± 1.3 (P≤0.001)	2.1 ± 1.4 (P≤0.1)	2.4
Eastern Ganges Tidal Plain	3.6 ± 1.8 (P≤0.001)	3.2 ± 1.6 (P≤0.001)	7.0
Meghna Deltaic Plain	3.0 ± 2.6 (P≤0.1)	3.4 ± 1.6 (P≤0.001)	5.2
Chittagong Coastal Plain	1.3 ± 1.4	3.4 ± 1.7 (P≤0.001)	-

4.6.4 Cyclone frequency and intensity

Based on the analysis as described in Section 4.4.4 of the Climate Change Scenario Repot (Submitted in June 2021), and in particular the most recent values presented in Knutson et al. (2020), the following scenarios are suggested as described in Table 4.8:

a) A low scenario (roughly corresponding to the mean regional scenario by Knutson et al. (2020)) in which the frequency of TCs of category 4 and 5 is increased with +4% and the intensity with +5%.

b) A high scenario (roughly corresponding to the 90% regional scenario by Knutson et al. (2020)) in which the frequency of TCs of category 4 and 5 is increased with 80% and the intensity with +8%.

To account for a possible increase in TC intensity as a result of climate change effects, design conditions of crest levels during CEIP-I were derived assuming an increase of 10% in maximum TC wind speed (see e.g. IWM & Royal Haskoning, 2018; Islam et al., 2013). It is expected that this value will provide lower estimates of extreme storm surge and wave conditions than the high scenario as suggested in Table 4.8. However, given the fact that the projections by Knutson et al. (2020), used as a basis for this table, were derived assuming a 2°C temperature increase, and considering that this temperature increase is likely to be exceeded by mid-century, it seems plausible that also a more extreme scenario as in Table 4.8 should be considered.

Table 4.8: Suggested scenarios of TC changes, both for frequency and intensity (maximum sustained wind speed).

	Low	**High**
Frequency	+4% TC (cat 4-5)	+80% TC (cat 4-5)
Intensity	+ 5%	+8%

5 POLDER DEVELOPMENT PLAN

5.1 Progress in April, May, and June 2021

This Chapter covers progress of Work from April, May and June 2021 under Component 5.A in the Terms of Reference.

Comp. 5A consists of three deliverables:
5A-1: Long Term Development Plan
5A-2: Review/Improvements on-going work (CEIP-I).
5A-3: Plan for 5 polders

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

Deliverable 5A-2 "*Reconstruction of the Polder at different coastal zones including their phasing and construction program. Review/Improvements on-going work (CEIP-I)*" was submitted in December 2020. Based on a brief history of polder reconstruction and a literature review of water management issues in the polders of Bangladesh, the ongoing and proposed CEIP-I interventions were assessed on future impact. As there is a strong focus on embankment construction, this included a risk assessment as part of the review to provide initial insights in the costs and benefits of the project.

After receiving comments on the draft report 5A-2, the consultants carefully reviewed the comments and had a discussion with the World Bank on 7 June (Mathijs van Ledden) to get a better understanding of the issues. The discussion focused on the risk assessment and cost/benefit analysis for cyclonic storm surges for two CEIP-I polders (35/1 and 40/2). An updated draft version was sent to Mr. Van Ledden on 7 July.

For Deliverable 5A-3 the following activities were conducted:

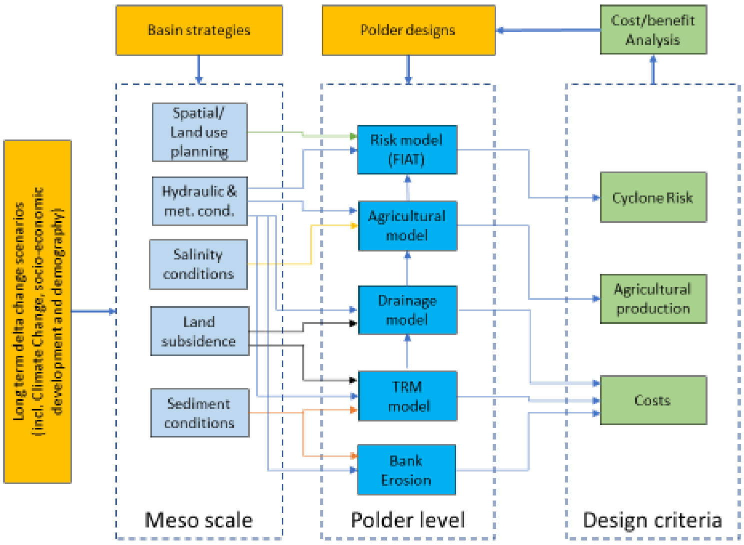
- Survey: mid-May the data of the survey for 5 polders conducted by IWM were consolidated. This data consisted of:
  - Embankment Survey
  - Khal Survey
  - Peripheral River Survey
  - Structure Survey
  - Topographic Survey
- Other data: an update of required data was prepared, and the status is as follows:

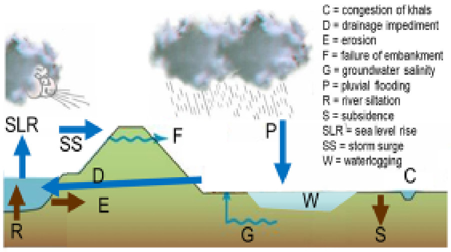
Of the 40 data categories, 26 *are* more or less sufficiently covered, 6 data categories come from models, whereas the remaining 8 categories are of older data sources or should come from expert judgement.

- Discussions on boundary conditions for the polders were conducted.

Parameter / process	**Relevance**	**Scenario**
Local rainfall	Drought risk / pluvial flooding	CC
Sea Level Rise	Flood risk, drainage problems	CC
Storm surges	Flood risk	CC
Salinity intrusion	Freshwater supply for agriculture	CC / upstream dams
Subsidence	Flood risk, drainage problems	GW abstraction?
Bank erosion	Embankment failures, land loss	??
Sediment concentrations	Tidal River Management potential; River sedimentation	??

- A framework for analysis was prepared (see figures).





Polder designs will be developed using an iterative process supported by a number of models. Each polder design consists of a selection of measures (such as embankment improvements, drainage improvements or tidal river management). The impact of these measures is calculated using the appropriate models. For instance, the effectiveness of drainage measures is estimated by using a drainage model, which on its turn provides input to an agricultural model. Likewise, the risk reduction of (new) embankments is calculated by the risk model. TRM is evaluated using a TRM model. Bank erosion under a specific polder design is estimated using a bank erosion model. Model results are providing output in terms of costs, risks and/or agricultural production, which on their turn are input to a Cost/Benefit Analysis. If the CBA results are unsatisfactory, adjustments to the polder design can be made.

All models are run under specific boundary conditions at meso scale, which on their turn are influenced by both basin strategies (at delta scale) and long term delta change scenarios, including climate change and socioeconomic development.

The figures below provide further details of the different models at polder level. Note that these models are still under development.

Agricultural model

VARIABLES:
- Land use
- Farming system
  - Crop selection
  - Land and water management*
  - Cultivation system (cropping intensity)
- Rice/crop cropping area
- (Rice) crop intensity
- Salinity
- Water availability/rainfall
- Agricultural inputs

*: see drainage model

Input

MODELS:
- MetaModel
- CROPWAT
- Yield estimation…

SCENARIOS AND MEASURES:
- Drainage improvements (water management)
- Salinity intrusion
- Cropping intensity

Model approach

- Annual Rice/Crop Production (Kg)
- Value of agricultural production (BDT)

Output

Cyclone Risk

VARIABLES:
- Topography (DEM)
- Extreme water levels
- Embankment levels
- Damage functions:
  - Mortality
  - Houses
  - Agriculture
  - Business and services
- Exposure:
  - Population
  - Land use
- Evacuation efficiency

Input

MODELS:
- SFINCS (inundation)
- FIAT Accelerator

SCENARIOS AND MEASURES:
- Population increase
- Economic development
- Agricultural development
- Climate change
  - Sea level rise
  - Cyclone frequency and intensity
- Subsidence rate
- Safety level
- Number of cyclone shelters

Model approach

- People affected (annual av.)
- Mortality (annual average)
- Expected Annual Damage

Output

Drainage model

VARIABLES:
- Sea level
- Tidal regime
- Topography (DEM)
- Drainage khals/system
- Precipitation
- Evapotranspiration

Input

MODELS:
- → IWM

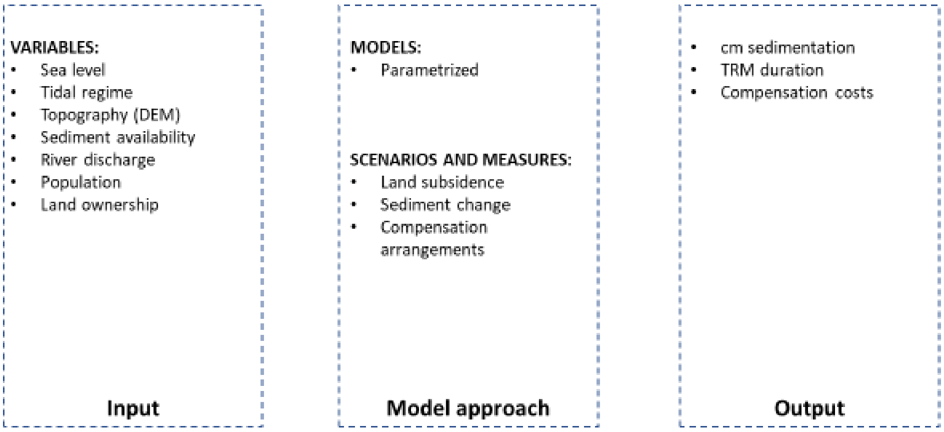
SCENARIOS AND MEASURES:
- Change in precipitation
- Change in evapotransp.
- Conditions of khals
- Pumping yes/no
- Subsidence rate
- Sea level rise
- TRM

Model approach

- Ha of waterlogged areas
- Duration and timing of waterlogging

Output

Tidal River Management model



VARIABLES:
- Sea level
- Tidal regime
- Topography (DEM)
- Sediment availability
- River discharge
- Population
- Land ownership

Input

MODELS:
- Parametrized

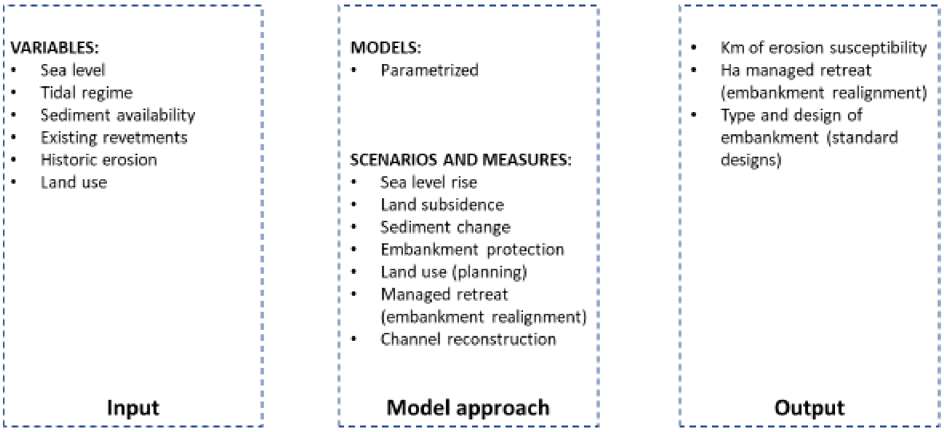
SCENARIOS AND MEASURES:
- Land subsidence
- Sediment change
- Compensation arrangements

Model approach

- cm sedimentation
- TRM duration
- Compensation costs

Output

Bank erosion model



VARIABLES:
- Sea level
- Tidal regime
- Sediment availability
- Existing revetments
- Historic erosion
- Land use

Input

MODELS:
- Parametrized

SCENARIOS AND MEASURES:
- Sea level rise
- Land subsidence
- Sediment change
- Embankment protection
- Land use (planning)
- Managed retreat (embankment realignment)
- Channel reconstruction

Model approach

- Km of erosion susceptibility
- Ha managed retreat (embankment realignment)
- Type and design of embankment (standard designs)

Output

6 UPDATING OF DESIGN PARAMETERS AND SPECIFICAITONS FOR CONSTRUCITON WORK

6.1 Introduction:

In 1950's country's economy was mainly based on agriculture. Large number people in southern and Southern coastal region were living below the poverty level. To increase the socio-economic condition of the people in coastal area it was humble necessary to boost up the agricultural production mainly rice. Huge area in coastal zone could not be used for normal agriculture production because saline water intrusion over the land during high tide. With a view to protect the agricultural land as well the whole coastal area from saline water intrusion polder concept was initiated. Coastal Embankment Project was initiated within 1950's to 1960's to build polders bounded by main rivers. Main component the polders were construction of embankment along the periphery of the polder and construction of sluices with flap gate across the small rivers and creeks. Embankments protect the land from spilling the water during high tide and flap gate at the river side of the sluices prevent the intrusion of saline water in the river during high tide. On the other hand, flap gate opens automatically during low tide drains accumulated monsoon rainwater in the polders into the rivers. Over the period Bangladesh Water Development Board constructed 139 polders in total in South-Western zone, Southern zone and South-Eastern zone. Embankment crest level was fixed considering the high tide level with free board.

6.2 Modernization of the polder system:

Over the passing time polders gave benefit to the people of the coastal region. With the increased population land became valuable and more human habitants developed within the polder area. But initially when the polders were constructed, attention was not given to storm surge, land subsidence and climate change effect (sea level rise) etc. Moreover due to lack of periodical maintenance peripheral embankments were threatened by the natural calamities. As a result devastating cyclone in 1960, 1979, 1991, caused death of lives and damage of properties. Due to strong cyclone preparedness activity in case of 2007(Sidr), 2009(Aila), Bulbul, Foni, Amphan and Iash didn't cause much death of lives but breaching of embankment caused damage of agricultural and economic activities. These cyclones also caused substantial damage of the embankments. After Sidr and Aila climate change effect was taken care for embankment modernization. On the other hand, the outfall rivers silted up due to various reason and as such drainage congestion became a major problem in the polder area. Keeping in mind to protect the livelihood of the coastal region Government of Bangladesh took initiative to modernize the polders considering all threatening factors. With assistance of World Bank, Bangladesh Water Development Board already started Coastal Embankment Improvement Project (CEIP) and in first phase improvement work for ten polders are completed. In second phase targeted for modernize twenty polders more. Improvement of rest of the polders will be taken phase wise. For modernization of all other polders an investment plan became essential and for that reason a conceptual design is necessary for designing rest of the polders considering all threatening factors.

6.3 Selected Polders for conceptual design as pilot program:

Consultant fixed a selection criteria and accordingly short listed 11 polder among 139 polders. After short listing Consultant visited 11 polders, consulted with local community and BWDB officials. Finally In this study 5 (five) polders are chosen as representatives after detail consultation with Bangladesh Water Development Board (BWDB) as sample case for conceptual design. Concept for designing one polder in one region will be replicated for neighbouring polders in that region and finally assess the future investment program for rehabilitation of the rest polders.

1) South-western region:
    a) Polder 15 in the District of Shatkhia
    b) Polder 29 in the district of Khulna.

2) South-Central region:
    a) Polder 40/1 in the district of Borguna.

3) South-East region:
    a) Polder 59/2 in the district of Noakhali

4) Eastern Hilly region:
    b) Polder 64/1a in the district of Chittagong.
    c) Polder 64/1b in the district of Chittagong.

It is noted that reconstruction of polder 15 is under consideration by Bangladesh government own fund and polder 29 has been rehabilitated in Blue Gold Program

6.4 Present status of the selected polders and inventory of structures:

1) Polder 15:

Total length of embankment:	30.50 Km
Top width of embankment:	4.30m
Crest level of embankment:	4.30M PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	5

Table 6.1: Inventory of Sluices in Polder 15

Sl. No.	Name of Sluice gate	No. of vent	Size of vent (V x H)	Name of outfall river	Present status
1.	DS-1	1	1.95m X 1.65m	Kholpetua	Active
2.	DS-2	1	1.95m X 1.65m	Kholpetua	Active (bad condition)
3.	DS-3	1	1.95m X 1.65m	Kabadak	Active (bad condition)
4.	DS-4	1	1.95m X 1.65m	Kholpetua	Active (bad condition)
5.	DS-5	1	1.95m X 1.65m	Kholpetua	Active (bad condition)

2) Polder 29:

Polder 29 is bounded by Lower Shalt river (north and east), Lower Bhadra river (east and south) and Gangrail river (west) in the Upazila of Dumuria and Batiaghata. This polder has been recently rehabilitated in Blue Gold program.

Total length of embankment:	49 Km
Top width of embankment:	4.30m
Crest level of embankment:	4.30m PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	16

Table 6.2: Inventory of Structures in Polder 29

Sl. No.	Name of Sluice gate	No. of vent	Size of vent	Name of outfall river	Present status
1.	S-1A	1	1.50m X 1.80m	Salta river	Active
2.	S-1B	1	0.90m X 1.20m	Lower Salta river	Active
3.	S-1	1	1.22m X 1.38m	Lower Salta river	Active
4.	S-2	2	1.22m X 1.38m	Lower Salta river	Active
5.	S-3	2	1.22m X 1.38m	Bhadra	Inactive
6.	S-3A	2	1.50m X 1.80m	Bhadra	Inactive
7.	Agunkhali	1	2.00m X 1.80m	Bhadra	Active
8.	S-4	1	0.90m X 1.20m	Bhadra	Active
9.	S-5	3	0.90m Dia	Bhadra	Inactive
10.	S-5A	1	1.50m X 1.80m	Bhadra	Active
11.	Shamvunagar	1	0.90m X 1.20m	Gangrail	Active
12.	S-6	1	1.38m X 1.20m	Gangrail	Active
13.	S-6A	1	1.07m X 1.35m	Gangrail	Active
14.	S-7	2	1.50m X 1.80m	Gangrail	Active
15.	S-7A	1	1.40m X 1.80m	Joyakhali	Active
16.	S-8	4	1.80m X 2.20m	Joyakhali	Inactive

3) Polder 40/1:

Polder 40/1 is bounded by Bishkhali river in the east, Baleshawar river at West, polder 40/2 North and Bay of Bengal at South.

Total length of embankment:	23.45 Km
Top width of embankment:	4.30m
Embankment crest level:	5.18m PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	30

Table 6.3: Inventory of Structures in Polder 40/1

SL No	Name of Sluice gate	No. of vent	Size of vent (V x W)	Name of outfall river	Present status
1.	Charlathimar (DS)	1	1.83m x 1.52m	Bishkhali river	Active
2.	Badurtala (DS)	1	0.90m Dia	Gabbaria	Active
3.	Padma (DS)	1	1.83m x 1.52m	Bishkhali river	Active
4.	Koralia (DS)	1	0.90m Dia	Gabbaria	Active
5.	Challatimara (DS)	1	0.90m Dia	Bishkhali river	Active
6.	FS-3	1	0.90m x 0.76m	Bishkhali river	Active
7.	FS-4	1	0.90m Dia	Bishkhali river	Active
8.	FS-5	1	0.90m Dia	Bishkhali river	Active
9.	FS-6	1	0.90m Dia	Bishkhali river	Active
10.	FS-7	1	0.90m Dia	Baleshwar river	Active
11.	FS-8	1	0.90m Dia	Baleshwar river	Active
12.	FS-9	1	0.90m Dia	Baleshwar river	Active
13.	Flushing	1	0.90m Dia	Baleshwar river	Active
14.	FS-10	1	0.90m Dia	Baleshwar river	Active
15.	FS-11	1	0.90m Dia	Baleshwar river	Active
16.	FS-13	1	0.90m Dia	Baleshwar river	Active
17.	FS-14	1	0.90m Dia	Baleshwar river	Active
18.	FS-15	1	0.90m Dia	Baleshwar river	Active
19.	FS-16	1	0.90m x 0.76m	Baleshwar river	Active
20.	Flushing	1	0.90m Dia	Baleshwar river	Active
21.	FS-17	1	0.90m Dia	Gabbaria	Active
22.	FS-18	1	0.90m Dia	Gabbaria	Active
23.	FS-19	1	0.90m Dia	Gabbaria	Active
24.	FS-20	1	0.90m x 0.76m	Gabbaria	Active
25.	FS-21	1	1.22m x 0.91m	Gabbaria	Active
26.	FS-22	1	0.90m Dia	Gabbaria	Active
27.	Flushing	1	0.90m Dia	Gabbaria	Active
28.	Flushing	1	0.90m Dia	Gabbaria	Active
29.	FS-23	1	0.90m Dia	Gabbaria	Active
30.	FS-24	1	0.90m Dia	Gabbaria	Active

DS- Drainage sluice, FS- Flushing sluice

4) Polder 59/2:

Polder 59/2 is bounded by Bishkhali river at East, Baleshawar river at West, polder 40/2 at North and Bay of Bengal at South.

Total length of embankment:	98.56Km
Top width of embankment:	4.30m
Crest level of embankment:	7.0m PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	10

Table 6.4: Inventory of Structures in Polder 59/2

Sl. No.	Name of Sluice gate	No. of vent	Size of vent (V x W)	Name of outfall river	Present status
1.	Rahmatkhali regulator-1	14	4.0m X 3.0m	Meghna river	Active
2.	Rahmatkhali regulator-2	14	4.0m X 3.0m	Meghna river	Active
3.	Char Ramanimohon regulator	1	1.20m X 1.00m	Camper khal	Active
4.	Char Ramanimohan pipe sluice	2	0.40m dia	Camper khal	Inactive
5.	Char Gazi, Ramgati	1	1.20m X 1.00m	Meghna river	Inactive
6.	Char Gazi, Ramgati	1	1.20m X 1.00m	Meghna river	Inactive
7.	Khair hat, Ramgati	4	1.95m X 1.65m	Meghna river	Active
8.	Balur char, Ramgati	1	1.20m X 1.00m	Meghna river	Inactive
9.	Khair hat, Ramgati	1	1.20m X 1.00m	Vulua river	Inactive
10.	Khair hat, Ramgati	1	1.20m X 1.00m	Vulua river	Inactive

5) Polder 64/1A:

Polder 40/1 is bounded by Shangu river at North, Jalkador Khal at East and Bay of Bengal at West.

Total length of embankment:	57.64 Km
Top width of embankment:	4.30m
Crest level of embankment:	5.48m PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	24

Table 6.5: Inventory of structures in 64/1A

Sl. No.	Name of Sluice gate	No. of vent	Size of vent (V x W)	Present status
1.	21A	1	1.82m X 1.52m	Inactive
2.	21	1	0.91m X 0.91m	Active
3.	22	1	0.76m dia CMP	Active
4.	22A	1	0.76m dia CMP	Inactive
5.	23	1	0.76m dia CMP	Active
6.	24	1	0.91m dia CMP	Active

7.	24A	1	1.22m X0.91m	Inactive
8.	SS	1	0.91m X 1.22m	Inactive
9.	25	1	1.22m dia CMP	Active
10.	SS	1	0.91m X 1.22m	Active
11.	5A	1	1.22m dia CMP	Active
12.	25B	1	0.91m dia CMP	Active
13.	25C	1	0.91m dia CMP	Active
14.	26	1	0.76m dia CMP	Active
15.	SS	1	0.91m X 1.22m	Active
16.	SS	1	0.91m X 1.22m	Active(Partly)
17.	26A	1	1.07m dia CMP	Active(Partly)
18.	SS	1	1.22m X0.91m	Active(Partly)
19.	27	1	0.91m dia CMP	Active(Partly)
20.	SS	1	1.22m X0.91m	Inactive
21.	28A	1	1.22m X0.91m	Inactive
22.	28	1	1.52m X1.83m	Active(Partly)
23.	29	1	1.22m X0.91m	Active
24.	21B	1	1.22m X0.91m	Inactive

6) Polder 64/1B:

Polder 40/1 is bounded by Shangu river at North and part of North-East, Jalkador Khal at West and Banshkhali Upazila roat at East.

Total length of embankment:	53.96 Km
Top width of embankment:	4.30m
Crest level of embankment:	5.48m PWD
Side slope of embankment:	River side- 1:3, Countryside-1:2
Number of Sluices;	35

Table 6.6: Inventory of Structures in Polder 64/1B

Sl. No.	Name of Sluice gate	No. of vent	Size of vent (V x W)	Present status
1.	1A	2	2.31m dia CMP	Active
2.	1	1	1.21m dia CMP	Active
3.	7	1	1.82m X 1.52m	Active
4.	7A	1	1.22m X 0.91m	Inactive
5.	SS	1	1.22m X 0.91m	Inactive
6.	8A	1	1.82m X 1.52m	Active
7.	8B	1	1.82m X 1.52m	Active
8.	8	2	2.13m dia CMP	Active
9.	9	2	1.82m X 1.52m	Active
10.	9A	1	0.91m dia RCP	Active
11.	SS	1	1.22m X 0.91m	Inactive
12.	10	1	1.22m X 0.91m	Inactive
13.	10A	1	1.22m X 0.91m	Inactive

Sl. No.	Name of Sluice gate	No. of vent	Size of vent (V x W)	Present status
14.	11	1	0.91m dia CMP	Active
15.	12	2	2.13m dia CMP	Active
16.	12A	1	1.22m dia CMP	Active
17.	12B	2	0.76m dia CMP	Active
18.	SS	1	1.22m X 0.91m	Active
19.	12C	1	1.22m X 0.91m	Active
20.	13	1	1.82m X 1.52m	Active
21.	SS	1	1.22m X 0.91m	Active
22.	14	2	2.13m dia CMP	Active
23.	15R-1	1	1.22m dia CMP	Active
24.	15A	1	1.52m dia CMP	Active
25.	15B	1	1.22m dia CMP	Active
26.	15C	1	1.82m X 1.52m	Active(partly)
27.	15D	1	1.22m X 0.91m	Active
28.	16	7	1.42m dia RCP	Active
29.	16A	1	0.91m dia RCP	Active
30.	17	2	0.91m dia RCP	Active(Partly)
31	18	3	1.06m dia RCP	Active
32.	19	3	1.06m dia RCP	Active
33.	SS	1	1.22m X 0.91m	Inactive
34.	20C	1	1.22m X 0.91m	Active
35.	20B	1	1.82m X 1.52m	Active

Note: CPM- Corrugated metal pipe.
RCP- Reinforced concrete pipe.

7 CAPACITY BUILDING

7.1 MSc Programme of BWDB Engineers

Three BWDB engineers have completed MSc programme in Water Science and Engineering with specialisation Coastal Engineering and Port Development 2019-2021 at IHE Delft

The IHE Delft MSc programme is organised in the following list of modules, taken sequentially, with the following structure:

Module 1 - Introduction to water for development

Module 2a - Introduction to water science and engineering

Module 2b - Hydrology and Hydraulics

Module 3 - Introduction to Coastal Science and Engineering

Module 4 - Port planning and infrastructure design

Module 5 - Coastal systems

Module 6 - Design of breakwaters and dikes

Module 7 - Process based coastal modelling

Module 8 - Climate change impacts and adaptation in deltas

Module 9 - Field trip and field work

Module 10 - Geotechnics engineering and dredging

Module 11 - Elective module

Module 12 - Summer course

Module 13 - Water science and engineering group work

Module 14 - MSc research proposal development (with Delft 3D course)

After the completion of the 14 modules, students successfully completed their thesis research in about 6 months and returned to Bangladesh and joined back to their offices of BWDB

Oli Afaz Chowdhury

Marzia Israt

M Nazmul Islam

Appendix- A.1

Training Program

List of Training Participants
BWDB Engineers

List of Participants of IGDCZ Training

S.L	Name	E-mail ID
1	Dr. Md. Sarfaraz Banda	sarfarazbanda48@gmail.com
2	Dr. Md. Khairul Islam	cso.dg@bwdb.gov.bd
3	Mr. M. A. Baker Siddique Bhuiyan	sohel0059@gmail.com
4	Mr. Abdullah Md. Mustofa Sorwar	se.gis@bwdb.gov.bd
5	Mr. Md. Kaisar Alam	xen.barguna@gmail.com
6	Mr. Jakaria Pervez	jakariapervez@gmail.com
7	Mr. Mohammad Samiul Hoque	samiul1979@gmail.com
8	Ms. Umme Fatima Romana Afroj	xen1.design6@bwdb.gov.bd
9	Mr. Tanjir Saif Ahmed	tanjirsaifahmed@gmail.com
10	Mr. Md. Manzur Rahman	maruf.ce2k7@gmail.com
11	Md. Mahfuzer Hassan	mahfuzer38@gmail.com

TRAINING SCHEDULE FOR IGDCZ OPERATIONS, LONG TERM MONITORING PROJECT, CEIP, BWDB

Training Venue: Project Office, Flat #3/B, House #4, Road #23/A, Banani, Dhaka 1213

Day	Time	Module	Topics	Key person/ Trainer	Remarks
Day 1 24/05/2021	10.00 - 10.30 am	Inauguration	Welcome address. Overview of the project	Project Director Md. Zahirul Haque Khan, DED(Opn), IWM	
	10.30 - 11.00 am	Refreshment			
	11.00 – 12.30 pm	Introduction to IGDCZ	- Overall - Database - Platform - Application	Dr. Mollah Md Awlad Hossain, Director, ICT, IWM Md. Humayun Kabir, Sr. GIS & Database Specialist, IWM Mohammad Kamruzzman, GIS Specialist, IWM	Presentation
	12.30 – 1.00 pm	Lunch & Closing			
Day 2 25/05/2021	10.00 – 11.00 am	Web GIS Based IGDCZ Application	IGDCZ Interface IGDCZ Database IGDCZ Operations	Md. Humayun Kabir, Sr. GIS & Database Specialist, IWM Mohammad Kamruzzman, GIS Specialist, IWM	Online Demonstration
	11.00 – 11.30 am	Refreshment			
	11.30 – 12.30 pm	Continuation	IGDCZ Metadata	Md. Humayun Kabir, Sr. GIS & Database Specialist, IWM Mohammad Kamruzzman, GIS Specialist, IWM	Online Demonstration
	13.00 – 14.00 pm	Lunch & Close			
Day 3 30/05/2021	10.00 – 11.00 am	User operations of IGDCZ	Exercise of Data View, Edit, Update by the users and feedbacks	Md. Humayun Kabir, Sr. GIS & Database Specialist, IWM Mohammad Kamruzzman, GIS Specialist, IWM	Practical Exercise
	11.00 – 11.30 am	Refreshment			
	11.00 – 12.30 pm	Continuation	Operations by the users and feedbacks	Md. Humayun Kabir, Sr. GIS & Database Specialist, IWM Mohammad Kamruzzman, GIS Specialist, IWM	Practical Exercise
	12.30 – 01.00 pm	Comments by one trainee Certificate distribution Concluding Remarks		One from the Trainees Project Director	
	1.00 – 1.30 pm	Lunch & Close of Programme			

Appendix- A.2

Data Layers/ data sets handover

Data Layers/data sets handover

Sl No	Layer Name	Shapefile/Table	Feature Type	SR System
1	Division	Division_Boundary_geo	Polygon	WGS84
2	District	District_Boundary_geo	Polygon	WGS84
3	Upazila	Upazila_Boundary	Polygon	WGS84
4	Union	Union_Boundary_geo	Polygon	WGS84
5	Polder	Polder	Polygon	WGS84
6	Project Extent	Projec_ Extent_geo	Polygon	WGS84
7	Road	Road_geo	Line	WGS84
8	Coastal DEM	cstdem2008a	Rater (50m, 50m)	BTM
9	Hydraulic Structure	Hydraulic_Structure_geo	Point	WGS84
10	SW Discharge	River_Discharge_Stations_geo	point	WGS84
11	Discharge Time Series Data	Excel Table	Table	
12	Groundwater Table	GW_Station_geo	Point	WGS84
13	Groundwater Time Series Data	GW_TSData	Table	
14	Rainfall Station	RF_Station_geo	Point	WGS84
15	Rainfall Time Series Data	RF_TSData	Table	
16	Surface Water Level Station	WL_Station	Point	WGS84
17	Surface Water Level Time Series Data	WaterLevel_TSData	Table (mdb)	
18	Salinity	base_dec; base_jan;base_feb;base_mar;base_apr;base_may;base_jun	Raster	BTM
19	Settlement	Settlement_geo	Polygon	WGS84
20	Waterbodies	Waterbodies_geo	Polygon	WGS84
21	Embankment	Total_Emb_geo	Polyline	WGS84
22	Cyclone Track	Cyclone_Data_1960_2009_geo	Polyline	WGS84
23	Bathy of bay of Bengal	Bathy_BBengal_geo	Point	WGS84