Government of the People's Republic of Bangladesh
Bangladesh Water Development Board (BWDB)

Coastal Embankment Improvement Project

Consultancy Services for Feasibility Studies and Preparation of Detailed Design for the Following Phase (CEIP-2)

Draft Inception Report

10 September 2021

Royal HaskoningDHV Enhancing Society Together · nhc northwest hydraulic consultants · SPMC · CEGIS · DDC Development Design Consultants Limited · KMC Ltd Working for safe living

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Abbreviations, acronyms and units

AED	Average Annual Expected Damage
ACL	Authorized Crest Level
ADCP	Acoustic Doppler Current Profiler
AHP	Analytical Hierarchy Process
ARIPA	Acquisition and Requisition of Immovable Property Act
ARIPO	Acquisition and Requisition of Immovable Property Ordinance
AsDB	Asian Development Bank
BADC	Bangladesh Agriculture Development Corporation
BARI	Bangladesh Agriculture Research Institute
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BoB	Bay of Bengal
BoB SAL	Bay of Bengal Salinity
BoQ	Bill of Quantities
BRRI	Bangladesh Rice Research Institute
BTM	Bangladesh Transverse Mercator
BWDB	Bangladesh Water Development Board
BM	Bench Mark
BoBM	Bay of Bengal Model
CBA	Cost-Benefit Analysis
CC	Climate Change
CCL	Cash Compensation Under Law
CDPo	Coastal Development Policy
CDMP	Comprehensive Disaster Management Program
CDS	Coastal Development Strategy
CDSP	Char Development and Settlement Project
CEGIS	Center for Environmental and Geographic Information Services
CEIP	Coastal Embankment Improvement Program / Project
CEIP-1	Coastal Embankment Improvement Program / Project – Phase 1
CEIP-2	Coastal Embankment Improvement Program / Project – Phase 2
CEP	Coastal Embankment Project
CERP	Coastal Embankment Rehabilitation Project
CES	Coastal Embankment System
CPP- I	Cyclone Protection Project - I
CPP- II	Cyclone Protection Project - II
CZ	Coastal Zone
CZE	Coastal Zone Embankment
CZPo	Coastal Zone Policy

CZWMP	Coastal Zone Water Management Program
CSPS	Cyclone Shelter Preparatory Study
DAE	*Department of Agriculture* Extension
DCF	Discounted Cash Flow
D&CSC	Design & Construction Supervision Consultants
DDC	Development Design Consultants
DEM	Digital Elevation Model
DHI	Danish Hydraulic Institute Denmark
DISREP	Distribution Sector Recovery Program
DGPS	Differential Global Positioning System
DLR	Director Land Records
DoE	Department of Environment
DoF	Department of Fisheries
DPM	Design Planning & Management
DSM	Digital Surface Model
DTM	Digital Terrain Model
EA	Environmental Assessment
EAP	Environmental Action Plan
ECA	Environmental Conservation Act
ECR	Environmental Conservation Rules
ECRRP	Emergency Cyclone Recovery and Restoration Project
ED	Executive Director
EDP	Estuary Development Program
EEWS	Early Erosion Warning System
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EMA	External Monitoring Agency
EMP	Environmental Management Plan
EMF	Environmental Management Framework
EPG	Embankment Protection Group
EPs	Entitled Persons
ES	Embankment Settlers
ESS2	Environmental and Social Standard 2
ESCP	Environmental & Social Commitment Plan
ESF	Environmental and Social Framework
ESS	Environmental Social Standards
FAO	Food and Agricultural Organization
FAP-7	Flood Action Plan-7
FCD	Flood Control & Drainage
FCDI	Flood Control Drainage & Irrigation
FGD	Focus Group Discussion

FFG	Foreshore Forestry Group
FM	Flood Management
FO	Field Office
FREMIP	Flood and Riverbank Erosion Risk Management Investment Program
FWOP	Future-Without-Project
FWIP	Future-With-Project
GBV	Gender Bases Violence
GCC	General Conditions of Contract
GCPs	Ground control points
GDP	Gross Domestic Product
GeoDASH	Geospatial Data Sharing Portfolio
GIS	Geographic Information Systems
GOB	Government of Bangladesh
GO	Government Organization
GPP	Guidelines for People's Participation
GPS	Global Positioning System
GRM	Grievance Redress Mechanism
GRRP	Gorai River Restoration Project
IA	Implementing Agency
IBRD	International Bank for Reconstruction & Development
ICB	International Competitive Bidding
ICZM	Integrated Coastal Zone Management
ICZMP	Integrated Coastal Zone Management Plan
ICZMP	Integrated Coastal Zone Management Program
IDA	International Development Agency
IESCs	Important Environmental and Social Components
IPC & WMPs	Infection Prevention Control and Waste Management Plans
IRR	Internal Rate of Return
INROS	Inros Lackner
IoL	Inventory of losses
IPCC	Intergovernmental Panel on Climate Change
IPSWAM	Integrated Planning For Sustainable Water Management
ITC	Information and Communication Technologies
IUCN	International Union for Conservation of Nature
IWM	Institute of Water Modelling
IEE	Initial Environmental Examination
KJDRP	Khulna Jessore Drainage Rehabilitation Project
KII	Key Informant Interview
KMC	Knowledge Management Consultants
LAPs	Land Acquisition Plans
LGED	Local Government Engineering Department

LGI	Local Government Institution
LMP	Labour Management Procedure
LRP	Land Reclamation Project
MCA	Multi-Criteria Analysis
M&E	Monitoring and Evaluation
MES	Meghna Estuary Studies
MIS	Management information systems
MoEF	Ministry of Environment and Forest
MoFDF	Ministry of Food and Disaster Management
MOWR	Ministry of Water Resources
MoL	Ministry of Land
MSL	Mean Sea Level
NCB	National Competitive Bidding
NEP	National Environmental Policy
NEMAP	National Environment Management Action Plan
NGO	Non Government Organization
NHC	Northwest Hydraulics Consultans
NWMP	National Water Management Plan
OCC	One-stop Crisis Cell
O&M	Operation and Maintenance
OP	Operation Policies
PSC	Project Steering Committee (PSC)
RAP	Resettlement Action Plan
REA	Rapid Environmental Assessment
RMS	Root Mean square
RPF	Resettlement Policy Framework
RTK	Real Time Kinematic
PAP	Project Affected People
PAVC	Property Assessment and Valuation Committee
PBM	Permanent Bench Marks
PD	Project Director
PDC	Polder Development Committee
PIU	Project Implementation Unit
PMU	Project Management unit
POM	Project Operations Manual
PPCR	Pilot Programme for Climate Resilience
PPR	Project Progress Report
PMIS	Polder Management Information System
PVS	Property Valuation Survey
PWD	Public Works Department

PRA	Participatory Rapid Assessment
JV	Joint Venture RHDHV-NHC-INROS
RAP	Resettlement Action Plan
RRA	Rapid Rural Appraisal
RCC	Reinforced Cement Concrete
RHDHV	Royal HaskoningDHV
RoR	Record of Rights
SA	Social Assessment
SCM	Stakeholders Consultation Meeting
SEP	Stakeholder Engagement Plan
SIA	Social Impact Assessment
SLR	Sea Level Rise
SMRPFW	Social Management and Resettlement Policy Framework
SPARSO	Space Research & Remote Sensing Organization
SPMC	Strategic Planning and Management Consultants
SRP	System Rehabilitation Project
SRDI	Soil Resource Development Institute
SSHSMP	Site-Specific Health and Safety Management Plan
SWMC	Surface Water Modelling Centre
SWZ	South Western Zone
SZ	Southern Zone
SOB	Survey of Bangladesh
SWRM	South West Region Model
SEA	Strategic Environmental Assessment
SEAA	Sexual Exploitation and Assault
SMRPF	Social Management & Resettlement Policy Framework
SWRSAL	South West Region Salinity
TRM	Tidal River Management
TBM	Temporary Bench Mark
ToR	Terms of Reference
WARPO	Water Resources Planning Organization
WB	World Bank
WMA	Water Management Association
WMIP	Water Management Improvement Project
WRS	Water Retention Structures
WSIP	Water Sector Improvement Project
WUA	Water Users Association
MWh	Megawatt hour
m	Metre
cm	Centimetre

ha	Hectare
l	Litre
mm	Millimetre
m^3/s	Cubic metres per second
m^3	Cubic metres
km	Kilometre
km^2	Square kilometres
Mt	Mega ton (10^9 kilogram)

0. Executive Summary

The Executive Summary will be included in the Final Inception Report after the Bangladesh Water Development Board has reviewed the Draft Inception Report.

1. Introduction

1.1 Background of the Project

The Coastal Zone of Bangladesh covers an area of 47,201 km^2 (32% of the country)[1], spans over more than 580 km along the Bay of Bengal and is part of one of the largest, youngest, and most active deltas in the world. The coastal landscape of Bangladesh is predominantly shaped by the confluence of three large rivers: the Ganges, the Brahmaputra and the Meghna (GBM), forming the largest delta in Asia and delivering an enormous amount of sediment to the Bay of Bengal[2] (see Figure 1.1).

Bangladesh's physical and cultural characteristics as well as the livelihoods of its people are defined by the GBM delta, which is endowed with an abundance of natural resources. The dynamically evolving coastal landscape of Bangladesh is controlled by underlying geology and topography of the delta and the dynamic interaction between the influx of water and sediment, the coastal processes such as tides and wave action, and episodic events such as cyclones and monsoons. The strength of the tides and the flatness of the delta causes the tides to influence river processes a long way upstream in the southern estuaries. Sixty-two percent of the coastal land has an elevation of up to 3 m above mean sea level, a figure which rises to eighty-three percent having an elevation of up to 5 m above mean sea level[3].

The Bangladesh coast is usually divided into four zones: the Ganges Tidal Floodplain West and East, Meghna Estuary Floodplain and the Chittagong Coastal Plains. The Ganges Tidal Floodplain West has the Sundarbans forest covering the first 60 to 80 km inland from the coastline and is characterized as moribund delta formation, the area has long drainage routes of low gradient and very little fresh water flow from the parent river (the Ganges). The Ganges Tidal Floodplain East is characterized by a younger stage of estuary development, the land being intersected by a number of rivers receiving water from the Lower Meghna river, and from the Padma river via the Arial Khan river and there is no substantial forest area. The Meghna Estuary Floodplain is morphologically very active and land accretion is higher than erosion. It includes islands such as Bhola, Hatia and Sandwip and mainland areas on the left bank of the Meghna river. The Chittagong Coastal Plain along the eastern side of the Bay of Bengal is directly exposed to the Bay of Bengal and has steep hills immediately to the east. It includes the longest stretch of beach in Bangladesh (from Cox' Bazar to Teknaf).

[1] Ministry of Water Resources, 2003. Delineation of the Coastal Zone, Program Development Office for Integrated Coastal Zone Management Plan (PDO-ICZMP), WP005. The administrative delineation of the Coastal Zone comprises 19 districts, 147 upazillas and the exclusive economic zone

[2] Kuehl, S.A., Hariu, T.M. and Moore, W.S., 1989. Shelf sedimentation off the Ganges Brahmaputra River System: evidence for sediment bypassing to the Bengal Fan. Geology. 17, 1132-1135

[3] Bangladesh Water Development Board. Coastal Embankment Improvement Project, Draft Final Report, Sept 2012

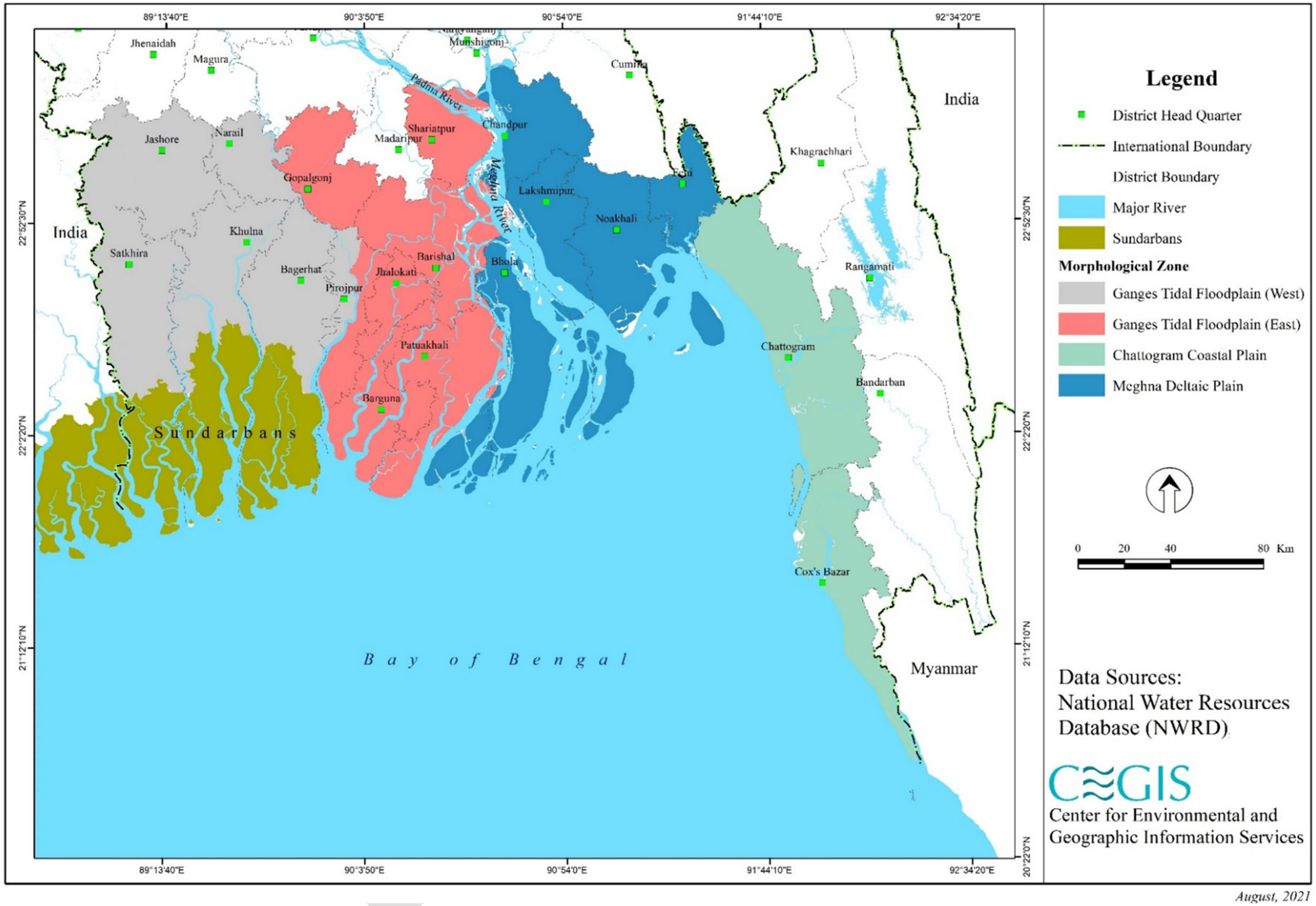

Figure 1.1: Coastal zone of Bangladesh

Being home to around 46 million people (29% of the total population[4]), the Coastal Zone is predominantly used for agriculture (more than 30% of the cultivable land in Bangladesh is in the coastal area[5]), as well as for other activities such as shrimp and fish farming, forestry, tourism, salt production, ship-breaking yards, ports and other industries. These growing opportunities, however, come with risks, as the coastal zone is well-known for its vulnerability to the coastal hazards[6].

Bangladesh is considered one of the most disaster-prone and climate vulnerable countries in the world, with the coastal zone being unceasingly influenced by river system's fluctuations as well as coastal processes such as tidal propagation and salinity intrusion and coastal threats such as cyclone events. Cyclones pose a major threat to coastal communities, causing inundation of the coastal land from the high storm surges which are generated and accompanied by powerful winds. In addition, slow-moving chronic stressors such as erosion, salinity intrusion and water-logging are presented frequently and extensively in the coastal zone, having severe impacts in both livelihoods and environment. These chronic stressors can result in loss of land, infrastructure failure, difficulties in operating the polder drainage systems and reduced agricultural productivity.

Over the past decades, the Government of Bangladesh has been making considerable attempts to reduce risk and save lives, reduce economic losses and protect development gains. Since the early 1960s, the Government of Bangladesh has been constructing Polders along the entire coastal belt to protect the people and agriculture crops from tidal inundation and saline water intrusion, as well as recover a large extent of land for permanent agriculture. A Polder can be defined as "is a low-lying tract of land enclosed by embankments known as dykes that form an independent hydrological entity which has no physical connection with outside water other than through manually operated devices (water control structures)". The existence of Polders prevents saline water to enter the agricultural fields, thereby boosting agricultural productivity and providing food security for the millions of people living in the Polder areas. In addition, the Polders protect against frequent tidal flooding, thereby preventing damage to people and crops and stimulating economic development for the local Polder communities. Polders are in addition equipped by Drainage and Flushing Sluices to control the water inside the embanked area.

Nowadays, some 139 Polders are present across the coastal zone, covering an area of 1.2 million ha (25% of coastal zone). The total length of the embankments running along the Polders is approximately 5,665 km, the total number of regulators is approximately 1,697, the total number of flushing inlets is approximately 1,202, and the total length of drainage channels is approximately 5,707 km. Existing embankment crest levels typically provide protection from the 5 to 10-year storm surge return period only (2% wave overtopping level)[7].

[4] Ahmad, H., 2019. Bangladesh Coastal Zone Management Status and Future Trends, Journal of Coastal Zone Management
[5] Ministry of Agriculture Bangladesh (2010). SRMAF Project, Soil Resource Development Institute
[6] Tessler et al. 2015. Profiling risk and sustainability in coastal deltas of the world
[7] Design Manual Procedures for Designs of Polders in Tidal Areas in Bangladesh, Md. Abdul Quassem, P.F. Raijmakers, J. Burger, Delta Development Project Bangladesh Water Development Baord, 1983

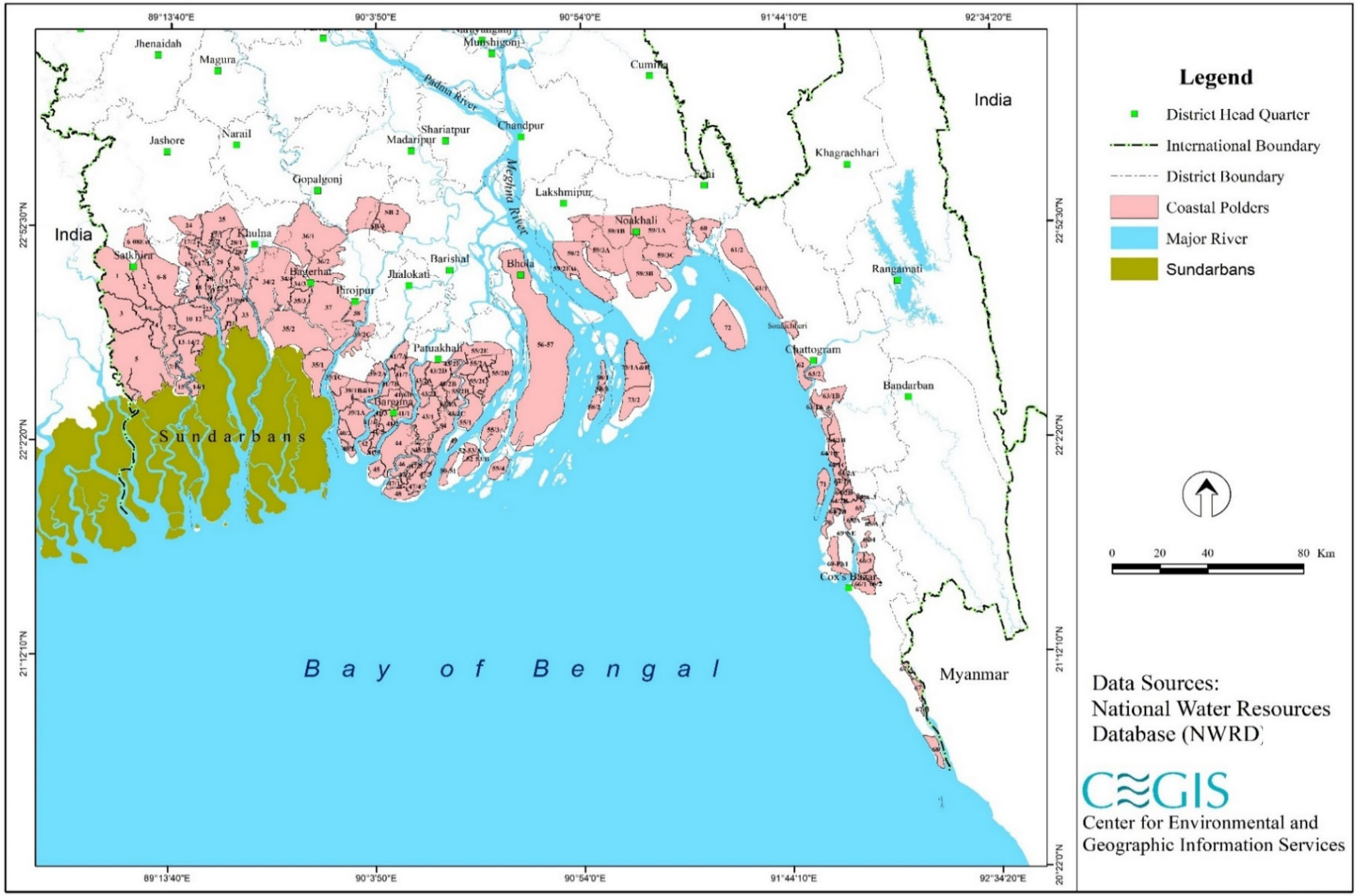

Figure 1.2: Coastal Polders Bangladesh

For the past 45-50 years, polders have significantly reduced the vulnerability to natural disasters and have created economic opportunities for the coastal communities, ensuring enhanced agricultural production. About 1.2 million hectares hectares of valuable land (approximately 70% of the total agricultural land of the coatsal zone) has become less prone to flood hazards and about 0.9 million ha area have been newly brought under cultivation.

In the recent years, the following cyclones struck the coast of Bangladesh: SIDR in November 2007, Aila in May 2009 and Amphan in May 2020. The number and severity of cyclones in Bangladesh and the associated mortalities have varied greatly during the past 50 years[8]. The two deadliest cyclones occurred in 1970 and 1991, with > 500,000 and almost 140,000 deaths, respectively. Bangladesh has made an outstanding progress during the past 50 years, managing to reduce deaths and injuries from cyclones, leading to an approximate 100-fold reduction.

Nevertheless, throughout the last years, the effectiveness of the polders in protecting the land and people within the polders, in many cases has been compromised by damages caused from severe cyclones, shifting coastal and river bank lines, deterioration due to frequent storm surges. Maintenance as well as management of the infrastructure leaves room for improvement.

The first major project, the Coastal Embankment Project (CEP), was implemented during the 1960's and early 1970's. Afterwards, the Coastal Area Rehabilitation and Cyclone Protection Project (CPP-I) in 1985, the Cyclone Protection Project (CPP-II), Coastal Embankment Rehabilitation Project (CERP-1) and second Coastal Rehabilitation Project (CERP-11) was implemented in 1980s, 1990s and 2000s. After cyclones SIDR and AILA struck the coastal zone causing severe damage to the infrastructure, life and property, the Government of Bangladesh (GOB) obtained an IDA/credit for Emergency Cyclone Recovery and Restoration Project (ECRRP), 2007 and proceeds from this credit would be used to meet the expenses for the Coastal Embankment Improvement Project (CEIP). The first phase of CEIP (CEIP-1) commenced with implementation in 2015 and is expected to be completed in June 2022 (see Figure 1.3).

Figure 1.3: Sluices and slope protection works under CEIP-1

[8] WMO, Ubydul Haque et al. (2011). Reduced death rates from cyclones in Bangladesh: what more needs to be done

1.2 Signing of Contract and mobilization

On signing of the Contract for Consultancy Services for Feasibility Studies and Detailed Design for the next Phase of the Coastal Embankment Improvement Project between the Bangladesh Water Development Board (BWDB) and the Consultant on 19th July 2021, the Team Leader of the lead firm of the Joint Venture (JV), being Royal HaskoningDHV (RHDHV) lead firm from The Netherlands, Northwest Hydraulic Consultants (NHC) from Canada and Inros Lackner (INROS) from Germany in association with Bangladesh sub-consultants Development Design Consultants (DDC), Strategic Planning and Management Consultants (SPMCS), Knowledge Management Consultants (KMC) and Center for Environmental and Geographic Information Services (CEGIS) has taken initiative to contact all professionals of the Consultant's Team so that immediately after signing of the Contract the team members joined and commenced the project activities as per work plan and staffing schedule of the Consultancy Contract.

1.3 Appreciation of the Terms of Reference

Overall the Terms of Reference (ToR) (see Appendix 1) are clear and well understood and Consultant's appreciation of the ToR at this point in time is elaborated in Chapter 3. Here it is only noted that the time frame for conducting the studies and preparation of detailed designs is very tight and a large number of deliverables is to be produced by the Consultant. The Consultant will be able to meet this tight time frame if comments on draft deliverables are received within a reasonable time after submission and in one round of comments.

1.4 Objectives

1.4.1 Objectives of the CEIP-2 Consultancy Services

The overall project development objective of the Coastal Embankment Improvement Project (CEIP) is to increase the resilience of the coastal population to natural disasters and climate change. More specifically, the project aims at (a) reducing the loss of assets, crops and livestock during natural disasters; (b) reducing the time of recovery after natural disaster such as cyclone; (c) improving agricultural production by reducing saline water intrusion which is expected to worsen due to climate change; and (d) improving the Government of Bangladesh's capacity to respond promptly and effectively to an eligible crisis or emergency. In view of obtaining the above objectives systematic rehabilitation of the coastal polders are essentially required as furnished below.

As per the Terms of Reference (see Appendix 1) the main objective of the Consultancy Services is to support Government of Bangladesh's Water Development Board (BWDB) in preparation of comprehensive coastal embankment improvement program and implementation of the following phases of CEIP. The Consultancy Services will be carried out with a detailed feasibility study according to the international standards, which will form the basis for project appraisal by the World Bank and the Government of Bangladesh and will also cover the detailed design and bidding documents of a batch of works to be implemented under the next phase of CEIP.

1.4.2 Objectives of the Draft Inception Report

The primary objective of this Draft Inception Report is to revise where needed and update the plan and activities proposed for implementation of the project. The duration of the Inception Phase of the project is one month, as assigned. The primary objective of this Draft Inception Report is to describe thoroughly the approach of each Task that will be carried out, in connection to the Deliverables, define the outputs that the project is expected to yield and provide a comprehensive work plan. In addition the Draft Inception Report aims to provide an overview of the results so far gained from the desk studies and field visits, to revise and if found necessary, to re-assess the project's scope of work and work programme.

The Draft Inception Report reflects the understandings the Consultant has at present and is explaining the approach that the Consultant intend to follow and inputs they propose to deploy to produce the intended deliverables.

For the effective planning of the CEIP-2 project the Consultant has already effectuated preparatory works. The Consultant has reviewed relevant project documents, policies and plans as well as rules and regulations which are relevant to this project. In addition, the Consultant has started by a high-level analysis of the whole polder system in the coastal zone and have identified the main physical, morphological, social and environmental characteristics of each zone. The latter, in combination with field visits, stakeholder consultations, have lead to a pre-selection of the 23 polders mentioned in the ToR..

The Draft Inception Report includes the Deliverable "Polder Screening Report" as indicated in the ToR (Appendix 1). In this chapter, the process of pre-selection of 23 polders out of the 122 remaining polders is elaborated. Use is made of data and information available to the Consultant and provided by BWDB. It should be noted, that due to limited availability of the data required to perform polder screening, the Polder Screening Report concludes in selection of 23 polders based on a number of factors and guidelines, however, a more detailed rationalization will be elaborated in the next report "Prioritization List of 13 Polders" when more consultations will be held.

1.5 Contents of the Draft Inception Report

This Draft Inception Report is the first output required for the Consultancy Services for Feasibility Studies and Detailed Design for next Phase (CEIP-2) under CEIP. It is meant to be brief and concise, putting emphasis on the methodology for each assigned task, the work plan and staffing schedule. This introduction chapter provides the setting for the report. The remaining chapters are:

Chapter 2: Mobilization and Start up Activities

Chapter 3: Detailed scope of works for Consultancy Services

Chapter 4: Approach and Methodology

Chapter 5: Polder pre-screening report of 23 polders

Chapter 6: Project organization and execution

Appendices 1 to and including 11 are supporting and providing detailed explanations and overviews in relation to the above chapters.

Chapter 3 elaborates on the various Tasks defined in the Terms of Reference and Consultant's interpretation of ***what*** has to be conducted and delivered and Chapter 4 describes **how** the Consultant will achieve the requirements of the ToR for a number of specific subjects.

2. Mobilization and start-up activities

2.1 Set-up of office in Dhaka and mobilisation of Experts

After receiving the letter to proceed from the Project Director, CEIP-1, BWDB on 25th July 2021, the Team Leader and Key Staff were mobilized and the assignment started from 20th July 2021. Due to the then COVID-19 lock-down restrictions in Bangladesh, meetings and consultations were held virtually.

Based on the date of the said letter to proceed, effective contractual commencement date of the Services is set on 9th August 2021 and thus as per Contract the latter being the reference date for submission of the deliverables.

Actions have taken in setting up project office in Banani, Dhaka. The Team Leader and the Deputy Team Leader were mobilized and the assignment at Dhaka office started with deployment of the selected professionals of the consultancy team as per approved staffing schedule of the Terms of Reference. The important issue relating to the effectiveness of mobilization and arrangement of necessary equipment like computer and accessories, facilities, and vehicles etc. were addressed. Consultant has also established a BOX[9] sharing folder in the cloud to facilitate information and data sharing.

Figure 2.1: Consultant's CEIP-2 office in Banani, Dhaka

[9] https://www.box.com/en-gb/home

2.2 Kick off meeting with CEIP-1 Project Director and PMU Staff

The Team Leader, the Deputy Team Leader and the key team members had a virtual kick-off meeting with the Project Director, CEIP-1 and CEIP-1 Project Management Unit Staff (PMU) on 28th July 2021 in which the objectives and activities of the Services were outlined together with the approach and request to the Project Director to provide data, to discuss the actual requirement of the projects and BWDB's perspectives, to organise meetings and provide introduction letters for the Consultant. The agenda of the meeting was:

1. Opening words by the CEIP-1 Project Director;
2. Introduction of Consultant's Team;
3. Objectives of the Consultancy Services;
4. Tasks to be conducted;
5. Commencement of the Consultancy Services;
6. Inception Report particulars;
7. Challenges;
8. Kind requests to CEIP-1 Project Director;
9. Recommendations of the CEIP-1 Project Director;
10. Questions and discussion.

2.3 Review of Project related documents and policies

2.3.1 Coastal Embankment Improvement Project Phase-1

2.3.1.1 Coastal Embankment Improvement Project Phase-1 in a glance

The Coastal Embankment Improvement Project Phase-1 (CEIP-1), implemented by the Bangladesh Water Development Board (BWDB) and funded by the World Bank (WB), safeguards the Coastal Zone of Bangladesh against flooding due to storm surges and cyclones, combats erosion and enhances the coastal resilience. Next to that project's objectives are to reduce the loss of assets, crops and livestock during natural disasters, reduce the time of recovery after natural disasters, improve agricultural production by reducing saline water intrusion which is expected to worsen due to climate change and improve the Government of Bangladesh's capacity to respond promptly and effectively to a natural disaster. The long-term objective of CEIP is to increase the resilience of the entire coastal population to tidal flooding and natural disasters by upgrading the whole embankment coastal polders.

CEIP-1 is the first phase (see Figure 2.2) of this long-term program and is still ongoing, while more than 75% of the works have been completed.

The existing embankment system in the Polders has a level of protection based on a return period of approximately 10 years. The present condition of the embankments makes it likely that an overtopping event can lead to disastrous breaches in the embankments, as seen after Sidr, Aila and Amphan. A net area of about 100,817 ha of the project will be protected when the project is completed, against hazardous events having a return period of 25 years taking into account climate change conditions predicted for 2050. The actual level of protection soon after project completion will be able to withstand a storm surges and cyclones having a return period of over 50 years.

For smooth supervision the 17 Polders under CEIP-1 were sub-divided into three packages as follows (see Table 2-1):

- Package-1(4 Polders: 32, 33, 35/1 and 35/3);
- Package-2 (6 Polders: 39/2C, 40/2, 41/1, 47/2, 43/2C and 48);
- Package-3 (7 Polders: 14/1, 15, 16, 17/1, 17/2, 23, and 34/3). This Package-3 is currently not being implemented under the first phase of CEIP due to limitation of budgets caused by amongst others significant increase in land acquisition cost and subsequently reallocation of the budget items under the loan agreement.

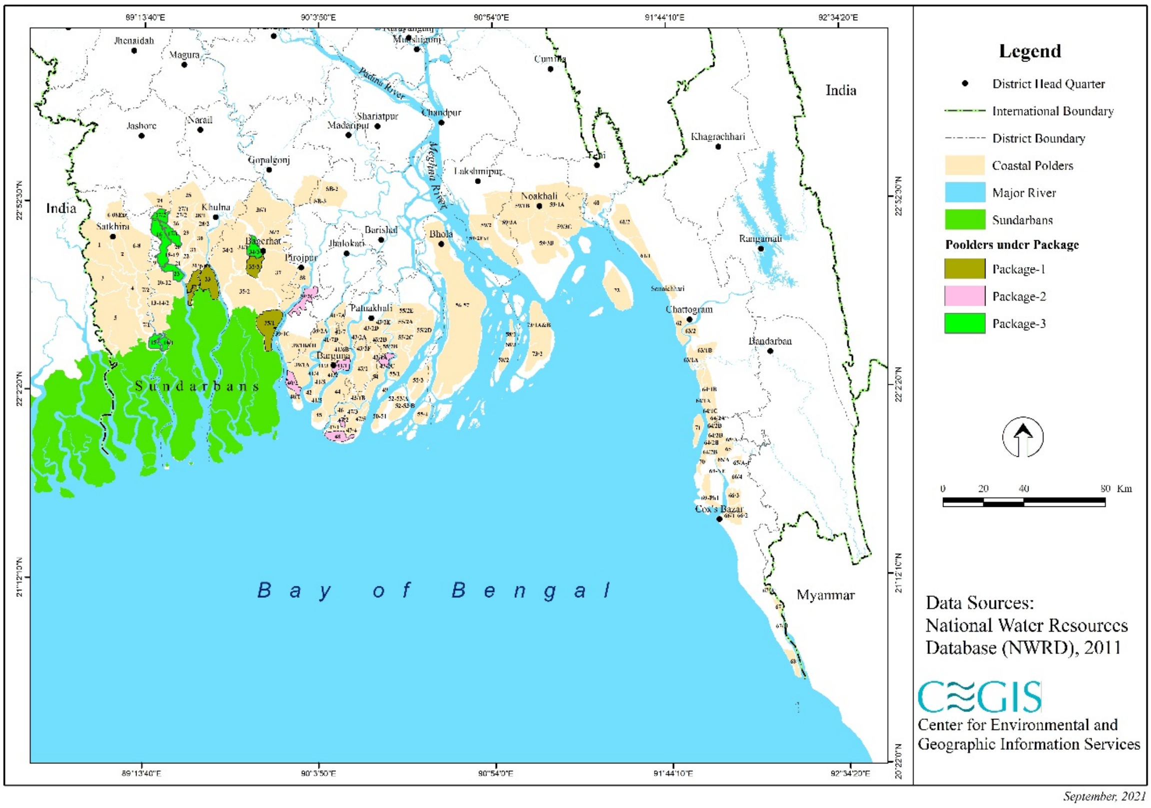

Figure 2.2: The 17 polders under CEIP-1

In order to make comprehensive improvements of the polders the CEIP-1 Project has a number of implementation components as follows: i) re-sectioning of embankments, ii) backing of embankment towards centre line, iii) retirement of embankments, iv) slope protection work, v) bank protection work, vi) afforestation on the foreshore area, vii) repair of existing sluices, viii) replacement of existing sluices, ix) construction of alternative structures, x) construction of additional structures where required, xi) construction of cross dams and xii) land acquisition and resettlement. The Consultant also conducted RAP/LAP and SIA/EIA studies.

The present feasibility study and preparation of detailed designs for the next phase of CEIP is part of a comprehensive coastal embankment improvement program under the following phase of CEIP.

Table 2-1: Summary of main features of the 17 Polders under CEIP-1[10]

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
01	14/1	Koyara	2933	2350	1880	470	0	25.00	4	0	0.00	Package -3
02	15	Shymnagar	3441	2925	900	2025	0	27.00	5	0	0.00	Package -3
03	16	Paikgacha, Tala	10445	8102	3050	5052	0	45.00	12	0	11.00	Package -3
04	17/1	Dumuria	5020	4000	4000	0	0	45.80	11	0	43.50	Package -3
05	17/2	Dumuria	3400	2700	2700	0	0	11.00	5	0	21.00	Package -3
06	23	Paikgacha	5910	4872	1048	3824	0	37.00	11	36	36.00	Package -3
07	32	Dacope	8097	6500	6497	5328	0	49.50	10	51	45.00	Package -1
08	33	Dacope	8600	7600	5120	1280	0	52.50	13	11	20.00	Package -1
09	34/3	Bagerhat	3656	2930	2930	0	0	17.00	10	6	13.00	Package -3
10	35/1	Sharankhola	13058	10700	10400	300	0	63.00	13	25	106.00	Package -1
11	35/3	Bagerhat	6790	5090	5090	0	0	40.00	3	10	75.00	Package -1
12	39/2C	Matbaria	10748	8500	3800	0	0	55.00	12	10	105.00	Package -2
13	40/2	Pathargatha	4453	3300	3300	0	0	35.53	25	18	47.00	Package -2
14	41/1	BargunaSadar	4048	3440	3440	0	0	33.81	22	14	33.00	Package -2
15	43/2C	Galachipa	2753	2000	2000	0	0	25.70	6	40	26.10	Package -2
16	47/2	Kalapara	2065	1850	1850	0	0	17.50	4	5	29.50	Package -2
17	48	Kalapara	5400	3715	3715	0	0	38.00	10	0	16.00	Package -2

2.3.1.2 Achievements so far

Even though the works under CEIP-1 are still ongoing, several achievements have been marked as well as a number of lessons learned can be already derived, related to used practices, performance of actual structures, challenges during implementation and general approach followed. Some of the achievements of CEIP-1 are listed below:

[10] CEIP-1 Monthly Progress Report DDCS&PMS Consultants, July 2021

- CEIP-1 interventions are already providing protection against erosion, storm surges and cyclones, which has been proven from the system behaviour the most recent super cyclonic storm Amphan which made a landfall in West Bengal on 20 May 2020. It was the strongest tropical cyclone to strike the Ganges Delta since Sidr (2007), but yet, caused much less damages than Sidr at the time in Bangladesh. Clearly, such comparison depends on many factors (cyclone track, land fall direction, tide etc.). However, it has been observed that, not only the CEIP-1 newly built embankments have remained mostly intact, but also these embankments have demonstrated to be adequately designed to prevent overtopping from storm surges.
- Construction of the Nalian Closure in Polder 32 has been an important milestone for CEIP-1. Its purpose is to allow Nalian River to return the Polder-32 again to the state as it was before cyclone Aila and have been completed successfully on 17 February 2020. The result of the construction of Nalian Closure Dam is the creation of a reservoir where rainwater can be stored, contributing to establishment of a secured cropping intensity for Polder 32. Furthermore, as the Closure Dam has disconnected Nalian River from Shibsa River, the impacts from tide are minimal. Subsequently, the embankments protecting Polder 32 (and running along Nalian River) are significantly less impacted by the reduced tidal prims, which makes the crest level requirements less strict, and thus more cost-effective.
- Increased agriculture production due to reduced salinity intrusion, is another early indication of the project's achievements.
- CEIP-1 has already achieved enhanced mobility on the embankments and as such improved access to schools and hospitals.
- Increased protection from coastal hazards, enhancement of agriculture production and easier connectivity are good indications of coastal resilience and socio-economic development.
- Social and environmental safeguarding has been a crucial aspect of this project and has been implemented as per GoB and World Bank Guidelines. In addition, throughout CEIP-1, good Team Work was developed between BWDB, World Bank and private parties involved. This is an important asset for continuation and implementation of the next phase of this project.
- CEIP-1 has paved the road, implementing gradually several design optimizations in view of practices and type and quality of material used, which provides a good starting point to introduce more innovations and possible cost reduction. For example, using automated CC-block manufacturing plants which allow optimization of the logistics, reducing construction time and hence reducing cost and enhancing quality of the works.

Figure 2.3: Nalian Closure under CEIP-1

2.3.1.3 Challenges encountered

Some of the challenges encountered during the feasibility studies and the implementation phases of CEIP-1 are listed below:

- The Polders under rehabilitation are situated by the side of the mighty rivers Sibsha, Passure, Baleshwar, Paira and also by the side of the Bay of Bengal, whose banks are subject to serious and frequent erosion, causing rapid reduction of set-back distances of the adjacent embankment. The latter has impact on the original alignment that was fixed during the study period, using the existing embankments as a reference. As a consequence of the change of the original alignment, revised LAPs were required, which is an extremely lengthy process and is hindering the works significantly. As such, already from the feasibility stage of a project, the alignment of the embankments requires to be designed prudently, taking into consideration the dynamic morphology of the river and coastal systems.
- Similarly, to the latter challenge, the location of riverbank protection works have been identified during the study period, based on which the design length has been fixed and the detailed design was prepared accordingly. By the time until implementation of the works, in several areas, the exact location as well as length of the planned bank protection works had changed radically due to dynamics of the river morphology. As a result, the contract value drastically increased when compared to the original contract value resulting in contract variations. For this reason, the identification of the location and length of the river bank protection works should be carefully done so that the length and volume of work is remain within the contract value to avoid frequent contract variation during execution of works.
- Land acquisition is a critical factor for the progress of the works. To obtain physical possession of the site first affected land owners need to be compensated. Within CEIP-1, the approval of payment of compensation to the affected landowners has taken a very long time, resulting in delays of the works in the field As a lesson learned for the next phase a realistic work plan should be prepared taking into account the actual time required for getting access to the site.

- One of the major challenges relates to the complexity of working in remote coastal Polders in terms of logistics. Poor road connections, many ferries in combination with scarcity of certain materials (for instance hard material for slope and bank protections and suitable earth filling for embankments), require logistics to be planned well in advance.
- As a result of COVID-19, CEIP-1 has been forced to adapt to significant challenges. Occupational safety and health for staff on-site, compliance with government regulations and travel restrictions, as well as managing supply chain interruptions, were some of the most vital challenges. A risk-mitigation plan which clearly sets out the actions depending on scenarios shall be made already in inception of a project, accounting for uncertainty factors.

2.3.1.4 Lesson learned from CEIP-1

Significant lessons learned from the implementation of CEIP-1 and of relevance taking into account when preparing the next phase of CEIP are presented below as follows:

Erosion:

- Focus will be given to the issue of erosion since it constitutes a significant factor hampering the stability of the newly constructed embankments, and will be directly addressed by proper design of bank protection works and/or other alternatives;
- The need for bank protection, in locations where retirement of the embankment is not possible due to local land use, should be carefully assessed with support of the outputs of morphological models. The latter allows for the identification of erosion hotspots and possible other vulnerable locations.
- Clear understanding of the coastal system and dynamics is crucial, which in combination with monitoring surveys allows for the identification of vulnerable locations.
- Regarding riverbank protection works and contract variation, it is important to consider updating the program where needed on a rolling basis due to the uncertainties associated with erosion. It also requires flexibility on funding allocation of certain construction contracts. Also the Development Project Proposal (DPP) would require some flexibility in this respect.
- Based on the above experiences, it is advised to include bank protections at those locations of the selected polders where it is now really needed and being the only solution and build in flexibility by including provisional sums for those locations which may have to combat erosion during the implementation period of the next phase of CEIP, typically having a duration of 4 to 6 years. The latter is illustrated by erosion in Polder 32 which only occurred after cyclone Amphan in May 2020 eroded land and hence causing changes in the hydro-dynamics of the system.

Figure 2.4: Erosive banks of polder 39/2C and bank protection works by CEIP-1

Figure 2.5: Embankment slope protection works in polder 35/1

Designs:

- Attempts will be made to update the design principles of bank protection, slope protection and embankments, as CEIP-1 has already paved the road, implementing gradually several design optimizations in view of practices and type and quality of material used; At a more detailed scale innovations should also be applied. Some have already implemented in CEIP-1 like e.g. the use of automated CC-block manufacturing plants which allow optimization of the logistics, reducing construction time and hence reducing cost and enhancing quality of the works, improvement in transitions and pitching of slope protection works and reducing the the number of CC-blocks in bank protection works by increasing the number of geo-bags.
- An important prerequisite for embankment works is the required safety level which determines the embankment height, since it will potentially result in cost reduction, limitation of land acquisition necessity and consequently more flexible and sustainable solutions. A policy should be developed which, among other things, describes how to protect the coast against storm surges, erosion and flooding;
- It is furthermore noted that new design guidelines for design of coastal interventions should follow a more adaptive approach which takes functional requirements, land use zoning and safety levels into account like e.g. is done in the Netherlands;

Land acquisition and resettlement:

- Regarding land acquisition and resettlement, it has been observed from CEIP-1 that the payment of compensation takes a very long time. More efficient ways and means for compensation should be investigated and the work plan should be prepared taking into account the time required to access the site.

- Significant cost increase occurred since the Feasibility Studies for CEIP-1 and actual implementation of the Project and resulting in deleting Package-3 of CEIP-1. Ways and means will have to be explored to avoid these type of surprises.

Figure 2.6: People living in the polders

Operation & Maintenance:

- Revisiting of the O&M requirements is significant for the smooth performance of the works both during construction and the design life of the project. Insufficient maintenance of the embankments and undercutting of dikes due to riverbank and coastal erosion lead to repeated implementation of Polder improvement and rehabilitation projects.
- Reduced required O&M funds making the allocation of required funding more feasible. The latter could be achieved through incorporation of such costs in the DPP.

Other:

- In relation to the Contractor's packages, works should be clustered in such a way that logistics are optimised and distances between the various sites should be minimised
- Bidding documents should take differentiation of works in different locations into account implying that e.g. different Bill of Quantity (BoQ) descriptions and technical specifications should be applied.
- Gaps are identified in the context of lack of ownership, responsibilities and participation which should be taken care of in the next phase.
- It is a common phenomenon in Bangladesh that during implementation of a rehabilitation project of coastal embankment (CERP, ECRRP, CEIP-1), one or more devastating cyclones hit in the coastal zone and damage embankment and other structures of polders including

many of the polders which are under the improvement project. Ongoing construction/repair works are also damaged. To ensure transparency and avoid duplication, fund from revenue budget or other source is not allocated to a polder by GoB which is a part of an ongoing development project. In that situation, revised DPP is required to approve to make provision for repair/reconstruction the damaged components of the project which needs time, and in that time, the magnitude of damage is increased and cost also increased. To avoid this in CEIP-2, a provision of allocation for emergency contingency plan may be included in the project cost with some condition such as the allocation cannot be used without prior permission of competent authority. Risk of damage of components of CEIP-2 due to a cyclone is very high and intended completion time may be required to extend if a devastating Cyclone hit in the project area and physical works and cost will increase as a result of it. If, provision for the amount of physical contingency and price contingency is increased for CEIP-2 project than those of other Projects, that will helpful for the smooth completion of the project.

A more detailed elaboration of the key lessons learned, as considered by the Consultant, is presented in the next session and a more thorough analysis can be found in Appendix 2.

2.3.2 Review of other Project related documents and literature

BWDB has been implementing various projects in the coastal areas of Bangladesh since 1960. According to the BWDB website (www.bwdb.gov.bd), the number of completed projects are 877. About 644 of the Projects/Sub-Projects relate to embankment repair, improvement and enhancement to protect the coastal regions from hydro-meteorological disasters and reduce overall vulnerability.

Several documents related to the next phase of the Coastal Embankment Improvement Project have already been reviewed by the Consultant during the Inception Phase, which allows the Consultant to already derive lessons learned, which contribute in a solid formulation of the approach that will be followed in CEIP-2. Those documents will naturally be revisited throughout the studies into more detail, while few other relevant reports will be reviewed afresh by the Consultant during the study of CEIP-2.

A summary of each project which have been reviewed is included in this present section and explained in more detail in Appendix 2, where lessons learned are elaborated. The Consultant will review more documents which are relevant to the Coastal Embankment Improvement Project, Following Phase (CEIP-2), where necessary.

Upon analysis of all documents, some lessons learned came up multiple times and are therefore deemed noteworthy. These lessons learned are:

- Cyclones hit the coastal area almost every year. During the implementation of CEIP-2, there is a very real possibility that a big cyclone may hit an on-going project. It is good practice to have a financial provision for addressing the probable damage, which will ensure a smooth completion of CEIP-2.

- Land acquisition, as well as Resettlement Action Plan (RAP) formalities such as payment of compensation and time for owners to vacate land can take 12-15 months minimum and must be planned taking this into account. Alternatives to land acquisition, such as long-term leasing should also be considered.
- Planning and design should be done for the whole coastal zone and its polders as sub-units, rather than planning and design on the basis of individual polders.

Coastal Embankment Project (CEP – 1958 to 1990)

The Coastal Embankment Project (CEP) was implemented to protect the low-lying agricultural land and isolated chars (islands) of the coastal belt of Bangladesh from inundation, intrusion of saline water during high tides and to increase the agricultural production of the area. Some 5665km of embankment was constructed to protect an area of about 1.22 million ha. The project improved the internal drainage of the polders, reduced salinity and significantly reduced the vulnerability of the local people against natural disasters. Over time however, due to changes in drainage patterns, sea level rise and lack of proper maintenance the effectively of the implementation has been reduced.

<u>Lessons learned:</u>

- Lack of adequate maintenance made the embankment of polders vulnerable and drainage channels become inoperable. After the implementation of CEIP II, proper maintenance of the embankment, drainage sluices and periodic re-excavation of drainage channels will need to be carried out to prevent the polders to from deteriorating over time.

Cyclone Protection Project – II (CPP-II – 1985)

Following a severe cyclone in May 1985, BWDB compiled a "long term plan for structural measures against cyclone surges". A feasibility and design study was done. The review of this report has enriched the idea for development of coastal polders on the basis of the latest scenarios of natural calamities, which in turn helped prepare the Planning and Design of CEIP-1.

Lessons learned:

- Similar to CEIP-1, planning and design of CEIP-2 will be carried out following the ideas of CPP-II

Coastal Embankment Rehabilitation Project (CERP – 1995 to 2003)

During the preparation of CPP-II, Bangladesh was struck by a severe cyclonic storm in April 1991. Instead of the improvements planned in CPP-II, it became immediately necessary to rehabilitate the damaged embankments and the CPP-II project was renamed Coastal Embankment Rehabilitation Project (CERP). In total 21 polders were selected for Feasibility Studies and implementation. During the implementation of CERP another severe cyclone struck Bangladesh in May of 1997.

<u>Lessons learned:</u>

- Coastal defences should be renovated to higher engineering standards in homogenous units. This not only has greater sustainability than isolated repairs of existing infrastructure, but it also provides a model that can be monitored to test the success of an innovation.

- Further lessons learned regarding time and cost management as well as embankment design are referred to in Appendix 2.

Second Coastal Embankment Rehabilitation Project (2nd CERP)

The World Bank Mid-Term Mission visited Bangladesh to assess the after-effects of the severe May 1997 cyclone as well as the implementation of CERP-I. During this visit, the idea of a 2nd CERP was launched. This project implemented the lessons learned from CERP-I to tackle the newfound issues through Feasibility Studies and detailed engineering. Several large components of the project included rehabilitation and improvement of embankments and water sector infrastructure.

Lessons learned:

- Prevent delay between preparation of costs estimates and commencement of work, as costs estimates can change over time and bidders may not accept a contract for work at the price tendered if the validity period of the tender security is exceeded.
- Further experience regarding specific successful embankment designs and notes on particular dykes are annexed in Appendix 2 and must be taken into account in CEIP-2

Integrated Coastal Zone Management Program (ICZMP) and 2nd CERP

The GOB with assistance from the World Bank, the Netherlands Government and other development partners have initiated an Integrated Coastal Zone Management Programme (ICZMP) to address the needs of the coastal area. All development activities in the Coastal Zone will be implemented under the ICZMP umbrella to ensure that: i) the coastal zone is developed in a systematic way; ii) scarce resources are utilized in a sustainable manner; iii) fragile eco-systems are protected to the fullest possible extent

Lessons learned:

- The ICZMP objectives have been used to define the primary objectives of CEIP-2.
- As the ICZMP objectives formed the basis for the CEIP-2 objectives, they are aligned with the broader objectives of the ICZMP whilst focussing specifically on water resources and safety against cyclone surges and river erosion.

Coastal Zone Water Management Programme

This programme was the output of the 2nd CERP preparatory consultancy which was running from July 1999 to December 2000.

Lessons learned:

- The programme, including its funding should be considered over an extended duration rather than a short period.
- The programme should involve multiple line agencies such as the BWDB, LGED, DF, etc. rather than just a single agency.

Fourth Fisheries Project

Since 1954, BWDB implemented more than 800 projects including Flood Control, Drainage and Irrigation Projects (FCDI) in the country as well as the development of 139 polder. These projects have adverse impacts on fisheries as important fish migration routes and movement from one habitat to another have been blocked. In addition to this, shrimp farmers are practicing shrimp cultivation in the polders during the he summer season by letting in saline water through unauthorized inlets in the embankments.

To mitigate the adverse impacts of FCDI projects on fisheries, BWDB carried out a Feasibility Study to provide fish pass and fish friendly structures in the completed projects under the 4th Fishery Project.

Lessons Learned:

- The 3rd Fisheries project had many deficiencies, but is still considered a successful project for the shrimp farmers. Embankments have been saved from major damage and the economy of shrimp culture is improving the living standard in the polders.
- To ensure protection against saline water intrusion in the polder, fish pass cannot be provided in any polder of CEIP-2.
- If the polder(s) under consideration in CEIP-2 is/are suitable for shrimp culture, and the local people have a desire to use it for this purpose it, to avoid a conflict of interest, it is strongly recommended to implement a shrimp and aquaculture component if the polder by creating a provision to let saline water into the polder. (On the basis of proposals from the local agriculture, fishery and Upa-zila Narbahi officer).

Emergency Cyclone recovery and restoration project (ECRRP – 2008 to 2018)

The Emergency Cyclone Recovery and Restoration Project (ECRRP) was launched in 2007 to support the Government of Bangladesh's efforts to facilitate recovery from the damage to livelihoods and infrastructure caused by Cyclone Sidr and to build long-term preparedness through strengthened disaster risk reduction and management.

Lessons learned:

- Supporting the countries systems to prepare for emergency projects is critical for a timely and impactful response
- Multi-sectoral projects require adequate planning for multi-sectoral coordination and implementation. Building strong capacity of Project Coordination and Monitoring Units (PCMU) is vital.
- Regular community consultations throughout the project can guide the appropriate choice of investments and generate practical improvements to increase impact
- Timely completion of projects in climate vulnerable and remote regions requires enhanced contract management measures. Critical Path Based Planning (CPB) can be undertaken with seasonality into it.

Blue Gold Programme (March - 2013 and on-going)

The Blue Gold Programme is implemented by the Ministry of Water Resources, through BWDB, and financed by the Government of the Netherlands and the Government of Bangladesh. It covers 25 polders with a combined area of 160,000 ha and will establish and empower rural community co-operatives to sustainably manage their sea defences, drainage and irrigation infrastructure. The overall objective of the Programme is "To reduce poverty by creating a save living environment and sustainable socio-economic development for 150,000 households on the 160,000 ha of polders".

Lessons learned:

- DPPs should include budget for all aspects, such as new works and land acquisition. In the Blue Gold Programme a major revision was required which caused delays.
- The DPP with DAE defined all interventions in minute detail, which limited flexibility and adaptivity. This should be prevented in CEIP-2.
- Further detailed advice regarding the construction of high-quality embankments and practical tips regarding earthwork are included in Appendix-2
- Various practical lessons learned on stakeholder management, WMOs and project / client management are included in Appendix-2

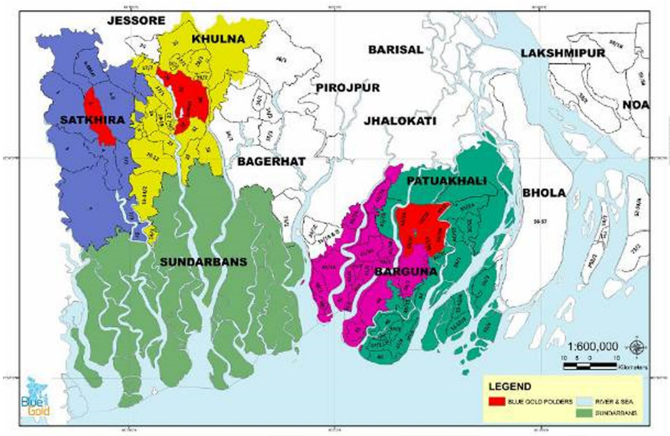

Figure 2.7: Blue Gold Polders

Integrated Planning for Sustainable Water Management (IPSWAM – 2002 to 2005)

The Integrated Planning for Sustainable Water Management (IPSWAM) Programme has been planned based on lessons learned in the Bangladesh water sector, which have led to the gradual development of a current policy framework.

<u>Lessons learned:</u>

- Institutional possessions broadly constitute "social capital", which is developed through: i) networks and connections; ii) membership of formalized groups or traditional social entities; and iii) relationship or trust, reciprocity and exchange
- Build on existing institutions instead of imposing new ones
    - Community-driven development is the key phrase, which means: i) Enabling institutional environment; ii) Participatory local governance; iii) Community control; and at the national level, a multispectral and multi organizational platform

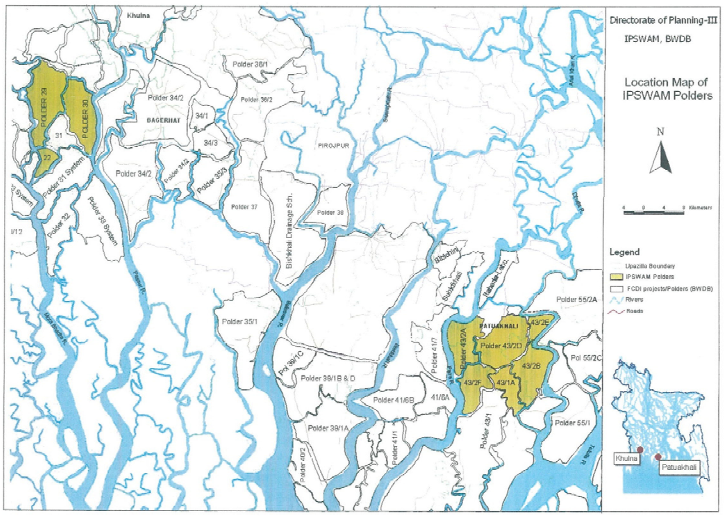

Figure 2.8: IPSWAM Polders

Long-Term Monitoring, Research and Analysis of Bangladesh Coastal Zone project

The objective of the Long-Term Monitoring, Research and Analysis of Bangladesh Coastal Zone project, is to develop relevant and state-of-the-art knowledge for the Bangladesh coastal zone, which can be used as a basis towards the development of long-term sustainable polders. The knowledge development is based on monitoring, modelling (at different spatial and temporal scale) and sharing of knowledge. It is therefore of primary importance that the conceptual design of resilient polders (i.e. the end-goal of this project) will properly account for the effects that climate change may have on the physical system and which can in turn affect the different coastal polders across the region.

<u>Lessons learned:</u>

- Although a research and development project, more context should be taken into account of end-users.
- Since it is not only a long-term project, the duration of the studies is also significant and hence earlier submission of reports and results would enhance the actual implementation of these results.

World Bank Technical Assistance Programmes

The World Bank undertook various Technical Assistance Programmes on Coastal Resilience, namely Component 1, which relates to the improvement of empirical and analytical evidence to support future investments and Component 3, which consists of Operationalizing Knowledge into On-going Projects on Investments in Coastal Resilience in Bangladesh. The studies focuses on understanding the physical system, the practices used and most importantly, the lessons learned to come up with sensible designs and investment strategies which fit in to the Bangladesh setting considering multiple aspects.

<u>Lessons learned:</u>

- Considering the broad range of topics and studies that are covered by these TAs, the list of useful lessons learned from this study is too long to include here. The list spans topics ranging from drainage and embankment improvements to maintenance and coastal resilience. The full list is included in Appendix-2.

ECOBAS

ECOBAS stands for Eco-engineered Coastal Defence Integrated with Sustainable Aquatic Food Production in BAngladeSh.

The objective of the ECOBAS project is to provide the coastal people of Bangladesh with an alternative approach for adaptation to coastal erosion and flooding compared to the traditional hardened or earthen embankments, which are often non-resilient, expensive and sub-optimal with respect to other functions such as providing a source of food, income and other ecosystem services

By using the concept of "eco-engineering", the natural resistance of shellfish reefs is used to combat the hydrodynamic forces and reduce human vulnerability to coastal erosion and flooding, while at the same time delivering a source of aquatic food.

<u>Lessons learned:</u>

- "Eco-engineering" generated interest among stakeholders and the media and resulted in active involvement and participation of the local community
- The extreme environmental conditions in Bangladesh pose challenges and resulted in a more time-consuming experimental phase.
- Data collection can be challenging in Bangladesh as sufficient and modern monitoring equipment was not always at hand and logistics support was limited.
- A combination of Earthen Embankments with oyster reef structures and mangroves has the highest benefits (compared to the current situation)

Figure 2.9: Artificial reef at south-east Kurubdia Island

2.3.3 Review of policies

A summary of each relevant policy which has been reviewed is included in this present section and explained in more detail in Appendix 2. The Consultant will review more policies which are relevant to the Coastal Embankment Improvement Project, Following Phase (CEIP-2), where necessary.

National Water Policy (NWPO – 1999)

The National Water Policy (NWPO) of the Government of Bangladesh aims to provide direction to all agencies and institutions that are working with / in the water sector to ensure that the water and associated natural resources are used judiciously so that future generations can be assured of at least the same, if not better availability of those resources.

As the CEIP-2 project Area is located in the saline zone, provision of a portion of surface run-off generated sweet water from rainfall inside the polder to agriculture and aquaculture can improve the living standard of the people of the polder.

Coastal Zone Policy (CZPo – 2005)

The Coastal Zone Policy (CZPo) has set the goal of Integrated Coastal Zone Management (ICZM) to create conditions in which the reduction of poverty, development of sustainable livelihood and the integration of the coastal zone into national processes can take place. These policies provide general guidance so that the coastal people can pursue their livelihoods under secured conditions in a sustainable manner without detailing the national environment

The realization of CEIP-2, which is part of the larger CEIP will satisfy several of the aspirations highlighted in this policy.

Coastal Development Strategy (CDS – 2005)

The Coastal Development Strategy's (CDS) objective is to select strategic priorities and actions in the implementation of the Coastal Zone Policy (CZPo) with the emphasis on the creation of an institutional environment that will enable the GoB to embark on a continuous and structured process of priotization, development and implementation of concerted interventions for the development of the CZ.

The objectives of CEIP-2 aim to fulfil several of the objectives of the CDS.

National Environmental Policy (NEPo -1992)

The objectives of the policy are to maintain ecological balance and overall development via protection and improvement of the country and thereby protect the country against natural disasters. The policy outlines the need to ensure environmentally sound development in all sectors via sustainable use of the country's natural resources.

National Land Utilization Policy (2001)

The National Land Use Policy (2001) has been declared to protect the agriculture land from other use. The policy aims to prevent the current tendency of gradual and consistent decrease of cultivable land to ensure that the production of food an meet the growing demand of the increasing population.

The Objective of CEIP-2 is also to increase food production, which will help the government with their implementation of the policy.

National Agricultural Policy (2013)

The National Agricultural Policy (NAP - 2013) is a revised version of the previous 1999 NAP. The policies objectives aim to: i) Ensure sustainable and profitable agricultural production; ii) make production diversified and adaptable to changes; iii) Improve the nutritious content, packaging and processing for export purposes; iv) improve the returns for farmers; v) promote agri-based industries to meet the demand for their products.

CEIP-2 will ensure a favourable environment for agriculture. Thus, the implementation of this project will help to achieve the abovementioned objectives of this policy.

National Adaptation Programme of Action (NAPA – 2005)

The GoB recognised climate change as an important issue and attempts were made to incorporate potential response measures for reducing impacts of climate change into an overall development planning process. Some of the measures suggested include: i) Coastal afforestation with community participation; ii) providing drinking water to coastal communities; iii) capacity building; iv) information dissemination to vulnerable communities; v) promote coastal crop agriculture; vi) adaptation to fisheries in flood prone areas.

Implementation of CEIP-2 will aid the implementation and intended measures of this policy.

National Biodiversity Strategy & Action Plan (NBSAP – 2007)

The National Biodiversity Strategy & Action Plan (NBSAP) is a national framework for initiating and executing activities leading to the conservation and sustainable use of biodiversity, and establishing mechanisms to ensure equitable sharing of the benefits derived from such activities. Some of the main objectives are to: i) Conserve and restore biodiversity; ii) Ensure long-term food, water, health and nutritional securities of the population through conservation of biological diversity; iii) Maintain and improve environmental stability for ecosystems

Bangladesh Climate Change Strategy and Action Plan (BCCSAP – 2009)

The Bangladesh Climate Change Strategy and Action Plan is part of the overall development strategy of the country. The strategy will be achieved through the implementation of an action plan that will be coordinated by the Climate Change Unit (CCU) and is based on 6 pillars: i) food security; ii) comprehensive disaster management; iii) infrastructure development, iv) research; v) mitigation and low-carbon development; vi)capacity building.

CEIP-2's project area is located in a coastal vulnerable area it may be relevant to coordinate with the CCU for necessary suggestions/guidance. As BWDB's polders are subject to the adverse effects of climate change, the implementation of CEIP-2 will be helpful to implement the action plan of this policy.

National Water Management Plan (NWMP – 2004)

In line with the principles of the NWPo, the National Water Management Plan (NWMP) provides a framework that the national and regional level within which the line agencies, local government and other stakeholders will plan and implement their activities and projects in a coordinated manner to achieve the national and sectorial objectives.

Bangladesh Delta Plan 2100

The Dutch funded Bangladesh Delta Plan 2100 is a long-term integrated techno-economic mega plan that integrates delta related sector plans and policies, enveloping a Delta Vision and strategies that make it possible to integrate sector plans and policies for the long term and to present actionable interventions with a road map for realization.

The overall objective of the project concerning the formulation of BDP 2100 was to realize a sustainable and commonly agreed strategy with all relevant stakeholders for an optimum level of water safety and food security, as well as sustained economic growth of Bangladesh and a framework for its implementation.

CEIP will need to plan and strengthen its embankment system considering BDP 2100's development scenarios. The required road networks as a result of the Padma Bridge and Payra port will require a combination of raising and strengthening the embankment as well as widening to accommodate the future traffic load. Furthermore, CEIP needs to consider the impact of the development of the region on the future cost and scarcity of land for acquisition.

2.3.4 Review of rules and regulations

A summary of each relevant regulation which has been reviewed is included in this present section and explained in more detail in Appendix 2. The Consultant will review more regulations which are relevant to the Coastal Embankment Improvement Project, Following Phase (CEIP-2), where necessary.

Bangladesh Water Development Board Act (2000)

The Bangladesh Water Development Act is an act that aims to ensure development and management of water resources by rescinding provisions of the Bangladesh Water and Power Development Board Order of 1972. Under this act, the Bangladesh Water Development Board in its present form has been created.

The Bangladesh Water Development Board Act is the legal safeguard for BWDB and according to the act, implementation of the CEIP-2 project is part of its structural functions.

Bangladesh Water Act, Act No. 14 (2013)

The Bangladesh Water Act provides for the right to water when it is used for the purposes of drinking, sanitation and sewage disposal, water control, protection and conservation of water resources. In addition, it regulates land ownership requirements, surface water, etc. The act provides provisions for punishment and financial penalty for non-compliance with the Act, including negligence to abide the government policy, ordinance, affiliation with perpetrators, etc.

Environmental Conservation Act and Amendments (ECA – 1995)

The Environmental Conservation Act aims to provide for conservation of the environment, improvement of environmental standards and control and mitigation of environmental pollution. The Government of Bangladesh established the Department of Environment (DoE) exercising the power of the Act and authorize the Director General to take measures as he considers necessary and expedient for the conservation of the environment and improvement of environmental standards

A strip of 10 km width all along the northern border of the Sundarbans has been declared as an Ecologically Critical Area (ECA). The northern boundary of the Sundarbans along the right bank of the Pussur River (Polder 33) lies within the ECA.

Environment Conservation Rules (ECR – 1997) and Amendments (2003)

The Environment Conservation Rules consist of a set of rules under the Environment Conservation Act (ECA) that enable the enforcement of the act. The rules among others include: i) the National Environmental Quality Standards for air, water industrial effluent, emission, noise, vehicular exhaust etc.; ii) procedures to obtain Environmental Clearance; and iii) requirements for Environmental Impact Assessment (EIA) according to categories for industrial land other development interventions.

Department of Environment's IEE/EIA Guidelines (1997 and 2021)

The Government of Bangladesh, with a view to providing for conservation and improvement of environmental quality as well as controlling and mitigating pollution of the environment enacted the Bangladesh Environment Conservation Act (BECA). Section 12 of this act stipulates that "No industrial unit or project shall be established without obtaining environmental clearance from the Director General of the DoE.

The CEIP-2 project will be implemented in an Ecologically Critical Area, hence an EIA will be conducted to obtain Environmental Clearance from DoE.

Bangladesh Wildlife (Conservation and Security) Act (2012); previously known as Bangladesh Wildlife (Preservation) Order (1973)

The Bangladesh Wildlife (Conservation & Security) Act provides for the conservation and safety of biodiversity, forest and wildlife of Bangladesh . The act establishes the Wildlife Conservation and Security Basic Legislation. Under this act the Wildlife Advisory Board was constituted. This board's duties and functions include: i) review and provide directives on conservation, development and management of biodiversity; ii) prepare an incentive scheme to increase awareness;

The act includes a schedule for the protection of wildlife. Some of the animals on this list occur within or adjacent to the polders like the Gangetic dolphin as well as the smooth-coated otter.

Protection and Conservation of Fish Act (1950) and Amendments (1963, 1970, 1982, 1995, 2000) & Protection and Conservation of Fish Rules (1985) and Amendments (1987)

The Protection and Conseration of Fish Act provides authority to take protective measures for the protection and conservation of all types of fish. Under this act, amongst others, the catching and selling of certain fish species and use of specific types of nets can be prohibited for certain periods. Other focus points include prohibiting the use of poison or explosives to catch fish and prohibiting the collection of fry or post larvae of fish, shrimp and prawns of any kind in estuary and coastal waters.

The Embankment and Drainage Act (1953)

The East Bengal Embankment and Drainage act consolidates the laws related to embankments and drainage, providing provision for the construction, maintenance, management, removal and control of embankments and water courses to improve the drainage of lands and for their protection from floods, erosion or other damage by water.

After implementation of CEIP-2 the act will be applicable to protect the project's components.

National Disaster Management Act (2012)

The National Disaster Management act forms the legal basis for the coordination of activities that involve disaster management, setting policies, formulation of rules and to build up infrastructure for effective disaster management to fight all types of disasters. The Department of Disaster Management (DDM) is responsible for the Disaster Management Act and to mandate the implementation of the objectives

Open Place, Park & Wetland Conservation Act (2000) and Amendments (2002)

The Open Place, Park & Wetland Conservation act stresses for the conservation of wetlands and open spaces. The act includes the country's municipal areas, playgrounds, open spaces, parks and natural water reservoirs (= wetlands), with an extra focus on those located in metropolitan cities, divisional towns and district towns municipal areas. According to the act natural water reservoirs or wetlands include rivers, canals, ponds, streams, fountains and land that conserves / holds rain water.

2.4 Data collection

The Consultant has already started collecting all the relevant that was accessible. Receiving this information and data in a timely manner is important for the successful implementation of the first stage of the project; the latter especially in connection to the selection of polders, as well as for the next stages of the Feasibility Studies. The required data in illustrated in detail in Appendix 6.

The Consultant has at this point collected data and information in relation to relevant projects such as Coastal Embankment Improvement Project Phase-1 (CEIP-1), Blue Gold Programme, ECCRP, Bangladesh Delta Plan (BDP2100) and other documents as illustrated in Section 2.3. Review of this data has made possible the derivation of lessons learned which will be incorporated in the study, and at the same time data and information in relation to the polders, design procedures and other relevant aspects have been derived. In addition the Consultant has reviewed an analysed the World Bank Technical Assistances: 1) Coastal Resilience: Developing New and Innovative Approaches in India and Bangladesh along the Bay of Bengal; Component 1: Improving empirical evidence and analytical support to future investments and 2) Developing Concept Design Solutions for Coastal Erosion In Bangladesh, and 3) Analytical study on the role of a probabilistic approach in polder and embankment design in Bangladesh.

It is worth mentioning that the Long Term Monitoring (LTM), Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), is expected to provide valuable information, data and insights for the CEIP-2 project. Thus, receiving of the data (access to the Data Base) and having the reports available is considered crucial, for both initiation of the studies as well as during feasibility. Consultant has already formally requested for the information of the LTM Project and access to the database system developed under the LTM Project. It is important to have the reports, even partially completed, and data of this LTM project as soon as possible.

Data collection has also been performed through stakeholder consultations and field visits as explained in the following Sections.

2.5 Consultations with stakeholders

Stakeholder consultations constitute a very important component of this study from the early beginning. Stakeholders of different levels will be engaged and the Consultant ensure maintaining their involvement throughout the whole duration of the project.

During the Inception Phase, the Consultant has been in communication with the Project Director of CEIP-1 (PD) and the various representatives of the BWDB, e.g. Executive Engineers (XEN). The purpose of the communications was to consult them as to the most vulnerable polders and as to obtaining an overview of the condition of the polders in relation to infrastructure and ongoing developments.

In addition, the Consultant has kindly requested the Project Director to arrange meetings with the following Ministries (Table 2-2). The purpose of these meetings are to explain the objectives and activities of this feasibility study and in parallel, receive their suggestions and views on the project approach and development.

Table 2-2: Proposed Ministries and Representatives for Consultations for consultations

Suggested Ministry	Suggested Representatives
Ministry of Water Resources, Bangladesh Water Development Board	DG, ADG-W, ADG-E, ADG-P, PD, XEN's of most vulnerable polders
Ministry of Planning	Representatives dealing with prioritisation of land use
Ministry of Finance	Representatives dealing with infrastructure budgets in the coastal zone
Ministry of Road Transport and Bridges	Representatives dealing with infrastructure where roads and embankments are combined
Ministry of Fisheries and Livestock	Representatives dealing with fisheries and livestock in coastal zone
Ministry of Environment, Forest and Climate Change	Representatives dealing with climate change scenario's
Ministry of Disaster Management and Relief	Representative dealing with DRM in coastal zone
Ministry of Local Government, Rural Development and Co-operatives	Representatives dealing with overlapping infrastructure development in the coastal zone.

The Consultant has plans to maintain communication with the Project Director and Team Leader of the Blue Gold Project, giving specific focus to the lessons learned, bottlenecks and success stories of the project. This Dutch funded Blue Gold Project which is building on the results and lessons learned from previous programs and on-going projects in Bangladesh, notably the Southwest Area Project, Coastal Embankment Improvement Project (CEIP-1) etc. and the Bangladesh and Dutch experiences and expertise in participatory water management in polders. Consultant will also liaise with the Dutch Embassy in Dhaka who is funding the Blue Gold Project.

2.6 Field visits

Field visits are crucial throughout the whole study period, from inception phase to feasibility and detailed design phase. The field visits will have a different nature according to the stage of the project and will either involve visual scanning of the area, social and environmental surveys (for LAP, RAP and EIA) or detailed engineering surveys (topographic/engineering survey and river cross-section survey) which will be used as input to the modelling and detailed design works.

During Inception phase, taking in to account of the COVID-19 pandemic situation and restrictions on movement, experienced experts from the Consultant's Team already visited several polders in the field, in order to gain a good understanding on the current condition of the polders and already identify locations which experience threats from coastal hazards.

In addition, the safeguard team visited some polders particularly vulnerable sections and talked to the local people about their opinion on rehabilitation, WMOs, tidal effect, land acquisition and displacement, etc. Such field visit will be continued during the study period for obtaining ground level information and opinion of the local people for the safeguard document.

The outcomes from the field visits serve as an input to the polder selection procedure. The field visits were mostly carried out around Satkhira and Khulna area. One of the reason of choosing this area was the vulnerability of the polders and the after the cyclonic surges in 2019 & 2020 (Amphan), these polders were impacted and no fruitful remedial measures for protecting the crops, shrimps and other installations have been taken so far. During those field visits, the Consultant has focused in visual observations, has taken pictures and reported the most prominent threats and damages of embankments and regulators.

Some of the key observations per polder are presented below. More detailed information per polder can be found in Appendix 7.

Polder 4

Figure 2.10: Polder 4 at Daksin Puijala, Assasuni

Polder 4 has a 80 km long embankment covering Assasuni Upazila under Satkhira District surrounded by mighty flowing rivers like Kobadak and Kholpetua and other small rivers. Due to the cyclonic surges hit of "Ayla" in 2009, "Foni" & "Bulbul" in 2019 and "Amphan" in 2020, polder 4 has been damaged tremendously. Some 80 km embankment need complete rehabilitation out of which 6.80 km is most vulnerable and 11.90 km is vulnerable. Therefore, the field division is asking 15 km riverbank protective works and 22 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 20. Moreover, 25 numbers box inlet are to be constructed. 54 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 30 ha area is required to be brought under afforestation. For this, around 150,000 seedlings will be planted.

Figure 2.11: Polder 5 km 89.500 at Chuna, Shyamnagar, Satkhira

Polder 5

Polder 5 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 194.35 km embankment need complete rehabilitation. Therefore, the field division is asking 20.083 km riverbank protective works and 23.313 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 43. Moreover, 63 numbers box inlet are to be constructed. 104 km drainage channel and 11 km small river are required to be re-excavated for smooth navigation. Next to that, 18.8 km river dredging is required. For environmental safeguarding, a green belt of about 140 ha area is required to be brought under afforestation. For this, around 400,000 seedlings will be planted.

Figure 2.12: Polder 7/1 at Jhapa-1, Assasuni, Satkhira

Polder 7/1

Polder 7/1 has 34.21 km long embankment covering Assasuni and Shyamnagar Upazila under Satkhira District surrounded by mighty flowing rivers like Kobadak and Kholpetua and other small rivers. Polder 7/1 has been damaged tremendously. Some 34.21 km embankment need complete rehabilitation out of which 7 km is most vulnerable and 13.50 km is vulnerable. Therefore, the field division is asking 5 km riverbank protective works and 15 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 7. Moreover, 12 numbers box inlet are to be constructed. 32 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 5 ha area is required to be brought under afforestation. For this, around 50,000 seedlings will be planted.

Figure 2.13: Polder 7/2 at Tutikhali-3, Assasuni, Satkhira

Polder 7/2

Polder 7/2 has 59.59 km long embankment covering Assasuni Upazila under Satkhira District surrounded by mighty flowing rivers like Kobadak and Kholpetua and other small rivers. Polder 7/2 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 59.59 km embankment need complete rehabilitation out of which 15.50 km is most vulnerable and 19.20 km is vulnerable. Therefore, the field division is asking 15 km riverbank protective works and 25 km embankment slope protection work for safeguarding the embankment. In addition, the existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 14. Moreover, 32 numbers box inlet are to be constructed. 62 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 55 ha area is required to be brought under afforestation. For this, around 150,000 seedlings will be planted.

Polder 10-12

Figure 2.14: Polder 10-12 at Kumkhali, Paikgacha, Khulna

Polder 10-12 has 67 km long embankment covering Koyra and Paikgacha Upazila under Khulna District surrounded by mighty flowing rivers like Shibsha, Kurulia and Koyra. Due to the cyclonic surges, Polder 10-12 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 67 km embankment need complete rehabilitation out of which 15 km is most vulnerable and 28 km is vulnerable. Therefore, the field division is asking 11 km riverbank protective works and 23 km embankment slope protection work for safeguarding the embankment. In addition, the existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 15. Moreover, 18 numbers box inlet are to be constructed. 52 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 70 ha area is required to be brought under afforestation. For this, around 260,000 seedlings will be planted.

Figure 2.15: Polder 13-14/2 at Hogla-2, Koyra, Khulna

Polder 13-14/2

Polder 13-14/2 has 91.77 km long embankment covering Koyra Upazila under Khulna District surrounded by mighty flowing rivers like Kobadak, Ungtihara and Koyra. Due to the cyclonic surges Polder 13-14/2 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 91.77 km embankment need complete rehabilitation out of which 35.70 km is most vulnerable and 30.68 km is vulnerable. Therefore, the field division is asking 25 km riverbank protective works and 25 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 16. Moreover, 33 numbers box inlet are to be constructed. 74 km drainage channel is required to be re-excavated for smooth navigation. Next to that, 15 km river dredging is required. Conditions of all the 12 sluices/water control structures is very bad and 4 of them are fully damaged. For environmental safeguarding, a green belt of about 40 ha area is required to be brought under afforestation. For this, around 250,000 seedlings will be planted.

Figure 2.16: Baroaria, Batiaghata, Khulna

Polder 29

Polder 29 has 49 km long embankment covering Batiaghata and Dumuria Upazila under Khulna District surrounded by mighty flowing Rivers like Gangrail, Bhadra and Upper Shaltha. Due to the cyclonic surges, Polder 29 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 49 km embankment need complete rehabilitation out of which 10 km is most vulnerable and 18 km is vulnerable. Therefore, the field division is asking 9 km riverbank protective works and 13 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 11. Moreover, 81 numbers box inlet are to be constructed. 72 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 70 ha area is required to be brought under afforestation. For this, around 240,000 seedlings will be planted.

Figure 2.17: Kismot Fultola, Botiaghata, Khulna

Polder 30

Polder 30 is situated in three unions covering a total of 8,048 ha land inside the polder, 27 water management structures (drainage sluice and flashing sluice) and 39 km of drainage canal inside the polder. Cyclone Aila and Sidr damaged the embankment though the Yeas, Mohasen, Bulbul and Nargis had very little impact on the Polder 30. Two locations have major impact due to the erosion of river and therefore, need to construct retired embankment. Re-sectioning of the embankment is also required in most areas of the embankment. Approximately 5 ha land will need to be acquired for rehabilitation of the embankment. It is estimated that about 800 residential household, more than 300 commercial enterprises and 6 Community Properties (CPRs) will potentially be affected due to rehabilitation of the polder. All and all, rehabilitation of the polder is an urgent need of the people.

Polder 31

Figure 2.18: Polder 31:at Kaminibashi, Dacope, Khulna.

Polder 31 has 47 km long embankment covering Dacope Upazila under Khulna District surrounded by mighty flowing rivers like Possure, Shibsha, Dhaki, Bhadra, Jhapjhapia and Chunkuri. Due to the cyclonic surges, Polder 31 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 47 km embankment need complete rehabilitation out of which 13 km is most vulnerable and 18 km is vulnerable. Therefore, the field division is asking 15 km riverbank protective works and 22 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 24. Moreover, 24 numbers box inlet are to be constructed. 72 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 60 ha area is required to be brought under afforestation. For this, around 225,000 seedlings will be planted.

Figure 2.19: Khona, Dacope, Khulna

Polder 39

The embankment of polder 39 is about 47 km long out of which 15 km is paved road. The remaining area is very vulnerable to river erosion threat. The polder is situated in two union and one municipality covering total 14,998 ha land inside the polder, 27 water management structures (DS and FS) and 7.5 km of drainage canal. The polder is always under river erosion and tidal surge threat. Cyclone Aila and Sidr created damage to the embankment. In many places the embankment breached. Water over-topping during large high tide is a common phenomenon since the embankment height is very low. Moreover, local people opined that in some places the embankment condition is very bad and they can be affected by tidal affect at any time.

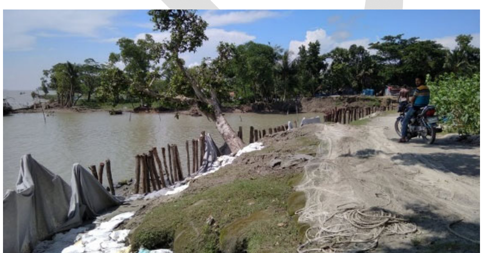

Figure 2.20: Polder-40/1, Chorlathimara

Polder 40/1

Polder 40/1 situated in one union covering a total of 3,567 ha land. As it is close to the sea, normal waves hit the embankment. Due to cyclone Yeas & Aila the embankment has suffered a lot of damage. Therefore, about 6 km of the area has river erosion threat. 1.5 km of embankment has to be replaced and 4.5 km has to be strengthened. Also protective work for 4.5 km embankment is urgently required. Rehabilitation of the embankment including reconstruction of fashing sluice & drainage sluice will require about 17 ha land acquisition. The opinion of the people of the area is to build sustainable and high-quality embankment without repairing the dams every year.

Figure 2.21: Polder-41/6A, Location-Jangalia

Polder 41/6A

Polder 41/61 situated in one union covering a total of 5,200 ha land. The total length of the embankment is about 34 km out of which 13 km paved road. Due to cyclone Yeas & Aila the embankment suffered a lot of damage. Therefore, about 3 km of area have river erosion threat. About 2.5 km of retired embankment is to be constructed and 1.5 km to be strengthened to protect from river erosion threat. Also protective work for 2.5 km embankment has to be done. Rehabilitation of the polder including retired embankment, protective work, re-sectioning and construction of flashing sluice & drainage sluice require about 13 ha of land acquisition. People strongly opined to build sustainable and high-quality embankment so that it doesn't need to repair every year.

Figure 2.22: Polder-47.1, Location-Nizampur

Polder 47/1

Polder 47/1 situated in one union covering a total of 2,834 ha land. The total length of the embankment is about 22 km out of which 5 km paved road. Due to the proximity of the sea and the shallowness of the river, tidal surge hit the embankment. In addition, the embankment suffered a lot of damage from cyclone Yeas & Aila. Therefore, about 3.5 km retired embankment is required and another 4 km protective work has to be done. All flashing sluice & drainage sluices need to repair. Rehabilitation of the embankment and construction /repairing of the sluices require about 18 ha of land will have to be acquired. The people strongly opined to build a sustainable and high-quality embankment.

Figure 2.23: Polder-55/1, Location-Barnatali

Polder 55/1

Polder 55/1 situated in one union covering a total of 5,200 ha land. The total length of the embankment is about 47 km out of which 22 km paved road. The polder is exposed to the river and vulnerable to river erosion threat. Due to cyclone Yeas & Aila the embankment has suffered a lot of damage. Therefore, about 2.5 km retired embankment is required and 10 to 12 km protective work is to be done. All flashing sluice & drainage sluices are to be repaired. About 13 ha of land will have to be acquired to develop the embankment. The people living on and inside the polder expressed their views to strengthen the embankment with a sustainable solution so that repairing will not be required every year.

3. Detailed scope of works for Consultancy Services

3.1 Introduction

This Chapter elaborates on the various Tasks defined in the Terms of Reference and Consultant's interpretation of ***what*** has to be conducted and delivered. As said, Chapter 4 describes **how** the Consultant will achieve the requirements of the ToR of some main subjects.

3.2 Task 1: Prioritization to select the next batch of polders for CEIP

Throughout the last 60 years, the 139 polders constructed along the coastal zone in Bangladesh have successfully protected the coastal population from storm surges and tidal flooding, while they have contributed in improvement of other treats such as water-logging and salinity intrusion, helping the coastal communities grow and safeguarding them. More specifically, the existing embankment crest levels typically only provide protection from the 5 to 10-year storm surge return period (2% wave overtopping level)[11].

Nevertheless, throughout the last years, the effectiveness of the polders in protecting the land and people within the polders, in many cases has been compromised by damages caused from severe cyclones, shifting coastal and river bank lines, deterioration due to frequent storm surges. In addition, indirect hazards such as salinity intrusion and sedimentation, also pose a continuing and significant threat to their health and livelihoods. The current condition of the polder protective infrastructure implies that a large part of the coastal population being exposed to tidal floods and natural hazards.

The existing vulnerability of the coastal zone to direct and indirect coastal threats, highlight the urgency to improve the polder infrastructures. Several projects have been introduced and implemented with the objective to improve the condition of the polders, such as Emergency Cyclone Recovery and Restoration Project (ECRRP), 2007 which was implemented to restore damages from Sidr and Aila cyclones. In 2013, the Coastal Embankment Improvement Project (CEIP-1) has initiated where 17 priority Polders have been selected for feasibility and implementation of rehabilitation and improvements including protection from climate change, which for firstly introduced. The Polders are clustered in six districts: Khulna, Bagerhat, Pirojpur, Barguna, Patuakhali and Satkhira mainly in the South West region.

Following CEIP-1, the next phase of CEIP is intended to improve certain polders of the remaining 122 and to thay end a selection will have to be made of a next batch of 13 polders. The selection of the 13 polders and the optimal investment option which will be taken forward in the current studies, will be performed within three sub-tasks of Task 1 as follows:

- Task 1.1: Prioritization of 122 polders and selection of 23 polders for detailed prioritization;

[11] Design Manual Procedures for Designs of Polders in Tidal Areas in Bangladesh, Md. Abdul Quassem, P.F. Raijmakers, J. Burger, Delta Development Project Bangladesh Water Development Baord, 1983

- Task 1.2: Detailed prioritization of 23 polders and selection of 13 polders for Feasibility Study;
- Task 1.3: Selection of an optimal investment option.

3.2.1 Task 1.1: Prioritization of 122 polders and selection of 23 polders for detailed prioritization

From the total of 139 polders along the Bangladesh coast, 17 polders have been included in the defined Packages 1, 2 and 3 of the CEIP-1 program. Currently only 10 polders of Packages 1 being polders 32, 35/1, 33, 35/3 and Package-2 being polders 39/2C, 40/2, 41/1, 43/2C, 47/2 and 48 are being implemented and the 7 remaining polders of the envisaged Package 3, being Polders 14/1, 15, 16, 17/1, 17/2, 23 and 34/3. In view of the above, 122 polders could potentially be considered for inclusion in CEIP-2 however it stands to reason that some of these 122 polders will never be eligible for inclusion CEIP-2 because it concerns locations where threats are relatively limited and remote in terms of logistic constructability and polders are less vulnerable because of the their condition or socio-economic developments cannot justify investments in polder improvements. Furthermore, certain polders will be improved by other Government budgets or other donors.

To narrow down the 122 polders, within this task, a sub-set of 23 polders will be selected, including the 13 polders which will be taken forward in CEIP-2. This sub-set should be generated after obtaining a concrete understanding of the coastal system, dynamics (both physical and socio-economic), vulnerabilities, potentials for development and last but not least, condition of existing protective infrastructure. It is envisioned that a subset of 23 polders from the original 122 polders can be relatively quickly selected without elaborating in detail based on a variety of reasons, for instance:

- The polders are very vulnerable to a combination of coastal threats;
- The population inhabiting in the polders is large;
- There are prospects of socio-economic developments in the polders;
- The condition of the coastal and drainage infrastructure is not good.

3.2.2 Task 1.2: Detailed prioritization of 23 polders and selection of 13 polders for Feasibility Study

The detailed prioritization of the to be selected 13 polders will be done via means of an extensive analysis of the 23 polders which will be derived from Task 1.1, and thereafter application of a Multi Criteria Analysis (MCA). The following steps will be followed:

- Definition of guiding principles of this selection procedure is crucial for this Task. In that way, all the relevant aspects and lessons learned from past as well as ongoing projects will be taken into account and as a result, a fully informed selection will be made. The guiding principles will be translated into selection criteria, which will serve as scoring for the MCA;
- The assessment of the existing infrastructure of the 23 polders, will reveal an initial list of locations which necessitate interventions and consequently, initial interventions (slope and

bank protections, sluices and associated infrastructure) will be defined depending on, amongst others, the statistics of physical parameters and the present and future bank erosion characteristics. Definition of their expected extents will necessitate in certain cases and will be used as input to the following steps;

- The estimation of cost of the interventions is also important for the prioritization of the polders. The estimated cost for each intervention will be based on market prices and empirical facts, and may also require concept designs of proposed interventions for calculation of the volumes and quantities. Tentative cost estimates of the interventions will be prepared which will be based on volumes and quantities derived from said conceptual designs and unit rates. This steps refers to embankments and slope protections, drainage/flushing sluices, channel excavation and river bank protections;
- Assessment of potential economic and societal benefits from implementation of relevant interventions to the polders, constitute an important factor for the prioritization. In combination with other parameters, the benefits will reveal whether an investment is considered acceptable or not. For the economic benefits, consideration will be given to the prevailing sectors in the coastal zone, such as agriculture and aquaculture, as well as the potential for future socio-economic developments of certain sectors (i.e. tourism, aquaculture etc.). As part of the societal benefits, the potential avoided damages to assets and the population of a storm surge inundation event will be considered as an important parameter. For this reason indications will be provided of the size of potential affected population, size of economic production and/or the amount or value of assets (buildings, roads, area of land for crops etc.) for the polders. These figures will provide tentative indications of possible benefits of interventions which are possible to compare and score over the polders;
- Assessment of the environmental conditions of the polders, such as salinity intrusion and sedimentation will be also closely looked at. In addition, the potential positive (and negative) impacts of construction of embankments will be considered. Depending on the economic activities, this environmental condition could lead to an urgency to rehabilitate the polder. Areas where severe water logging is occurring could be avoided for the first batch of selected polders if there is no direct solution at hand, however, Tidal River Management may be considered;
- Land acquisition plays a very sensitive issue, as shown in CEIP-1, that will be looked at closely. During construction and re-alignment of the embankments, the people living in proximity of the construction works have been affected, both positively and negatively. At the same time, land acquisition is a critical factor for the progress of the works. To obtain physical possession of the site first affected land owners need to be compensated and that is taking significant amount of time. In addition, optimization of works will be considered, for instance, when there is a possibility to combine the construction of embankments with roads, a win-win situation will occur, making the chances for that polder more favourable;
- Logistics of the construction, e.g. clustering the polders nearby into a package, and availability of construction materials like earth for the embankments will also be considered;
- All the outputs from the analysis from the previous steps will be incorporated in a MCA scheme, which will be comprised of representative criteria and weights of each criteria

which will be formed via consultations with key-stakeholders. The MCA will result in selection of the final 13 polders out of the said 23 polders. Within this task, the MCA conducted in 2012 within CEIP-1 will be reviewed and re-assessed in terms of actualisation of the various weighting and scoring values and conditions of the various polder components and some of the criteria and information will be used as inputs to the new MCA that will be developed. This list of prioritized polders will then be used as input for the next task which will include the preparation of an optimal investment option.

3.2.3 Task 1.3: Selection of an optimal investment option

An optimal investment option will be made to define a CEIP-2 project with an investment cost of about US$400 million or about 25% of the total coastal embankment system rehabilitation cost need whichever is acceptable to the Government of Bangladesh and the World Bank. The investment option will include the 7 polders taken over from CEIP-1 and the additional selected 13 polders, resulting from Task 1.2. It is noted that said assumed investment cost of about US$400 million will have to be confirmed by BWDB and the World Bank.

The optimal option must be such that it will be optimal in terms of technical and institutional consideration and extent of disaster risks reduction, in terms of minimal environmental impact to neighbouring schemes, maximum returns to the investments in first phase of the program, beneficiary participation in the program. The chosen option must be proven for its standalone optimal performance response to the investment plan.

3.3 Task 2: Preparation of Feasibility Studies for the 20 polders (including updating/reviewing 7 Polders of Package-1 of CEIP-1) selected in Task 1

3.3.1 Task 2.1: Preparation of feasibility level designs

After finalizing the list of new 13 polders for the study, feasibility level designs will be prepared by the Consultant following the approved guidelines that would include new construction of drainage sluice/flushing regulators and reconstruction or strengthening of the existing those type of structures and embankments. Feasibility level designs for internal drainage system and bank protection works will also be prepared if needed as per outcome of hydrological model analysis. Designs will be completed following the BWDB's approved design manual/guidelines. The feasibility level designs will not require to be approved by BWDB but they will be more or less the final concept which will submit for approval to BWDB. The following tasks will also be followed for preparing the feasibility level designs of the 13 new polders where and when needed

3.3.1.1 Review of earlier programs

For the investment plan, 20 polders will be the part of this feasibility study, out of which 7 were already prepared under CEIP-1. The Consultant will review the related reports and designs prepared for these 7 polders as a part of review of earlier programme and will be updated if needed.

Based on the available data to BWDB and data will be collected from field during study, finally 13 polders will be selected from 122 polders. The following lessons learned from CEIP-1 will be applied in preparation of design of the polders of CEIP-2:

- Datum used in CEIP-1 will be used for all survey works for this study;
- For fixation of embankment crest level, 25 years storm surge return period will be applied;
- Allowances for subsidence and sufficient freeboard will be added to fixed the design crest level;
- Design will complete following the approved design criteria and specifications prepared by Consultant of CEIP-1 and manual and technical specifications of BWDB and;
- For sustainability and protection against storm surge, slope protection works will be included in design where needed.
- From the design of CEIP-1 polders, the preliminary idea about dimensions of structures, embankment and materials used can be calculated. There are different sizes of structures. Construction cost of structure and embankment can be assessed for feasibility study.
- Land acquisition issues.
- Availability of construction materials at location of works.
- Realignment of embankments to cope with uncertainties in predicting erosion.

3.3.1.2 Data collection

To conduct the prioritization of the polders, field level data/information about embankment length, nos. and condition of existing drainage sluices, flushing regulators, catchment area, population, economic activity, cross-section survey data for khals of the polder and adjacent rivers etc. will be required. For design of new construction/re-construction works, data about foundation soil properties, local rainfall data and water level data of adjacent rivers etc. will be required. Data and information about existing infrastructure of polders and its present condition will be collected from BWDB and other ongoing studies and projects and information about population, economic activities will be collected from other Governmental sources and other acceptable sources.

For preparation of design of new construction works, necessary water level data and information of adjacent rivers will be collected from BWDB, spot levels inside and outside adjacent area of embankment, existing embankment's cross-section, drainage channel's cross section will be collected from topographic survey on the ground, cross-section of adjacent rivers will be measured by combining bathymetric survey and topographic survey. For collection of data related to foundation soil, geotechnical surveys and investigations will be carried out.

More specifically, for engineering survey data (topographical, bathymetric, river and tidal creek's cross-sections etc), hydrometric data (water level, stream flow data, salinity data etc.), morphological data (sediment load, bank and bed erosion, change of bank line over the time etc) and site investigation using appropriate technology on the ground such total station, DGPS, echo-sounder, ADCP and satellite imagery, GIS and other computerized systems to gather data necessary for morphological and river engineering studies as mentioned above and for improving and calibrating available hydrodynamic, storm surge, and morphological models to test for various strategies and alignments and design for coastal embankment system to provide most optimal solution for improving its performance considering technical, economic, social and environmental aspects.

For preparation of the land acquisition plans, necessary data will be collected from Land Sections of Deputy Commissioner's Offices and from the spot.

3.3.1.3 Topographic surveys and bathymetric and hydrometric surveys

The objective of the survey work is to collect field data of the surrounding area of the 13 polders which will be selected, for supporting the model studies (calibration and for providing design parameters), planning and detailed design of the 13 polders.

The Consultant will undertake bathymetric surveys of peripheral rivers and drainage channels, embankment surveys, installation of temporary bench marks, proving XYZ, water level surveys, discharge observation and velocity profiling, suspended sediment sampling and analysis, bed material samples, drainage channel surveys.

The specific items of work and specifications are defined in Table 3-1. It should be mentioned that the estimated quantities are defined based on an average polder. Those quantities will be further detailed once the 13 polders have been selected, however it is not expected to surpass those estimated quantities.

Table 3-1: Bathymetric and topographic surveys items of work

Items of work and initial specifications	Unit	Estimated Quantity
1. Topographic surveys for 13 polders		
Topographic survey[1] at 50mx50mm interval by total station	km^2	900
Embankment Survey[2]: Cross-section survey along the Embankment 500m interval (including structure inventory)	nos.	1,000
Installation Bench marks[3] in pair every 10 km apart. (1000mmx300mmx300mm)	nos.	100
Proving XYZ by DGPS observation by static mode (every 10 km)	nos.	100
2. Bathymetric surveys for 13 polders		
River cross-section survey[4] @ 1000 m interval	nos.	850
Cross section along the peripheral river[5] of the 13 polders @ 1000 m interval extended up to high bank or up to embankment	nos.	800
Cross-sections along the river bank protection work[5] for 10 km for Bank Protection Works @250m (total for 13 Polders). For each km 3 cross sections are needed because the other two are covered from above. 10 km x 5 points =50 no	nos.	50
Drainage survey within the polders[6]: Cross-section survey of the drainage channel 500m interval	km	1,000

3. Hydrometric surveys for 13 polders		
Water Level observation[7] at half an hour interval for 6 months duration (monsoon) at 2 locations in 13 polders including gauge plunk purchase, gauge installation and required BM fly (26nos X 6 months = 156 gauge-month)	nos.	156
Discharge Observation[8] by ADCP including sediment sampling at 13 location (one in each polder) covering neap and spring tide in monsoon period (13 locations X 2= 26 nos.)	Nos.	26
Collection of suspended sediment sample[9] during discharge measurement in three depth locations, three times per day and analysis in the laboratory (13 obs. X 9 nos = 117)	nos.	117
Collection of bed sample[10] (in connection to the previous activity, three times a day) and analysis in the laboratory (13 x 3 nos.= 39)	nos.	39

3.3.1.4 Geotechnical surveys and investigations

The objective of geotechnical surveys and investigations in this study are, determination the characteristics of sub-soil under the foundation of drainage sluice/flushing sluices to be constructed and also determination of the bearing capacity of the underneath soil of those structures and embankment to be constructed. The results of this investigation will be required to take decision, whether any foundation treatment will be required or not for the safety of the structures to be constructed and what would be the type and depth of foundation for the given structure.

The scope of the geotechnical investigations/ surveys for drainage sluices and flushing sluices:

- Execution of exploratory borings, recording of sub-soil stratification and position of ground water table;
- Execution of Standard Penetration Test (SPT);
- Collection of disturbed soil samples up to the final exploration;
- Collection of undisturbed soil samples;
- Execution of laboratory tests on soil samples to determine the physical and mechanical characteristics of the underlying soil deposit;
- Evaluation of bearing capacity of soil at different layers;
- Preparation of report with all works.

Exploratory boring approximately at 190 drainage sluice and 120 flushing regulator sites in 13 select polders will be carried out. These figures are based on an average polder. Those quantities will be further detailed once the 13 polders have been selected, however it is not expected to surpass those estimated quantities. The depth of exploratory boring will be average 20.00 m for drainage sluice but maximum 25 m depending on soil condition and up to 15 m for flushing regulators and embankment.

The laboratory investigation categories that shall be performed refer to the following, and the number of required tests per laboratory investigation category relates to the soil type and shall be carefully defined on a case-by-case basis:

- Natural moisture content;

- Atterberg limits;
- Density (wet/dry);
- Grain Size Analysis;
- Unconfined Compression tests;
- Direct Shear test;
- Specific gravity;
- Consolidation test.

The following will be reported per boring:

- A site plan or plans showing the location, number and designation of each borehole or trial pit
- Description of methodology used for surveys and analysis;
- Logs for all boreholes;
- Logs for all trial pits;
- Correlation of soil property with Standard Penetration Test;
- Soil characterization;
- Laboratory test results and analysis of:
    - Bore logs for each borehole (showing the soil classification, the number of blows on spoon and Standard Penetration Test results);
    - Graphs in relation to Partical Size Distribution Test of Soil;
    - Graphs in relation to Unconfined Compression test;
    - Graphs in relation to Direct Shear Test;
    - Graphs in relation to Consolidation Test of Soil;
    - Summary of all above results
- Bearing capacity analysis of the soil;
- Conclusions and recommendations regarding the sub-soil condition of each sluice.

3.3.1.5 Hydraulic and hydrological analysis modelling

In connection to the hydraulic and hydrological analysis modelling the following will be conducted:

1) Review of existing morphological/ hydrological/ hydraulic mathematical analysis and model data to extract relevant and detailed information as inputs of the hydraulic/hydrological analysis/modelling of the selected 13 polders.
2) Statistical downscaling of different climatic parameters, such as rainfall or temperature, to assess the future climate change.
3) Use of GIS (Planform analysis, land use, Social infrastructures & afforestation Map preparation, erosion and accretion assessment, drainage/khal network mapping, river connectivity mapping etc) to gather data necessary for morphological and river engineering studies for improving and calibrating numerical models. Development, updating and calibration & validation of 2D hydrodynamic Bay of Bengal model using Delft3D as well as development, updating and calibration & validation of 2D cyclone induced storm surge model, wave model using Delft3D. The results of these models and the and statistical analysis of storm surge levels, waves, wind, monsoon water level and monsoon wind will

contribute in definition of sea level rise, monsoon water level, height of storm surges, waves and cyclonic wind for 13 selected polders.

4) Statistical analysis of historical cyclone induced storm surges, wave, wind, monsoon water level, monsoon wind to calculate different return periods and frequency for cyclone induced storm surges and their probable direction, desirable level of protection for 13 selected polders.
5) Definition of design hydrological event scenarios (rain and tide) for 13 selected polders as input to the drainage modelling.
6) Development, updating and calibration & validation of quasi 2D Drainage model using SOBEK. The results of this model will be used for assessment of effectiveness of existing drainage system, options for drainage improvement plan and selection of design parameters for sluices (such as locations of sluices, capacity and number of vents).Assessment of salinity intrusion, water logging and sedimentation for 13 selected polders based on the model results, review of the existing mathematical analysis and interviewing local people.
7) Determine hydraulic design criteria (crest level, slope, design water level etc) for the 13 selected polers based on findings from hydrodynamic, storm surge and drainage model.

3.3.1.6 Planform analysis and river bank erosion forecast

In connection to the planform analysis and river bank erosion forecast the following will be conducted:

1) Collection of historical maps and satellite images from U.S. Geological Survey (USGS) and Consultant's archives for the 13 selected polders.
2) Assessment of temporal changes of the plan form characteristics (such as changes in width, bedform migration or sinuosity) for the 13 polders by analyzing historical maps and time series satellite.
3) Delineation of banklines from historical maps and satellite images to assess shifting of the banklines of the rivers.
4) Forecasting of the future development of the rivers in the study area for the next 15-20 years based on the observed planform development, shifting of the river course and erosion pattern.
5) Identification of the locations that are vulnerable to erosion and outlining probable structural measures (length and location of the measures) for riverbank erosion management within the study area.
6) Generation of erosion-accretion maps for the coastal region for 13 selected polders applying GIS techniques.

3.3.1.7 Assessment internal water management polders

In connection to he assessment of the internal water management of the polder the following will be conducted:

1) Identification of draining congestion and water logged areas from results of drainage modelling and by interviewing local people.
2) Delineation of catchment areas for the 13 selected polders using Digital Elevation Model (DEM).
3) Delineation of existing drainage network and drainage pattern from historical maps and satellite images.
4) Assessment of drainage volumes based on the delineated catchment area for the 13 selected polders, considering future climate change.
5) Assessment of capacity of existing channels considering future climate change based on calculated drainage volume.
6) Adequacy check of existing cross drainage structures (i.e. sluice gates, regulators etc), considering future climate change.
7) Assessment of existing sedimentation scenario inside polders by interviewing local people.
8) Assessment of possibility of water storage/retention within existing water bodies inside the 13 selected polders
9) Analysis of water demand inside the 13 selected polders for effective water management.
10) Preparation of detailed polder maps for the 13 selected polders showing the interventions, as well as the foreshore and social forestry afforestation program.

3.3.2 Task 2.2. Project benefits and economic analysis

In general, the main purpose of the CEIP-2 project is to obtain, by protected in selected polders from tidal flooding and frequent storm surges, more agricultural output from the land as compared to general farming conditions. Incremental agricultural benefits obtained from the difference between "With" and "Without" project conditions are called Agriculture benefits. In the calculations of the production values, both the local monetary unit BDT and US$ will be used due to the similar reasons explained for project costs. Current prices of the country are difficult to be used because of the existing high inflation and high subsidizing of some products to reach in a state of equilibrium. Furthermore, these prices will be checked for the products in the international trade, by calculating their "economical" prices. During the evaluation of "Without" project situation, the existing Agriculture facilities will be taken into consideration, Net production values will be calculated according to cropping patterns in both irrigated and rain-fed conditions, and the present crop yields determined. In the "With" project conditions, the net production values will be calculated according to the cropping pattern expected for the project conditions, assuming that, the project are will be protected and the expected increments on the crop yields will be realized at the end of the development periods.

3.3.3 Task 2.3: Social assessment and beneficiary participation aspects

The CEIP-2 will be implemented in different locations along the coastal region of Bangladesh. Taking into account of the magnitude of impacts of tidal surges, river erosion and other natural disasters over the decades on the people and embankment a detailed social assessment will be carried out. It will emphasize on the potential impacts of the project on the people and the society in the project influenced area. The objectives of the social assessment will be:

To examine and assess the overall social & human development and poverty profile of the project areas based on primary and secondary data such as statistical yearbooks, poverty data, field visits, Participatory Rapid Assessment (PRA), key informant interviews, land use patterns and socio-economic profile of the Project areas:

- Consultations with project beneficiaries to assess attitudes and responses to the Project and ascertain the nature and scope of local participation in project planning and implementation.
- Undertake stakeholder consultation with women group, gender analysis, and recommend mechanisms to enhance women's participation in project planning and implementation;
- To conduct socioeconomic survey among the households in the project influenced area to assess the social impacts of the project on the potential project affected persons and other stakeholders
- To summarize major issues and recommendation for addressing social impacts and poverty issues of target beneficiary population.
- To examine and assess the overall social & human development and poverty profile of the project areas based on primary and secondary data such as statistical yearbooks, poverty The report is based on the findings of the census, socioeconomic surveys, field visits and small group discussion and PRA with the people in the project influenced area.

The social assessment report will be developed based on the findings of the census, socioeconomic surveys, field visits & small group discussion and PRA with the people in the project influenced area. Special emphasize will be given to the people living inside the polder and living/dealing in on the embankment.

Scope of the social assessment

The scope is defined as follows for the Social Assessment but will be finalized during conducting study in consultation with the BWDB and World Bank.

- Collect and review of secondary information/ documents.
- Identify and select of project influenced area.
- Develop and finalize study tools and techniques.
- Conduct the survey to collect socio-economic data/information.
- Conduct consultation meetings, PRA within and surrounding area of the project location
- Analysis data, evaluate and prepare report.

As a part of comprehensive Social Assessment studies, socio-economic data is required to meet the following objectives:

- To get a comprehensive understanding about the overall socioeconomic condition of the respective community people inside the polder and surrounding areas i.e. information about their livelihood utilities, income source, social structure, dimension, community access to common facilities etc.
- To assess the existing status of resources within and surrounding the project site that might be impacted due to project intervention.
- To assess the attitude and perception of the community people towards the project.

Small Ethnic Community Policy Framework (SECPF)

If the social assessment and analysis indicates that small ethnic communities are present in project area, a Small Ethnic Community Policy Framework (SECPF) will be developed as a standalone document. A polder-specific social-screening and impact assessment will be carried out and small ethnic community development plan (SECDP) will be prepared. Separate consultation meetings will be held with the small ethnic community people to obtain broader community support. Leader of the ethnic community will be consulted during the study period keeping a free, prior and informed consent (FPIC) approach: A small ethnic community policy framework (SECPF) will be developed following feedback from the consultation process in agreement with the BWDB and World Bank. Bengali version of the final SECPF will be circulated among the small ethnic co0mmunity people.

Gender Analysis and Disability Assessment

Based on consultations with stakeholders and individual interviews during the study with various occupational groups particularly women and persons with specially-abled a Gender Analysis and Disability Action Plan will be prepared. The analysis will help the development of gender-and disability action plan for the project to provide guidance on detailed polder-wise designs and implementation methods.

Preparation of Gender Based Violence (GBV) Action Plan

To minimize the risk of GBV and SEA, and to put in place an effective response mechanism, GBV/SEA risk assessment will be carried out during the study and a GBV action plan as a part of the Gender and Disability Action Plan will be prepared following the World Bank ESF.

The activities for addressing the risks of GBV and SEA to be outlined in the GBV Action Plan will be included in the contractor's Environmental and Social Management Plan (CESMP). The codes of conduct, community engagement and GBV roadmap will be tailored to the level of risks assessed for the project.

Methods to be adopted for social assessment

The social assessment will tap data from both primary and secondary sources. Secondary data will be taken from national statistical reports; World Bank guidelines and policies (ESF and ESS 1-10), and relevant government laws and regulations. The safeguard team including field support staff members will be deployed to conduct survey and PRA with the people living on the embankment, within and outside the selected polders irrespective of vulnerability, gender, occupation and religion. A census & socioeconomic survey (CSS) will be conducted among the affected people including residential households, shops and community properties staying on the embankment in all 13 polder areas. A detailed socioeconomic survey will also be conducted with the households and shops (100 per polder) living on the embankment (30%), inside (60%) and outside (10%) the polder. Participatory rapid assessment (PRA), focus group discussion (FGD), etc. will be held with different level stakeholders of the project area. At least one PRA and two FGDs will be conducted in each 13 polders. The socioeconomic data will be collected on a sample basis from the households considering occupation, income level, location of residence (whether close to the embankment or far away), land ownership pattern, etc. from the nearby and far villages. The households will be selected from all categories of occupational groups of the project areas. Secondary data of the project area will be consulted from the community series of the Bangladesh Bureau of Statistics (BBS) and other government published documents.

3.3.4 Task 2.4. Environmental Management Framework (EMF)

The proposed interventions of CEIP-2 project will have significant impacts on the natural environment and the people living in that area. Proper environmental assessment and environmental management plan is essential to address the impacts of the project. This EMF has been developed to ensure that neither the project activities (both in terms of needs and quality) nor the environment is compromised through the program intervention. The EMF presents possible impacts of the CEIP-2, mitigation, enhancement, contingency and compensation measures, environmental management and monitoring plan, and institutional framework including inter-agency cooperation for implementing EMP.

The EMF will facilitate compliance with the World Bank's environmental safeguard policies and with the Government of Bangladesh's policies, acts, and rules. The EMF will contribute to ensure environmental sustainability by:

- Preventing and/or mitigating any negative environmental impact that may emerge from the rehabilitation and improvement of polders.
- Enhancing environmental outcomes of the activities by proper implementation of the Environmental Management Plan.
- Ensuring the long-term sustainability of benefits from afforestation, and community environment.
- Management plan by securing the natural resource base on which they are dependent; and facilitating support in establishing an environmental management system (EMS) in BWDB) to enable it to target, achieve and demonstrate continuous improvement in environmental performance of the polder system from preconstruction to operation and maintenance stage.

Scope of works

1. Review of environmental policies, regulations, and lessons learned;
2. Defining geographic scope and project components for EMF;
3. Development of Environmental Management Framework (EMF);
4. Consultation and Disclosure Plan.

3.3.5 Task 2.5. Update framework for Monitoring and Evaluation

Under the ongoing CEIP-1, the Consultant for the so-called Third Party Monitoring and Evaluation of overall implementation of CEIP is responsible for the monitoring and evaluation of project performance as well as project impact. The primary purposes of the framework they have established and their services include; (i) carrying out independent monitoring and evaluation of project progress, inputs, outputs, processes, outcomes and impacts in relation to the various project works and activities; (ii) carrying out independent monitoring of project specific operational risks and mitigation measures; (iii) providing independent and regular feed back to the Project Steering Committee (PSC) on its evaluations of the above as well as on any other specific issue as directed by the PSC. Via the BWDB website http://117.58.247.164/ceip/ the results of this monitoring can be followed. Based on experience of the ongoing CEIP-1, the said monitoring framework will be assessed, and recommendation will be made for improvements and changes which may be needed when designing the interventions of the next phase of CEIP.

3.3.6 Task 2.6. Assessment of International Waterway Aspects

Under CEIP-2 project, the polders which will be improved, are the existing polders. Under this project no new polders will construct no any new channels will close. So, the project itself will not interfere in the river or estuary system's morphology or on their flow dynamics. So, the project has will have no significant impacts on the river system of the project area.

There is an international water way Mongla-PirojpurJ-jhalakathi-Barisal-Chandpur-Ashuganj. Indian ships are used the root to transport goods from its western part to eastern part. Bangladeshi cargo vessels/ships also use this root to carry goods to and from Dhaka. Part of this root is the Mongla-Goshiakhali Khal. There is a problem of heavy siltation, but the BWDB polders have probably no effects on it. If the models show any effects on this root, then recommendations for mitigation of those effects will be included in the feasibility study report.

3.4 Task 3: Preparation of Detailed Design and Bidding Documents, EIA's and LAP/RAP

3.4.1 Task 3.1 Detailed Designs and Bidding Documents

3.4.1.1 Introduction

In view of the limited time of the studies, the preparation of detailed designs and bidding documents will follow the same procedure as is followed in CEIP-1 and described more specifically for CEIP-2 in this Section. Section 4.6.3 is describing a number of innovations which could be taken forward in the detailed designs and will therefore not be described here because application of said innovations will very much depend on the local circumstances and thus of the selection of the 13 polders to be included in the invest plan. Once the preparation of the detailed designs commence, application of these innovations will be considered and discussed with the BWDB.

3.4.1.2 Detailed designs

The objective of detailed design is to complete detailed structural design for all the interventions like embankments, drainage sluices, flushing regulators and flushing inlets, slope protection works and bank protection works including the foundation of where needed. Under this study, necessary topographical, bathymetric, hydrometric survey and site investigation using appropriate technology on the ground will be carried out before detailed design. Appropriate alignment of embankment of polders will be determined by using hydrologic/hydraulic, sediment transport, erosion, and plan-form and morphological models and design criteria will be derived from the mathematical model studies.

To prepare most suitable design of the structures and embankments and expedite the detailed design works, a team of experienced design engineers will visit the specific sites with approved design criteria for CEIP-1 which are aligned with BWDB Design Manuals and Circulars. Care will be taken so, that structurally sound, environmentally sustainable and economically viable designs can be prepared and optimum project benefits can be achieved.

During design of embankment, sufficient crest width for the use of embankment to use it as local roads for improving communication in the area will be taken care of. For establishment of internal link with peripheral embankments and other areas, ancillary structures will be proposed on canals, if needed. Consultant will ensure river bank protection works, slope protection works for embankment stretches that require such protection, fix straight and bends linking alignment of embankment to prevent and reduce the damage of direct surge and to minimise O&M cost.

Detailed structural design of all interventions will follow updated design parameters and the design methodology which have already been developed during preparation of detailed design for the works under CEIP-1.

Consultant will also review and update the detailed design of 7 Polders (14/1, 15, 16, 17/1, 17/2, 23 and 34/3) which were under Package-3 of CEIP-1.

3.4.1.3 Carry out a comprehensive site examinations

Bathymetric, Hydrometric, Topographic and Geotechnical surveys for 13 polders will be conducted already from feasibility stage (Task 2.1). The scope of these investigations is described in Section 3.3.1.3 for the bathymetric, topographic and hydrometric surveys, whereas in Section 3.3.1.4 for the geotechnical surveys.

During detailed design stage of the 13 polders, the adequacy of those surveys will be assessed and in the case that more surveys will be required, Consultant will perform those surveys, taking care of the margins (estimated quantities) and the specifications as defined in Task 2.1.

3.4.1.4 Design criteria

Under the following phase of CEIP-2, maximum 20 polders will be improved in which drainage sluice, flushing regulators, embankment, bank protection works will be constructed and those type of existing infrastructures will be repaired and rehabilited. If there are large and deep breaches in embankment, closure works may be required and be designed. Embankment rest width may be increased to facilitate construction of road in future.

As, by following the design criteria of BWDB the polders wear constructed, detail design of hydraulic structures, embankment, bank protection works etc. for CEIP-2 will be carried out following the approved design criteria of BWDB/design manual of BWDB.

The design criteria for hydraulic structures, embankment, bank protection works etc. have been already developed in CEIP-1. Consultant will review and update the approved design to identify and remove its short comings if any. Consultant will review and update the design criteria if necessary and if there has any difference with the criteria of BWDB and will use it as guideline.

Suitable numerical models will be developed by Consultant, to assess the effectiveness of existing drainage system, fix embankment crest level, designing improvement measures considering extreme flood event and storm surge considering climate change impacts. Hydraulic model simulation results will provide the essential information for setting up design parameters for fixing design crest levels of embankment and polder drainage system. These will also considered and use.

3.4.1.5 Appropriate construction materials

Consultant will select and recommend appropriate characteristics and quality/specification of construction materials to be used in construction works. In general, construction materials which has been using in construction works of CEIP-1, same quality of those materials will be allowed to use to implement CEIP-2, but Consultant will review to identify any drawback and will update if necessary. The specifications of construction materials will be illustrated in detail and included in the technical specifications of the bidding documents and will also be included in the detailed design. At sites, due attention will be paid to availability of materials like e.g. earth for the filling of the embankments.

The soil of canal re-excavation can, if suitable, be used for the construction and repair of the embankments and back filling works, if quality of excavated soil/spoil earth will match with the technical specifications and minimize future environmental hazard of soil disposal.

3.4.1.6 Prepare technical specifications and engineering drawings

Technical specifications have already been developed for Package 1, 2 and 3 of CEIP-1. Consultant will review the technical specifications, will update and modified if needed and then it will be recommended for use for in the different packages of CEIP-2. Technical specification of BWDB will also be used as guide line.

The objective of preparation of detailed drawings is to develop working drawings for approval of BWDB and for construction works. Detailed working drawings of proposed infrastructures will be prepared by using AutoCAD and Civil 3D program and will be plotted to suitable scales/same scale used in CEIP-1. Standard size of drawings (A3) will be produced for all structures. Copies of drawings along with respective computation sheets will be submitted to the BWDB for review and comment. On receipt of comments those will be discussed with BWDB's concern design office and the agreed and valid comments will be incorporated to finalize the drawings, which will be approved by BWDB.

3.4.1.7 Engineers cost estimates

After detailed design and preparation of the drawings of drainage sluices/flushing regulators, embankments, drainage canals, bank protection works, repair/renovation of existing structures, Consultant will calculate the quantities of each of the item of works to prepare cost estimate and BOQ for all works of every polder/package under the CEIP-2. Consultant of CEIP-1 prepared a special rate (analysis rate) schedule of different items of construction works for use to prepare cost estimate though there were approved rate schedule of BWDB for the area of polders selected for rehabilitation. BOQ included in the bidding document prepared for invitation of international tender. Consultant will review that rate schedule and update it by incorporating the present market rates and also incorporate new items if those will be required for construction works of CEIP-2 and not included previously. Cost estimate of construction works of CEIP-2 will be prepared on the basis of the updated special schedule of rates. Based on the calculations of quantity of works, total quantity of different type of materials required, type of nos. of different type equipment and there acquired cost can be estimated separately. This information may be used in preparation of special schedule rates, technical specification and bidding document.

3.4.1.8 Detailed designs for embankment

Before the detailed design, physical condition of the existing embankment and requirement of new/retired embankment will be verified by Consultant. The vulnerability of the embankment against river erosion, wave action and threat or fact of overtopping by previous storm surges, rate and pattern of river bank erosion near the embankment will also be checked at field level. These will be justified by the outcomes of hydro morphological mathematical model analyses. In the detail design embankment, parameters such as crest level, crest width, side slopes etc. will be required to include. To fix the embankment crest level, the followings are to be considered:

- Considering the project life and climate change assumption, storm surge level of 25 years return period to be taken into account;
- Required freeboard to be added to limit the wave-overtopping with storm surge level of 25 years return period;
- An additional margin to allow for uncertainty in computation of 25 years surge level;
- Additional allowance for subsidence to be added with the above;
- Subsidence of ground levels.

Mathematical model analyses will be conducted and form the outcomes, design parameters of embankment will be finalized. Moreover, Consultant may use the previous experience achieved from implementation packages under CEIP-1.

Selected polders which are located in the upstream areas and far away from the coast are not appreciably influenced by cyclone induced storm surge. Particularly in these upstream areas, maximum water level is occurred during the monsoon floods and not during cyclones and the embankment might be overtopped during the monsoon. Considering these, some polders will be designed based on maximum storm surge level and wave run-up for cyclonic wave and others will be designed based on maximum monsoon water level and wave run-up for wind induced wave during monsoon.

If in any segment, due to low level of ground, embankment height may be relatively high. In that case considering the slope stability, an additional berm may be provided in the Country side C/S) of embankment as additional support against cyclone surge.

Some embankments may include an additional berm as temporary flood shelter (see Figure 3.1).

Top width of embankment will be fixed considering the future use of it as a for improvement of communication. Design parameters will be provided separately for all polders which will be selected for this study.

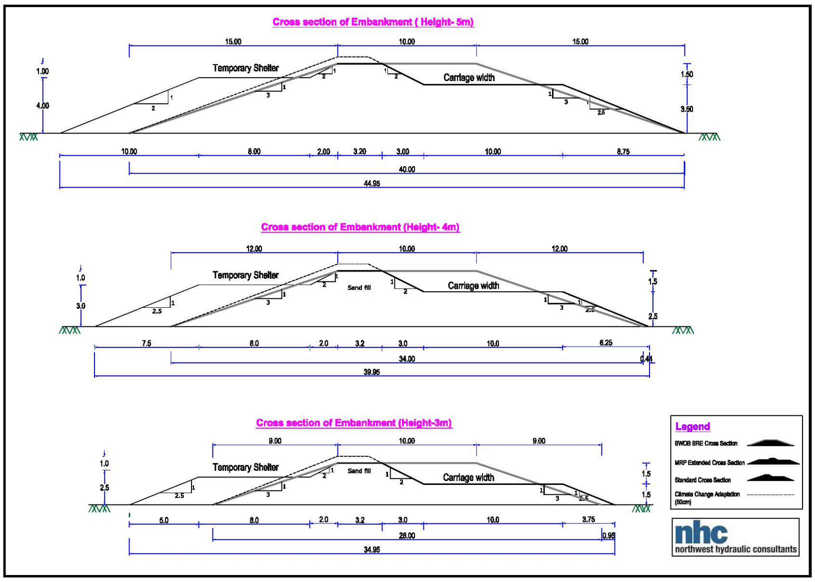

Figure 3.1: Example of cross section of embankment

3.4.1.9 Detailed design drainage infrastructure and bank protection works

Detailed design of drainage infrastructure and bank protection works will be done by Consultant which will cover preparation of required drainage infrastructure for inside area of the polders, drainage sluices where the drainage system has deficiencies due to inadequate channel section, poor condition/damage of structures or whether the peripheral river receiving drainage water channel is blocked for any reason and bank revetement work, where the embankment or/and structures has become under the threat of river bank erosion. The design parameters to be applied will be determined from topographic survey and by using hydraulic models to simulate the past, present and future scenarios, taking into account the impact of sea level rise and enhanced storm surge heights. Moreover, design engineers will finalize the sill level, vent opening size and nos. of drainage sluices /flushing regulator through hydraulic simulation for each hydraulic structure considering specific site conditions which will be cross checked with the outputs of hydraulic model analyses. Design criteria for time required to drain the polders will be established together with the BWDB. The structural design of the different components of drainage regulators will perform by following BWDB's approved design manual and Appling various loading considerations to make it optimum for multipurpose use in future and cost effective. Similarly, foundation design of drainage sluices will be selected based on the sub-soil investigation report for each specific site. Detail design of river bank protection works will be carried out following the BWDB's approved design manual and results/outcomes of hydraulic models. Detail design of damaged works of existing structures will be carried out based on the design data collected by topographic/engineering survey, outcomes of hydraulic models and following the BWDB's approved design manual. Consultant will design water control structures in such a way that silts in the d/s channel can be washed away by a self-cleaning mechanism of where d/s channel is relatively long also to keep the O&M cost to minimum.

3.4.1.10 Preparation of bidding documents

International Competitive Bidding (ICB) bidding documents have already been prepared for Packages 1, 2 and 3 under CEIP-1 as per guidelines of World Bank. Consultant will review those bidding documents before use in the subsequent packages of CEIP-2. If any modification or needs anything to add, Consultant will do that before use those to prepare bid document for packages of CEIP-2. On completion of preparation of detailed design/drawings, BoQ, finalized technical specifications, Consultant will finalize the bidding documents and will send them to World Bank and BWDB for No objection and approval.

For the process of tendering, list of a number of qualified contractors will be prepared by inviting proposal/tender by issuing prequalification documents. Prequalification document was prepared in CEIP-1 for 3 packages. Consultant will review that document and up-date/modified if necessary. The contractor who wants to be a pre-qualified contractor shall have to fulfil the requirements of the technical experience, financial capabilities, required qualified and experienced professionals, types and nos. of equipment under his/her possession which will be included in the bid document as the pre-qualification criterion. If, the prequalification exercise does not result to qualify a satisfactory number of potential bidders and the Borrower proposed to replace the prequalification process by a post-qualification exercise as of CEIP-1, decisions of contractor selection procedure (either pre-qualification or post-qualification) will be finalized following the decision of BWDB/GoB and the World Bank. If BWDB/GoB and the World Bank agree, tendering procedure of two envelop system may be adopted.

Add here that the bidding process in CEIP-1 was problematic while the use of smaller packages (and for riverbank protection works) the inclusion of goods packages could reduce the complexities. For example, concrete blocks and geo-bags could be procured through different packages centrally and then shifted to the site. This will result in better quality and allow smaller local contractors to participate and do the work for 'their' locality.

3.4.2 Task 3.2 Environmental Impact Assessments (EIAs)

The main objective of the consulting services is to support the BWDB in the preparation of a comprehensive coastal embankment improvement program and implementation of the following phases of CEIP. The consultancy services will be carried out with a detailed feasibility study according to the international standards, which will form the basis for project appraisal by the WB and the GOB and will also cover the detailed design and bidding documents of a batch of works to implement under the CEIP-2 project.

The main objectives of the EIA study will comprise:

- To assess the potential environmental impacts, including any residual impact of the proposed project;

- To describe the existing environment of the area;
- To identify mitigation measures to minimize the impact;
- To prepare an environmental management and monitoring program.

Table 3-2:Specific objectives of the EIA study.

Major Activities	Objectives
Major Activity 01 (A)	Inception Report
Major Activity 01 (B)	Environmental Assessment Report of selected polders
Major Activity 02	Prepare an Environmental Impact Assessment (EIA) to identify all potentially positive and negative Environmental risks and impacts in line with the World Bank's Environmental and Social Framework (ESF) and propose mitigation measures and recommendations to ensure all negative environmental risks and impacts are duly mitigated and provide achievable alternatives to avoid/minimize potential and adverse environmental impacts;
Major Activity 03	Identify various stakeholders and develop a Stakeholder Engagement Plan (SEP) and disclosure procedure for engagement and consultation with the same down to the finalization of the Environmental Management Plan (EMP)
Major Activity 04	Develop a written Labour Management Procedure (LMP) which will set out how project workers will be managed, following the requirements of national law and this E&S.
Major Activity 05	Provide inputs to prepare the Borrower's Environmental & Social Commitment Plan (ESCP)
Major Activity 06	Assess Institutional Capacity of MoEF/DoE and additional implementing agencies and develop institutional Capacity Development Plan for DoE and all other related agencies.
Major Activity 07	Conduct a review of appropriate country laws and requirements to address the Environmental and Social impacts. Identify the implication of the Government of Bangladesh (GOB) and World Bank policies/acts/regulations/ESS for the project.

The scope of this task is the following:

Assessment of Environmental issues

- Task 1: Assess environmental issues associated with all proposed project activities;
- Task 2: Literature review for all environmental issues in the project area.

Prepare Environmental Impact Assessment (EIA)

- Task 3: Prepare environment screening;
- Task 4: Design and carry out an EIA;
- Task 5: Verify the EIA study with the relevant Environmental Social Standards (ESS) of the World Bank.

Develop Stakeholder Engagement Plan (SEP)

- Task 6: Identify various stakeholders for Environmental Management Plan (EMP) Preparation;
- Task 7: Develop a SEP;
- Task 8: Develop an EMP.

Develop Labour Management Procedure (LMP)

- Task 9: Develop a written LMP;
- Task 10: Verify developed LMP with the requirements of national law.

Prepare Environmental & Social Commitment Plan (ESCP)

- Task 11: Prepare the Borrower's ESCP;
- Task 12: Connect with EMP & ESCP.

Assessment of Institutional Capacity

- Task 13: Assessment of the existing Institutional Capacity of MoEF/DoE;
- Task 14: Develop future institutional Capacity Development Plan for MoEF/DoE;
- Task 15: Develop future institutional Capacity Development Plan for other related agencies.

Review of appropriate country laws to address E&S impacts

- Task 16: Conduct a review of appropriate country laws and requirements to address E&S impacts;
- Task 17: Identify the implication of GOB laws;
- Task 18: Identify the implication of World Bank policies/acts/regulations/ESS for the project.

3.4.3 Task 3.3 Resettlement Action Plan (RAP)

Resettlement Policy Framework (RPF)

The RPF is a guiding document for preparation and implementation of the RAP and other safeguard documents of the project. Following activities will be carried out to develop the RPF:

- Review secondary data available with the client about the project, particularly social and resettlement related documents;
- Conduct stakeholders consultation and key informant interviews with the potential affected people and other major stakeholders;
- Assess the institutional capacity of the BWBD and format a guideline for development of capacity;
- Assess stakeholders engagement strategy and developed a guideline for stakeholders engagement during the project period;
- Ensure gender mainstreaming and disability inclusion in the project process;
- Assess gender-based violence risks and develop a guideline for mitigating gender-based violence risks in the project;

- Assess project impact on the small ethnic community and develop a guideline for the small ethnic community development;
- Develop a concrete guideline for preparation of the RAP for the project.

Resettlement Action Plan (RAP)

RAPs will be prepared on the newly selected 13 polders to be rehabilitated for which detailed designs will be prepared. The safeguard Consultant will review the RAPs prepared for work packages under the CEIP- I and other projects such as the Coastal Embankment Rehabilitation Project and River Bank Protection Project. The steps and methods for preparation of the RAP have been formulated following other similar projects including CEIP-1.

Review project documents: The safeguard Consultant will review project interventions and designs including requirement for additional land in the 13 polders following the Acquisition and Requisition of Immoveable property Act 2017, the World Bank operational policies on social safeguards (ESS5, ESS7) and the RPF.

Carry out social Screening: Social screening of each polder will be carried out as per requirement of the World ESF. People living inside the polder, on the embankment and outside the polder will be interviewed during social screening at the 13 selected polders regarding social inclusion, participation and gender issues, public health implication due to project interventions, tidal effect, GBV risks, etc. This will be analysed in the screening process.

Stakeholders Consultation Meeting (SCM): SCMs will be held with various stakeholders in small groups in open and accessible places considering the COVID 19 pandemic situation. The sessions are organised to disclose the objectives of the project and seek broader community support to ensure stakeholders engagement in project planning and implementation stage. The meeting will also confirm the cut-off-date of the affected properties. The meeting will be held prior to the census and IOL. Necessary COVID norms (wearing masks, hand sanitizing, distancing) will be followed during these consultation meetings.

Census and detailed measurement of losses: 100% of the census will be carried out for Project Affected Persons (PAPs) with their housing, income and livelihood resources and the current users of the agricultural lands to be acquired.

Video capturing of the alignment: A video will be captured for the all affected properties including vacant land, crops, structures, trees, pond etc. after household numbering but before starting the census and IOL survey. This video capturing is generally called a 'running video' which will be carried out to prevent fraudulent claims in the future and to fulfil the requirement of the ARIPA 2017. After conducting the census and IOL survey, a video will be captured of the affected properties along with the household head or his/her senior proxy.

Property Valuation Survey (PVS) /Market Survey: A PVS/market survey will be conducted to estimate the fair land market value and replacement costs (i.e. market value and transaction costs) of affected land of the substations. Mouza rates (established by the GOB) for the year 2020 will also be collected from concern Tahsil Office (Union Land Office) to assess the recorded price. Collected information from various sources will be summarized and replacement costs will be determined to prepare the estimated budget for land acquisition and resettlement.

Identify the legacy of incomplete land acquisition: The legacy of incomplete land acquisition or no acquisition of land used will be identified by consulting the BWDB for existing embankments. A devised approach for the acquisition of land for the first works package will be indicated in consultation with the affected land owners and the BWDB.

Identify Alternatives: The social safeguard Consultant will identify alternatives to minimize land acquisition, resettlement and population displacement. This will be done for the communities that were considered in the engineering design and identification and selection of relocation options. In addition, alternatives and sites suitable for relocation and acceptability to the communities will be assessed.

Drafting the RAP: The RAP will be drafted based on the census and detailed measure of losses survey following the guidelines of the RPF. The RAP will also contain the polder wise summary impacts and measures taken for the resettlement and land acquisition management.

Public Disclosure on the updated draft RAP: In the meantime, the updated draft RAP will be disclosed for any comments from the PAPs and other stakeholders. Feedback from the stakeholders will be taken into consideration for the finalization of RAPs in consultation with the BWDB and WB.

Finalization of RAP: The draft RAP will be finalized incorporating all comments. The final RAP will subsequently be submitted to the BWDB. The Executive summary of the final RAP will be translated in Bangla.

3.4.4 Task 3.4 Preparation of Land Acquisition (LA) Plans and LA Proposals:

The LAPs and land acquisition proposals will be prepared during this feasibility phase for each of the 13 selected polders. The safeguard team will prepare the LAPs for the embankment and hydraulic structures (drainage and flushing sluice) following the Acquisition and Requisition of Immovable Property Act (ARIPA) 2017. The BWDB will submit the land acquisition proposals to the concerned DC offices enclosing necessary documents (administrative approval, etc.) following the ARIPA 2017.

The government of Bangladesh has enacted the ARIPA 2017 in September 2017. Later the Ministry of Land (MoL) approved a guideline for the implementation process of the ARIPA 2017. A resettlement policy has been introduced by the GOB in 2018. The LAPs for each of the finally selected 13 polders will be prepared following the ARIPA 2017. After submission of the LAPs to the PMO, the Project Director will submit the land acquisition proposals to the concerned DC offices as per GOB Format.

Steps and methods to be adopted for the LAP preparation

The following steps and methods will be followed during the preparation of LAPs for each of the 13 polders. All Mouza maps (latest published), Khatians and other necessary documents as per ARIPA 2017 will be collected from the concerned offices. Maps of previously acquired land by the BWDB will be collected from the concerned BWDB offices. Necessary support from the PMO will be sought in this case. Necessary formats (plot schedule, CHA Form, etc.) will be prepared as per requirement of the ARIPA 2017.

Baseline survey and base map preparation: Considering any existing alignment map, KMC will conduct a primary baseline survey to identify the Mouza names and sheet numbers that fall within the project right of way under the administrative boundary. This process will include primary and secondary data-base survey to ascertain the Mouza names , JL number, and the sheet numbers as well.

Collection of Mouza maps of previous land acquisition: It is known that land acquisition was done during construction of the existing embankment. Such acquisition documents (maps, etc.) will be collected from the concerning BWDB offices and or DC offices to check whether the embankment is still on the acquired land or shifted due to river erosion. The LAP team will check each and every Mouza with the ground reality.

Collection of latest published Mouza maps: The KMC survey team will collect the latest published Mouza maps for which revenues have been collected. These will be collected from the Directorate of land Records or from concern DC offices. LA Proposals will only be submitted on the latest published Mouza maps.

Digitization of the Mouza maps: After collection of genuine Mouza maps, an AutoCAD Engineer will digitize all Mouza Maps before georeferencing. This will help to calculate the land quantity in each plot and correctly set the alignment and adjust where required.

Collection of layout lan/alignment: KMC will require the correct layout plan/alignment for preparation of the LAP. Upon receipt of the layout plan/alignment, the LAP team will draw the alignment on the Mouza maps with pencil. This will be treated as draft alignment drawing as it still requires ground truthing before finalization.

Georeferencing of the plots: KMC will conduct georeferencing with maximum care to ensure the highest accuracy and minimize the offset. The Land Acquisition Expert and Jr. GIS Expert will ensure to correct the georeferencing during ground truthing before finalization of the LAP.

Collection of land ownership details and fill up CHA Form: the LAP team will collect the land ownership details, khatian etc. from the DC offices or Upazila Assistant Commissioner land office. The list of recorded owners will be written on the CHA form with other information as required in Column 1-4.

Preparation of plot index: The plot index will be prepared considering the category of land (as per record), total quantity of land in the respective plots, proposed acquisition area, Khatian numbers and names of recorded owners. In addition, Mouza wise plot index will be prepared based on the prescribed "Umo" and "Cha" form of the LA Act 2017.

Preparation and submission of polder wise LAP: After maintaining the standard practice and following all steps above, KMC will prepare a draft LAP and submit the draft to the Client for their initial comments and suggestion. The LAP will contain Mouza maps duly printed on tracing cloths (as per requirement of the ARIPA 2017) and plot index. One LAP will be prepared for each polder. Khatians (duplicate copy) will also be submitted along with the LAP.

Review of Draft Polder Reports For 7 Polders (Package 3 Under CEIP- 1)

LAP and RAPs have been prepared for the Seven Polders under Work Package 3 of CEIP-1. Under the current ToR for CEIP-2, the safeguard team will review the LAP considering the design of the embankment, land acquisition laws and procedures, calculation of the area of affected plots and other necessary papers /documents. Among others the issues to be looked into whether:

- Polder wise LAP has been prepared;
- Any changes of the embankment alignment/design due to Super Cyclone Amphan has been taken into account;
- Updated alignment has been drawn on the latest published Mouza Maps;
- Mouza maps has been drawn on the tracing paper prior to draw the embankment right of way;

- All Khatians have been collected and recorded owners list have been correctly written in the CHA Form;
- Field Truthing has been done and matched with the ground reality;
- Printed the Mouza maps on the tracing cloths with appropriate scales as per requirement of the ARIPA 2017;
- Proposed acquisition and previous acquisition has been correctly marked with separate colour;
- Plot schedule has been correctly done and total area of land and previous acquisition (if any) has been mentioned ;
- Any other tasks as per ToR has been done or anything missing.

The safeguard team will update the LAP (if required) as per ARIPA 2017 and submit to the Project Implementation Unit (PIU) as well. Regarding the RAP the safeguard team will review the impacts of a category identified during the census and IOL survey, entitlement matrices, grievance mechanism, etc. and ensure matching the policy of the RAP with the Social Management and Resettlement Policy Framework (SMRPFW) of the CEIP-1. Any bottlenecks in the RAP in terms of description, data presentation, impact identification, consultation, policy principles, legal and policy framework, grievance mechanism, relocation, implementation issues and monitoring mechanism will be identified and reported as well. It will be ensured that:

- The RAP has been updated based on the census and IOL data as per revised LAP;
- Consultation meetings with the potential affected people and other stakeholders have been carried out and their feedback have been reflected in the RAP;
- Embankment design, LAP and RAP will be in same line;
- Property Valuation Survey (PVS) has been conducted and current market price has been assessed and applied for preparation of the land acquisition and resettlement budget;
- Various Committees (PAVC, GRC, PRAC) have been placed and their ToR has been described;
- Land acquisition and resettlement cost and budget has been prepared considering policy matrices of the RAP;
- Roles and responsibilities of the executing agency, implementing agency and other offices agencies associated with the project have been correctly described;
- Database has been retained in the Access/SQL Server and in XL sheet as well.

The safeguard team will update the RAP following the World Bank ESF and submit required copies to PIU. In addition, the safeguard team will review the EIA including EMP following applicable national legal and regulatory framework and the World Bank ESF. Any bottlenecks will be identified and updated as per current World Bank Framework.

3.4.5 Task 3.5 Project Implementation Plan and Procurement Packaging

A Project Implementation Plan will be prepared together with a proposal for a Procurement Packaging. The following aspects will be taken into account:

- Construction scenarios and work packages;

- Clustering of polders in such a way that distances between construction sites and stock piling and manufacturing sites are minimised. Also accessibility to water for transportation of construction materials via barges will be taken into account;
- Implementation Plan, arrangement and project management cost estimate. In this respect also location of contractor's plants and workshops will be looked at together with locations of regional and site offices of future supervision consultants;
- Availability of materials such as earth for construction of embankments;
- Development Project Proforma/Proposal (DPP).

Consultant will provide Technical Specifications in accordance with international standards in order to ensure quality of the proposed works. The Technical Specifications will be including in the bidding documents in addition to BWDB's standard itemised specifications. The preparation of tender documents and contracts for construction will be based on the FIDIC Red Book (Ed. 2017) for embankment and civil works and hydraulic structures. Consultant will also review if 'plant design build' contract will be necessary in accordance with FIDIC Yellow Book (Ed. 2017) for any mechanical and electrical equipment for regulators and drainage pumping stations. Consultant will explore opportunities for involving Water Management Groups within polder areas to re-excavate existing drainage channels, embankment turfing and other minor work repair packages. However, these works should comply with Technical Specifications, so that quality of works must not be comprised whether International, national or local contractors will be contracted to deliver CEIP-2 work packages. Consultant will ensure that the environmental and social mitigating measures identified in the EMP and RAP are covered in the works contracts and that Contractors are made aware of these and duly implement the mitigating measures.

Consultant support will cover all aspects of procurement and contract management, including preparation of a procurement and contracting strategy, implementation plan, procurement plan, preparation of afore mentioned detailed designs and technical specifications, obtaining permits and/or approvals, prequalification of contractors, preparation of tender documents and overseeing the procurement process, bid evaluation process, supply of goods and services contracts, and coordination with the PMU, implementing agencies and coordination with other ongoing programmes for the polders.

Consultant will prepare cost estimates for project management, detailed designs, supervision services and other services required for project implementation.

Based on the optimal investment option, the Consultant shall assist PMU in preparation-of Project Proforma/Proposal (DPP) of CEIP-2. These will be aligned with the World Bank's Project Appraisal Document (PAD). Based on Consultant's previous experience preparing DPPs Consultant feels comfortable that Consultant can offer BWDB the required level of support. A typical Development Project Proposal (DPP) in Bangladesh consists of the following sections:

1. Project title;
1. Sponsoring Ministry/Division/Executing Agency (BWDB);
2. Objectives of the Project;
3. Project implementation period;
4. Estimated Cost of the Project and source of
5. finance;

6. Year wise estimated cost;
7. Location of the Project;
8. Economic cost wise comparison
9. Item wise proposed quantities and cost;
10. Financial analysis;
11. Main features;
12. Cumulative expenditures;
13. Log frame;
14. Location wise cost breakdown.

The basic initiator and responsible person is the Project Director who will prepare the draft DPP which will be sent to the Ministry. The Ministry will than send the DPP to the Planning Commission. Thereafter it will be discussed in so-called Pre-Pre-ECNEC (Executive Committee of the National Economic Council, Pre-ECNEC and ECNEC meetings and sent to the Ministry of Finance and/or Prime Minister's Office for approval; the latter depending on the value of the DPP. Consultant has been assisting Bangladesh Authorities with the preparation of various DPP's; having said that, Consultant is also aware of that this may be a time consuming and lengthy process. Consultant therefor assumes that the various authorities involved (as stipulated here above) will commit to swift reviews and approvals and as such allowing Consultant to properly assist BWDB. In view of this, Consultant will already in an early stage initiate this process.

To allow for flexibility, e.g. for cost of bank protection works (see also Section 4.6.3.4), Consultant will also explore, together with the relevant Governmental Authorities, ways and means on how to integrate this into the DPP.

3.4.6 Task 3.6. Operation and Maintenance (O&M)

Operation and maintenance (O&M) has to cover a comprehensive Operation and Maintenance plan for all key components of the proposed polder design including the embankments, canal system, sluices and bank protection works. Polders require a long-term O&M commitment in order to sustain. Considering maintenance aspects early on in the design process will optimize the design and reduce lifecycle cost significantly. Apart from decommissioning, the operation and maintenance phase may be considered the last phase of a project. Still it covers most of the project lifecycle. O&M are long-lasting activities that may be adapted to changing socioeconomic needs and environmental trends.

4. Approach and Methodology

4.1 Introduction

This Chapter describes particulars of the approach and methodology on **how** Consultant will conduct the Services required to fulfil the requirements of the Tasks described in the previous Chapter. Next to more general descriptions, Consultant highlights specifics of a number of challenging and more complex aspects of the current Feasibility Study and Detailed Design.

The selection of the polders to be included into the invest plan for the next phase of CEIP requires a structured approach and timely decision making by the Bangladesh Authorities based on clear criteria and priorities set forward. A MCA has to that end been developed and the way it will be used is elaborated.

Consultant would furthermore take the opportunity to introduce new approaches of adaptive design that would make it possible to make more economic designs that can be conveniently upgraded if and when condition require it.

Lessons learned from the ongoing implementation of the first phase of CEIP are extremely important and will also be highlighted and taken into account.

At the end of the day it should be appreciated that within 12 months detailed designs and cost estimates will have to be delivered together with a feasibility assessment forming the basis of the DPP and PAD needed to formalise the loan agreement for the funding of next phase of CEIP.

4.2 Consultations, data collection and field visits

4.2.1 Consultations with field stakeholders

Stakeholders will be analysed, and all level stakeholders will be consulted during study period at polder level. Consultation meetings with various categories of stakeholders including potential affected people (landowners, squatters, tenants, wage earners), management committee of community property, local government representatives, influential people, etc. will be held at the polders (13 Polders) to obtain people's opinion about urgency of the project. Consultation meetings will be held at the hotspots (bazar area, settlement, etc.) along the embankment. People will be consulted about their dependency on the polders, livelihood opportunity, reasons, and length of occupying the embankment, land use inside the polders, impacts of tidal surges on their livelihoods, potential impacts of the project on their residence, business, community properties, etc. A stakeholders engagement plan (SEP) will be developed to ensure participation of the people in the project planning and implementation phase.

A Stakeholder Engagement and Communication Plan will be defined to identity and classify them in following groups:

- Approvers (design and feasibility);
- Statutory consultees (e.g. DoE);

- Directly affected groups (landowners and government authorities); and
- Interest groups.

Consultant will arrange following meetings and workshops throughout the project.

Strategy meetings with the Project Director and Senior BWDB Officials
Consultant will arrange a number of strategy and decision making meetings with the Project Director and other Senior BWDB officials to agree the project objectives, output, methodology for pre-screening of polders (122>23), shortlisted polders (23>13), feasibility study requirements and procurement plan for bidding documents.

Workshops with BWDB and Stakeholders
The Consultant has allowed for following outcome focussed workshops. Relevant deliverables for workshop shall be issued ahead of each workshop. All participants should review those documents ahead of the workshop so they can actively contribute to the discussion and decision making. These workshops will be facilitated with the aim to achieve approval of key milestones for each stage of the deliverables (see Table 4-1).

Table 4-1: Planned workshops

Type of Workshop	Participant groups	Deliverables to be discussed	Outcome
Inception and pre-screening workshop	PMU, Zonal Chief Engineers, ADG, DG	1. Inception Report 2. Ranking of polders for pre-screening	1. Approval of Inception Report 2. Approval of selection of 23 no. prioritised polders
Prioritisation workshop	PMU, Design Circle, Zonal Chief Engineers, ADG, DG	1. Prioritisation Report 2. Design Criteria Report	1. Approval of 13 shortlisted polders. 2. Approval of Design Criteria
Feasibility Workshop	Feasibility approval panel	1. Feasibility Report	1. Approval of the Feasibility Report
Land acquisition consultations	Field team and wider stakeholders	Land Acquisition Proposal	Explanation of the project benefits
Public Consultation	DoE, stakeholders	EIA	EIA approval

During selection of 13 polders out of 23 polders
Once 23 polders have been selected, the Consultant team will collect information which will allow for a good assessment and selection of the 13 most urgent polders for CEIP-2. Different levels stakeholders' opinions will collected and justified opinions will be considered. Opinion of the field level stakeholders such as local public representatives, local administration, officials related to agriculture, fisheries and disaster management and some farmers, fisherman and people of other profession who are living in and around the polders will be collected during data collection at field level and field visit by the associated persons/members of the consults team through discussion with them. Consultant will try to collect information about most vulnerable points of embankment against cyclone surge, internal drainage situations, their demand about

additional structures, about future water requirement and management etc. from them. Their opinions will also be considered to estimate the volume of resettlement required.

During the preparation of the designs

Consultant will also discuss with the related design people of BWDB before/during design of structures to collect their opinion regarding design works and about the use of BWDB approved design manual.

During feasibility in relation to social and environmental assessments

Mass consultation and small group consultation will be held at the hotspots along the selected 23 polders. All of the marketplaces and villages along the embankment will be covered by the consultation meetings. Considering COVID-19 pandemic situation, the consultation meetings will be held with small groups in a free space so that people can maintain physical distancing. Each of the meeting will cover maximum 30 people and each of the participants will be provided mask and hand sanitizer before inter into the meeting venue. Temperature of the participants will be measured by Auto-Thermometer. A COVID guideline has been developed to circulate among the participants during the meeting and will ensure participation of all level stakeholders. All relevant DGHS COVID-19 policies & Guidelines[12] will be followed and maintained accordingly. The stakeholder analysis will be done and a stakeholders engagement plan (SEP) will be developed as part of the safeguard documents. At least 0.1% (1 out of 1000) of the local people living on and inside the polders will be consulted in the small group meetings and 1% (1 out of 100) affected people will be consulted through Rapid Rural Appraisal (RRA) and focus group discussion. RRA and FGD will cover various occupational groups with land owners, squatters, tenants, vendors, wage earners will be held to obtain their opinion about the project. Management committee of community property, local government representatives, influential people, will also be consulted during the study period. Opinion of the people will be considered during preparation of the safeguard documents.

Risk mitigation plan related to COVID

Consultant would like to confirm that irrespective of the challenges posed by the COVID-19 pandemic, Consultant feel comfortable to be able to execute the assignment as per the requirements of the ToR. The strong local presence of our Consortium in Bangladesh and our modus operandi during this pandemic gives us sufficient confidence that this assignment can be executed in a timely manner. Should one of Consultant's Staff members fall ill due to COVID-19, a sad reality in these extraordinary times, Consultant feels confident that the resource base is sufficiently strong to provide a suitable replacement if and when needed.

If, COVID-19 pandemic situation continues, consultation with stakeholders may be arranged on Zoom platform/Video conference.

In Appendix 9, the COVID regulations in relation to COVID are presented.

4.2.2 Data collection

In general the data will be retrieved from the following sources:

- Literature (relevant projects, studies);

[12] https://www.dghs.gov.bd/index.php/bd/publication/guideline

- BWDB like the reports of CEIP-1 LTM and access to data base developed under CEIP-1-LTM
- Stakeholder consultations;
- Visual field surveys;
- Detailed social and environmental surveys;
- Engineering surveys;
- World Bank like the reports prepared under the various Technical Assistance programmes.

Appendix 6 presents a list of data required for this study. This list will be updated during Feasibility.

Data collection through engineering surveys

Data which will be used as inputs for the modelling works and detailed designs for the 13 selected polders will be collected via engineering surveys. The methodology is explained in Section 4.4.

Data collection through detailed social and environmental surveys

The safeguard team will collect from primary and secondary sources for preparation of the Environmental Impact Assessment (EIA), Environmental Management Framework (EMF), Resettlement Policy Framework (RPF), Resettlement Action Plan (RAP), Land Acquisition Plan (LAP) and Small Ethnic Community Planning Framework (SECPF) for the project. Environmental study and documentation will collect primary data on soil, surface water, ground water, noise, air etc. as per DOE guideline and World Bank Environmental and Social Framework (ESF). Primary data will be collected from the various locations (randomly selected) along the embankment inside and outside the polders.

Census and socioeconomic and inventory of losses survey will be conducted among the affected people within the project right of way along the embankment. All of the affected people irrespective of title to the land will be covered under the census survey. Affected assets will be surveyed under inventory of losses (IOL) survey. Qualitative data will be collected through small group consultation, PRA/RRA and focus group discussion during the study. Property valuation survey will be carried out among various cross section of the people in the affected mouzas to obtain current market price of the land other properties. All of the data collected from various cross section will be used for preparation of the resettlement action plan.

Initially a reconnaissance field visit will be conducted in the Project area to identify the project and its functional objectives. After this, rapid rural appraisals (RRAs), participatory rural appraisals (PRAs), focused group discussions (FGDs) and interviews with key informants will be conducted to collect data and information on the environmental and social aspects of the Project area. Local knowledgeable persons including community representatives, traders, teachers, and political leaders will be interviewed individually to reflect upon the problems regarding the polder. They will be also requested to highlight possible solutions that the project should bring about as per their indigenous knowledge and experiences.

The baseline condition of the project area will be drawn according to the information collected from secondary and primary data sources through literature review, field investigations and consultations with different stakeholders. The baseline condition will be established with respect to water resources, land resources, agriculture, livestock, fisheries, ecosystems, and socio-economic conditions including identification of problems in respect of the proposed project sites and adjoining area.

Source and methodology of both primary and secondary baseline data collection on water resources, land resources, agriculture, livestock, fishery, ecosystems, and socio-economic resources will be presented in the details data collection sections.

4.2.3 Field visits

Field visits are crucial throughout the whole study period, from inception phase to feasibility and detailed design phase. The field visits will have a different nature according to the stage of the project and will either involve visual scanning of the area, social and environmental surveys (for LAP, RAP and EIA) or detailed engineering surveys (topographic/engineering survey and river cross-section survey) which will be used as input to the modelling and detailed design works.

Table 4-2: Planned field visits

Stages of study	Field visit
Screening of polders (122 to 23)	Quick visual inspection
Prioritization of polders (23 to 13)	Visual surveys along all polders and stakeholder consultations
Preparation of Feasibility Designs	Engineering Surveys (Bathymetric, Hydrometric, Topographic and Geotechnical)
Social and Environmental Assessment	Field visits and smaller scale Social and Environmental Surveys
Preparation of Detailed Designs	Detailed Engineering Surveys (Bathymetric, Hydrometric, Topographic and Geotechnical)
Land Acquisition, Resettlement, and Environmental Impact Assessment	Field visits and larger scale Social and Environmental Surveys

Prioritization of polders

Detailed information on the proposed Project including objective, nature and location of interventions, construction works, and other related aspects will be obtained from the Design section of CEIP-2 Consortium. The safeguard team will be interpreted this information for assessing the environmental and social impacts of the proposed interventions.

Field visit will be held in at least 25% of the primarily selected 23 polders during prioritization of the 13 polders. This is due to movement restrictions for Corona pandemic situation but during detailed feasibility study all of the 13 selected polders will be visited and conducted necessary studies. Social & environmental screening checklist will be filled up during field visit to provide necessary inputs in prioritizing the 13 polders. Senior professionals of the safeguard team will visit the field along with technical team to obtain opinion of the people from various cross sections including farmers, businessmen, local government, BWDB officials and local administration.

Feasibility level

Experienced design engineers will visit the site for site selection of new structures and data collection for embankment, damaged structures and river bank protection works/erosion. Topographic survey and cross-section survey of river and khals will be also conducted. During carried out of these investigation, Consultant's experienced design engineers will visit the field to monitor the activities.

During the field visits, the associated experts/professionals will meet/talk with the field level stake-holders and collect their opinion and demand from the project. Necessary guide lines will provide to the associated experts/professionals, so that they can collect only the data/information required for the study.

Consultant will monitor the data collection and will visit the works at field level as and when needed to check the quality and progress of the works.

Risk mitigation plan related to COVID

A description about the survey plan for field survey considering COVID-19 can be found in Appendix 9.

4.3 Selection of proposed polders for CEIP-2

Among the most significant actions of the Bangladesh government to protect people against the cyclones and other coastal related threats, has been the construction of some 139 across the coastal zone. From the total of 139 polders, 17 polders have been included in the CEIP-1 for implementation of rehabilitations and improvements. Following CEIP-1, within Phase-2 of CEIP is intended to select a next batch of 13 vulnerable polders for implementation of infrastructural improvement works. The selection of these 13 polders will be performed in two stages. The first stage will include pre-screening of 122 polders and narrowing to 23 polders by means of a high level assessment, whereas the second stage entails detailed prioritization of 13 polders out of the 23 polders of the first stage. Figure 4.1 shows the flow of activities.

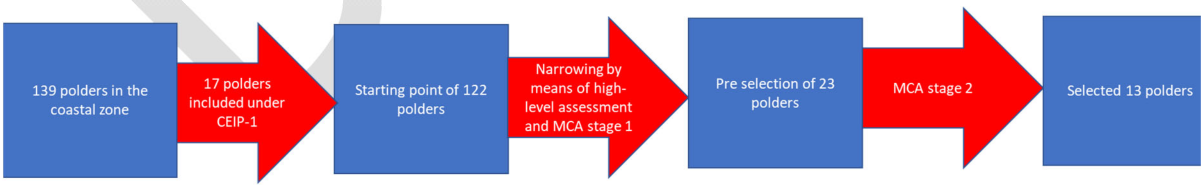

Figure 4.1: Various steps in selection process

4.3.1 Preliminary screening of 23 Polders out of 122 Polders

As this Task has been already performed by the Consultant within the Deliverable "Polder Screening Report" as stipulated in the ToR, hereunder a brief explanation of the approach is presented and reference is made to Chapter 5, were this approach has been implemented and reported in detail. Pre-screening of the 122 polders in the coastal zone is carried out via means of a straight-forward framework, which allows to implement a quick-assessment and conclude to a first subset of polders which are considered most vulnerable and appear suitable to be taken forward in CEIP-2. The initial subset is intended to be less than 122 and more than 23 polders.

Table 4-3: High-level assessment steps

Activities	Actions
Understand the dynamics of the coastal zone and identification of the vulnerabilities	Desk study and experience of Consultant in coastal zone of Bangladesh
Convert the storm surge vulnerabilities into risk affecting the coastal zone	High-level and preliminary risk assessment developed in GIS environment
Exploration of polders of high investment priority and polders which are taken forward under other investment funds and thus can be left out	Desk study of Master Plans (BDP2100, Coastal Zone Policy etc.) and stakeholder consultations
Definition of condition of polder infrastructure (embankments, bank protection, regulators)	Field visits, information from BWDB, consultations

These steps result to a subset of, less than 122 and more than 23 polders. This initial subset will be further assessed in order to narrow down to 23 polders using partially a Multi Criteria Analysis tool. More information on the MCA and its use in various stages of the project is outlined in the following section. After submission of the Polder Screening Report, which shortlists 23 polders, the Consultant will arrange a high-level meeting with BWDB to agree on the final list of polders to assessed for prioritisation. Considering the tight deadlines for completion of prioritisation within 2 months after commencement of the Services, the Consultant will finalise the polders during this meeting which will be confirmed in writing by the BWDB. Hence, no additional polders can be included or excluded in the list while Consultant moves on to prioritisation stage.

4.3.2 Multi Criteria Analysis tool

Since this Task has been already partially performed by the Consultant within the Deliverable "Polder Screening Report", hereunder a brief explanation of the approach is presented and reference is made to Chapter 5, were this approach has been implemented and reported in detail.

The first step, before commencing the development of the Multi Criteria Analysis (MCA) tool, is to define the guiding principles of this project. The guiding principles will outline the rationale of the MCA and the content of the scoring criteria. Definition of the guiding principles will be extracted from important lessons learned from past/ ongoing projects, visions of plans and policies, personal judgement of the Consultant and last but not least, the views of the BWDB and other key stakeholders. More specifically, amongst the most important projects/policies which contribute in delineation of the guiding principles are:

- Both feasibility studies and implementation phase of CEIP-1. Important aspects are amongst others, feasibility, technical design, numerical modelling, environmental and social assessment, land acquisition, resettlement, bidding and construction;
- The Blue Gold Programme since internal water management is very relevant for CEIP-2 and it goes in hand with the rehabilitation and construction of new regulators;

- The Bangladesh Delta Plan 2100 (BDP2100), which paints the horizon and defines the wider direction of CEIP-2, and must be very closely looked at in order to derive socio-economic development scenarios, projections and visions.

The guiding principles are translated into criteria which will be used within the MCA. The scoring of each criterion ranges from 1-5, with 5 being the worst score (for instance if the condition of an embankment is bad and is also breached in many locations, the score will be 5 and will imply high priority and in case that the embankment is in a very good condition the score will be 1, implying low priority). Weights will also be assigned to each criterion based on a pairwise comparison. For this method, each criterion is matched head-to-head (one-to-one) with each of the other candidates. Each criterion gets 1 point if it is considered more important than another criterion and 0 points if it is considered less important than the other criteria. This is done for each head-to-head comparison, resulting in a pairwise comparison matrix this will be done together with the main stakeholders.

In addition, the MCA conducted in 2012 within CEIP-1 is reviewed in terms of actualisation of the criteria used, the various weighting and scoring values and conditions of the various polder components. This serves as input to the new MCA developed within this project.

The MCA tool will be used during two stages of the study:

- MCA stage 1: For pre-selection of 23 polders out of the first subset of polders (as explained in the previous section);
- MCA stage 2: During selection of 13 polders out of the 23 prioritized polders (as is explained in the following section).

The difference in the use of the MCA tool in those stages mostly lies within the level of detail:

- The purpose of the first stage is to make an informative selection of 23 polders out of the reduced sub-set of polders, using the information that has been collected from secondary sources. In other words, discard polders which could not be easily and rationally discarded using the higher-level assessment performed in the previous section, since consideration of additional aspects was considered necessary;
- The purpose of the second stage is to further detail the characteristics (physical, social, environmental and economic) of the 23 polders and preliminary define the interventions needed, in parallel with assessing the benefits. This stage will constitute the basis for selection of the 13 polders. Thus, the information that will be used as input to the MCA will have more detail. Further explanation on the assessment of the 23 polders is provided in the following section.

As mentioned in the beginning of this Section, the Polder Screening Report (Chapter 5) the Consultant defines the initial screening list of 23 Polders out of 122 Polders, based on the approach described above.

4.3.3 Prioritization of 23 polders for selection of 13 polders for optimal investment

Definition of required interventions for each of the 23 polders

The existing polder infrastructure in the 23 polders will be assessed by collection of information available in the BWDB and by conducting field visits for visual observation of the condition of these infrastructure, and by Consultations with BWDB Representatives, performing interviews with people living in those polders, Consultant's experience and other stakeholders.

Understanding of the dynamics of the coastal and riverine system around the polders is crucial for defining which areas are prone to erosion, which areas are expected to be severely impacted from storm surge or tidal fluctuations. Discussions with people living in the polders will also play an important role in definition of the vulnerable areas, areas suffering from drainage congestion, waterlogged areas and other vulnerable locations.

The assessment of existing polder infrastructure and their conditions, in addition with the understanding of the system and inputs from people living in the polders, will result in an initial list of locations which necessitate interventions and consequently, initial interventions (slope and bank protections, sluices and associated infrastructure) will be defined depending on the statistics of physical parameters and the present and future bank erosion characteristics.

The Consultant will use hydraulic/ hydrological, morphological and drainage modelling results from CEIP-1 implementation as well as from the Long Term Monitoring Study when this becomes available for understanding of the system, within this Task. In that manner, the interventions initially proposed in this stage of the study, will be realistic in terms of technical aspects, extent and costing. In that way, they can be effectively taken forward and further detailed in feasibility stage and thereafter detailed design. Several alternatives will be explored based on the level of suitability with the physical and socio-economic and environmental setting.

It should be mentioned that the purpose of definition of the interventions is to make an informative selection of the polders which will present the highest benefits and cost-benefit ratios, and that means that the level of detail of this analysis is not required to be deep. Thus, the proposed interventions will be defined based on secondary data of other (recent) studies, and it is expected that during feasibility (next Tasks) the exact extents, levels and other design specifications will be altered in accordance to the results of the modelling and engineering surveys.

Amongst others, the following aspects will be investigated:

- Various strategies and alignments will be analysed in the process of reaching an optimal solution for improving the effectiveness and stability of the various embankment components;
- Exploration of potential for land acquisition (i.e. for retirement of embankment). Information can be collected from mouza maps;
- Identification of areas which are suitable for afforestation and/or mangrove development;

- Identification of areas for stock yards of soil for embankment construction/repair, construction yards for contractors and disposal sites for excavated material in connection with canal re-excavation if needed;
- Identification of suitable locations for development of innovative solutions such as multi-purpose embankments.

As already mentioned above, the results of the analysis of the most suitable alternative in this level will be guided by the level of detail of the information for the 23 polders, and will finally present the basis of the optimal solutions which could be taken forward in this feasibility study.

Based on an initial list of 23 polders, the following estimations can be made in terms of intervention types and extents:

- A polder will require in average 35 km of embankment raising and improvement works. Some 95% of embankments will be designed as interior dykes (located in the banks of tidal rivers) with a crest level of approximately 4.5 m and side slopes in the order of 1:2 – 1:3. There might be some marginal embankment on the bank serving channel drainage purposes. Marginal embankments have a height of 2.5 m with 1:2 side slopes. The types of embankment that face the sea are usually constructed with crest level ranging from 4.5m to 6m, side slopes of 1:5 – 1:7 and crest width of 6m. The actual crest level will be calculated based on the selected design return period, the predicted storm surge level in each section, the design waves and other factors. As such, the above are only rough estimations based on experience from the CEIP-1. In addition, if the BWDB preference is to build roads on top of embankments will constitute a factor for definitions of the design parameters;
- Bank protection works will be applied in areas where erosion is severe, and at the same time retirement of the embankments is complex due to land acquisition issues. The highly morpho-dynamic character of the rivers will be assessed in order to consider for locations that are not erosive at the present time of the study, but might be in the near future. The selection of locations and extent of slope protection works should be following a risk-based and flexible approach. Optimal design methods will be considered for effectiveness and cost-efficient structures; for instance, combination of CC-blocks with geobags. Further details on design optimizations are provided in next Chapters. The expected length of bank protection works in each polder is approximately 1 km;
- Slope protection works will need to be considered for interior embankments. As for the bank protection works, the selection of locations and extent of slope protection works should be following a risk-based and flexible approach, considering the wave loads and the currents. The expected average length of bank protection works per polder is 2 km.
- The average number of drainage sluices expected to be repaired and/or constructed per polder are expected to be less than 15 and the number of flushing sluices is expected to be less than 10. Drainage structures are mainly 1 to 3 vent drainage and flushing sluices. It is also expected that few structures will require repair works but the majority of the structures will require total reconstruction. At this stage of the study, drainage model results from past studies will provide an indication of sizing of openings but currently most of the structures are inadequate so will require widening. There were some studies on eco-friendly sluice design suitable for fish migration between polders and tidal rivers which we can include as an innovation;

- Excavation of drainage channels will be required and is expected to have an in average 30 km per polder;

Definition of costing of proposed interventions for each of the 23 polders

Tentative cost estimates of the interventions will be prepared which will be based on volumes and quantities derived from potential initial designs (where necessary) and unit rates. Unit rates will be based on Bangladesh Schedules of Rates centrally determined or by the Schedules determined by BDWB Regional Offices. The Consultant will also access the unit rates used in the current Contractor's Packages 1 and 2 when determining unit rates for this feasibility study. Escalation will also be taken into account. The cost of the rehabilitations/ interventions should also include the expected land acquisition costs.

Assessment of economic and societal benefits from implementation of those interventions to the polders

In this phase of more detailed selection a preliminary estimation of potential benefits of protection interventions will be undertaken. Direct benefits in terms of asset damage reduction will be tentatively estimated based upon flood maps (or indications of % of flood affected land per polder) and an inventory / field survey and/or GIS maps of assets of the polders (buildings, roads, agricultural crop land, aquaculture surface). Based upon indications of asset values (per m2 building, m road, m2 of agricultural crop land) etc.) indications of potential benefits will be made. These will be compared with investment costs and preliminary benefit-cost (B-C) ratios will be deduced and translated to numerical scores per polder (the higher the b-c ratio, the higher the score as input in the MCA).

Assessment of the environmental conditions of the polders

The environmental conditions in those polders will be assessed based on existing reports, field visits and stakeholder consultations. More specifically, the ecologically sensitive areas will be identified, as well as the aquatic fauna and salinity intrusion.

Other factors that will be assessed

The aforementioned aspects are very crucial for the selection of 13 polders and description of the required interventions, however other matters have to be considered as well. Those matters relate to the guiding principles and subsequently, the criteria used in the MCA (as explained in Section 4.3.2 and defined in Chapter 5).

Special focus will be given to land acquisition and displacement, institutional aspects in relation to water management, as well as stakeholder policies and strategies. In addition constructability will be put in the spotlight and logistics and travel times, availability of construction materials and implications in relation to land acquisition will be addressed. Last but not least, the risk assessment tool as referred to in Section 4.3.2 and explained in Chapter Chapter 5, will be updated with more accurate and recent information and as such will form a more reliable basis for polder selection.

Selection of 13 polders with optimal interventions

All the above information for the 23 polders, collected either from field visits and stakeholder consultations, or from available data and assessments, will form basis of the inputs to each of the criteria comprised in the MCA.

4.4 Data collection and engineering survey

4.4.1 Level datum and benchmarks

Definition of Datum

Datum means something which is used as a basis for calculating or measuring. In this Study, datum is the reference level which will be used in an engineering survey such as a Topographic and Bathymetric survey, Geotechnical investigation, Modelling, Design, water level measurements etc.

Establishment of the PWD datum

The National Mean Sea Level datum used by the Survey of Bangladesh (SoB), and Survey of Pakistan before 1971, and Survey of India before that, was based on a Mean Sea Level established in India and transferred along several long lines of levels respectively to the North West, South West and South Central Regions, to the Dhaka Region and to the South East. The PWD datum which has been used to set out all structures constructed by BWDB (and by EPWAPDA before) was assumed to be related to the SoB MSL datum by a fixed level difference which set the PWD datum 0.46m below the accepted MSL datum. It is also thought that BWDB Hydrology pillars which are marked in mPWD are also related to the SoB (we will call these Old SoB pillar levels)

Bangladesh established its own 'First Order Levelling Network' during 1991-1995 under a grant aided project. During that period Survey of Bangladesh established a 'Tidal Observatory' at Rangadia, Chittagong, a 'National Vertical Datum' at Gulshan, Dhaka, 465 benchmarks on about 2,386km first order levelling route covering 70% area of the country excluding coastal and hill tract districts.

Establishment of a verifiable common level for CEIP-1

After implementation of the "First Order Levelling Network" the new Levelling Network was well established and (New) SoB pillars (ie pillars depicting the revised MSL levels) were available for use throughout the Coastal Zone except at Hiron Point. All the Old SoB pillars were re-surveyed by SoB and it was found that there were errors of up to 50cm between the new MSL and the old MSL in the Coastal Zone, but that in other places (such as in the North West) the error was much smaller. The varying conversion factor most likely origins from land subsidence and possible errors in the original levelling network which was carried thousands of kilometres from MSL determined in Visakhapatnam in India. During discussions between the CEIP-1 consultants and SoB officials it became clear that it was not possible to convert new SoB to old SoB everywhere using a constant difference.

As it was not possible to establish a constant relation between the MSL of SOB and the mPWD used in BWDB, all surveys carried out within CEIP-1 were based on the latest SoB survey network. As it was customary to express levels in mPWD for BWDB projects – every level in the

CEIP-1 project expressed as "mPWD" was obtained by adding 0.46m to the level measured above the latest MSL datum of SoB. It is important to note that this mPWD has no relation to the old PWD datum which does not exist anymore. All levels used by the CEIP-1 have been given in this datum (called "new PWD" internally for convenience). This new datum has been applied to:

- All embankment surveys;
- All cross-sectional survey of drainage khals;
- Surveys of existing structures;
- All designs made and documented by the project;
- The water levels used in the IWM models for CEIP-1.To be more specific:
    - Bay of Bengal Model southern boundary uses a global tidal model, in which is expressed in height above the true mean sea level. The consultant converted the model datum to the new PWD datum. The consultant certified that this model therefore needed no adjustment.
    - The South West Region Model uses Hiron Point as main boundary, where the datum has been corrected over the years to conform to old PWD levels which matched the BWDB Hydrology Network used to calibrate the model. This needed correction. The correction was made by adjusting the datum value until the model matched water levels recorded at several calibration points (such a Mongla Port), after conversion to new PWD, because new SoB bench marks were available at these points. A 50 cm correction at Hiron Point and similar corrections at other downstream boundaries was sufficient to obtain a working model which could be used for modelling polder drainage consistently. Figure 4.2 shows the relationship between the old datum and the new datum at Hiron Point.

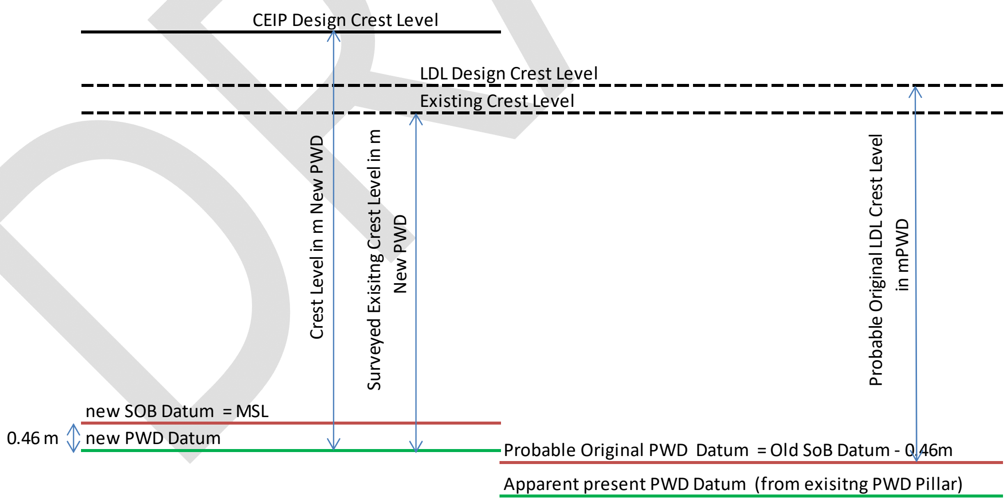

Figure 4.2: Relationship between the old datum and the new datum at Hiron Point

Datum recommended for use in preparation of CEIP-2

To keep consistency in the engineering surveys, the same level datum as was used in CEIP-1 is advised to be used in the engineering survey of CEIP-2. Therefore, in CEIP-2 the Reduce

Level (RL) of the mPWD will be mSoB+ 0.46 m. In the note on all designs and drawings, the method of level conversion to SoB level will be included

Establishment of PBM and TBM at selected points

Bench Mark (BM) refers to a mark on a permanent object (such as a concrete post set into the ground) indicating elevation and serving as a reference in topographic surveys and tidal observations. In this project, two types of Bench Marks will be in use- Permanent Bench Mark (PBM) and Temporary Bench marks (TBM).

The SoB has established permanent BM pillars across the whole country. For a fee, the latitude, longitude and RL of these BM pillars can be requested from the SoB. As it is known that the value of the past SOB BM (based on a Mean Sea Level established in Vishakhapatnam on the Indian coast) differ from the present reference (based on a Mean Sea Level defined from 'Tidal Observatory' at Rangadia, Chittagong) and because of various reasons including land subsidence those BM pillars are inconsistent between one another as well. In addition, these pillars are not available in all polders and as such, it is expected that additional BMs need to be established. For example, in CEIP-1, these inconsistencies led to the establishment of 35 nos. permanent bench at 5 km interval around the polders of Package-1 (P-32, P-33, P-35/1, P-35/3 and P-39/2C).

As such, within CEIP-2, additional BM pillars will be also established. To ease the checking of the RL of embankments and structures during the construction, PBMs can be established at an interval of 5-6km along a line more or less parallel to the alignment of embankment. It is thus expected to establish a number of 100 nos. Permanent Bench Marks (PBM) around the 13 polders. These PBMs will have to constructed as RCC pillars with a foundation and to be established on stable ground to avoid settlement, within a distance 10-15m from the embankment toe and one or two in every polder in such a clean area that those can be used as GPS monitoring station if required. The RL of each BM pillar will be fixed with reference the available nearest SoB's pillar. As it is customary to use levels in mPWD in BWDB, the levels of the PBM will have to be documented in mPWD.

In addition, temporary Bench Marks will be established in between the permanent Bench Mark by engraving the existing structures/installing pre-cast RCC poles. These will for instance be placed at points on the upper side of existing sluices/regulators or any other permanent structures in and around the alignment of embankment. It is important to point to the fact that these bench marks are also not permanent and that they have to be verified against the control level network maintained by SOB periodically. If the project has established one or more regularly updated reference station within each polder, this verification could become standard operating procedure for the project. The PBM locations will be sited in accordance with the following guidelines:

i. To be established in solid ground (not in swamp or paddy land);
ii. Minimum of 10 metres from toe of roads, embankments, canals or drains and in areas not subject to change;
iii. Having enough clearance for receiving uninterrupted satellite signals.

The Consultant will preliminarily select the locations in consultation with the BWDB.

All the Permanent Bench Marks will be connected to the nearest SOB geodetic survey control marks. Vertical controls of the PCPs and TCPs will be established by Spirit Levelling. Experienced surveyors will be engaged for the job from the nearest SOB Bench Mark monuments to the BMs and then to the TCPs. Closing will be made for the each segment during the fly levelling.

Carrying out construction on land the is continuously undergoing subsidence It is necessary to recognise that all permanent and temporary bench marks established within a polder are subject to slow subsidence- but not necessarily at the same rate. The rate of subsidence would be of an order not exceeding 10mm per annum. Although the total subsidence that would occur within the main construction period of two years would be small but not insignificant, it is necessary to monitor levels accurately throughout the lifetime of the rehabilitated polder system to maintain awareness of the stability of all structures within the polder.

All designs will continue to refer to the NewPWD datum – despite the fact that there would/could be a gradual drift of the level of the bench mark pillars carefully constructed and installed for use by the project. This implies that the correct level value of each bench mark pillar has to be established at regular intervals (say - three times during each construction season).

It is not likely the Survey of Bangladesh will update their primary level network at such frequent intervals. As it is not practical to run frequent levelling lines from the sea level reference station in Chittagong to the project area(s) a more direct method has to be deployed. It is proposed that one or more GPS monitoring stations are installed within close enough proximity to the contractor's work sites to enable all reference stations to have their bench mark levels verified at regular intervals (three times per season as suggested above). All surveys carried out for setting out new project components and/or for rehabilitation/re-excavation work would use this local verified bench mark.

4.4.2 Geotechnical surveys and investigations

Geotechnical surveys and investigations will be carried by deploying the following equipment and the specifications of ASTM/BS standards.

a) Drilling and sampling

Consultant will make available at the job site all equipment, accessories, tools and auxiliary installations as required for a satisfactory execution and progress of the works in accordance with the specifications. For drilling in non-cohesive and cohesive soil, Consultant will ensure supply of drilling equipment capable of drilling boreholes with a minimum inside diameter of 100 mm to the full depth (up to 25.00 m) of the hole and adequate samplers for recovery of the soil to be stored on plastic bags, sample tubes or in core boxes. Equipment for hand auguring shall be capable of drilling holes to a maximum depth of 5m with provision for recovery of samples. Adequate equipment will have to be made available to take disturbed and undisturbed samples of cohesive soil as well as non-cohesive material from the boreholes.

b) Storing of samples

Watertight plastic soil bags of various sizes shall be available to keep all disturbed soil samples. The borehole number and the depth of the sample shall be written on the outside of the bag. Undisturbed samples shall be stored in the sample tube and transported to the laboratory for inspection and testing.

All samples shall be labelled and stored in wooden core box and the boxes shall be made of boards having a minimum thickness of 2 cm. Core boxes shall be available at the site before commencement of any drilling work. The boxes shall be 1.10 m wide. They shall be equipped with a cover which can be locked.

The borehole number, box number and depth of the section of samples shall be written on the inside of the box cover and on the small side of each box. The borders between different strata and sections of core or sample loss shall be marked with boards between the samples, indicating the depth.

c) Sampling

Non-cohesive soils:

At the top of each new stratum, and thereafter at 1.5 m intervals on depth, a standard penetration test shall be performed using the split barrel sampler. At the top of each new stratum, and thereafter at 1.5 m intervals of depth, a bulk disturbed sample shall be taken from the drill tools. The first sample will be taken at or close to the existing ground level (at 0.91 m depth).

Cohesive soils:

At the top of each new stratum, and thereafter at 1.50 m intervals of depth, an undisturbed sample shall be taken. Wherever possible, sampling shall be carried out using Shelby tubes of the largest possible diameter. Normally 100 mm diameter samples will be required. Generally, the minimum acceptable diameter shall be 75 mm for depths up to 8 m and 63 mm for depths exceeding 8m. If there is inadequate recovery or the sampler cannot be driven, this should immediately be followed by a standard penetration test. A Standard Penetration Test shall in any case be performed at 1.5m intervals in between taking undisturbed samples. A small disturbed sample shall be taken at the bottom of each undisturbed sample.

All soil samples from the boreholes will be kept at the Consultants Dhaka office. They will be stored immediately after extraction from the borehole. The samples will be transported by Consultant immediately to the testing laboratory. Samples for testing will be indicated by Consultant. All samples not selected for testing shall be retained by the Consultant for one month after submission of the final investigation report and may then be disposed of.

d) Borehole Logs

Detailed borehole logs will be prepared for all boreholes. The borehole log shall include the following information:

- Numbers of boreholes;
- Location and elevation of borehole in accordance with the survey performed for all borehole locations;
- Type of drill rig and samplers;

- Drill hole diameter;
- Date of commencement and completion of borehole;
- Final depth of borehole;
- Casing sections;
- Soil profile;
- Results from standard penetration tests and permeability tests;
- Groundwater table;
- Flushing water losses;
- Core recovery percentage per drilled core length;
- Depth and type of samples recovered.

e) Standard Penetration Test (SPT)

General:

SPT tests will be executed according to Test 19 of BS 1377 or ASTM D-1586 for measurement of the resistance of soil to penetration of a standardized sampler.

Equipment:

Any drilling equipment shall be acceptable that provides a reasonably clean hole before insertion of the SPT sampler to ensure that the penetration test is performed on undisturbed soil and driving of the sampler is not hampered by collapsed borehole walls. The SPT sampler shall be in accordance with Test 19 of BS 1377 or ASTM D-1586. The sampler size shall be 50.8 mm. The drill rod shall have a stiffness of at least an A-rod with an outside diameter of 1 5/8 inch (41.2 mm) to avoid whipping under the blows of the hammer. The drive weight assembly, driving head, and free fall distance shall all be in accordance with test 19 of BS 1377 or ASTM D-1586. The friction between drive weight and guide shall be negligible.

Test procedure:

The tests procedures will be executed as follows:

- Drill and clear out the borehole to testing elevation without disturbing the borehole bottom. Bottom discharge bits and open tube samplers with jetting shall not be allowed. Maintain the water level in the hole at or above groundwater level. Casing shall be used to stabilize the borehole if necessary. Casing shall not be driven below testing elevation;
- With the SPT sampler resting on the bottom of the hole, drive the sampler with blows from the driving hammer until 0.45 m have been penetrated or 60 blows have been applied;
- Repeat this operation at intervals of 1.5 m in the borehole in homogeneous strata and at every change of strata;
- Record the number of blows required to effect, each 0.15 m of penetration. The first 0.15 m is considered as seating drive. The added number of blows required for the second and third 0.15 m of penetration is termed as, the ”penetration resistance, N”. If less than 0.30 m is penetrated, the logs shall state the number of blows and the fraction of penetration;
- Bring the sampler to the surface, open it and describe the sample of soils recovered. In case of the selection of the sample for further testing, close and seal the sampler and

label it with boring number, depth of penetration, number of blows. Otherwise store the sample in a soil bag and core box.

f) Permeability tests in boreholes

General:

Falling head or constant head tests has to be carried out in boreholes as directed by the Engineer to determine the permeability of the soil strata.

Equipment:

Any drilling equipment may be used that provides a clean hole before adding water for the permeability test. Appropriate equipment will have to be available and have sufficient capacity such as water pumps or tanks to enable satisfactory conduct of the tests.

Test

Tests shall be carried out in accordance with recommendations given in BS 5930 and as stated below.

The borehole shall be drilled to the test depth and the bottom of the hole carefully cleaned of all loose or contaminated material. Bottom discharge bits and open tube samplers with jetting shall not be used. If necessary, the borehole shall be stabilized by the use of casing. Water level in the borehole shall be maintained at or above groundwater level. Casing shall not be driven below the testing depth.

The following laboratory tests except the Triaxial compression test for each bore hole (at least one for each borehole) will be carried out following the standard and by use of equipment stated in laboratory test manual. One Triaxial compression test will be done for each new drainage sluices. The tests will be carried out in the laboratory of the Consultant. If any test cannot be conducted in the laboratory of the Consultant, then it will be carried out in a recognised laboratory:

- Natural moisture content;
- Atterberg limit (Liquide limit, Plastic limit, Shrinkage limit);
- Density (wet/dry)
- Grain size analysis;
- Direct shear test;
- Triaxial compression test;
- Unconfined compression strength test;
- Specific gravity;
- Consolidation test.

4.4.3 Topographic surveys

a) Land survey

Topographic surveys are required to identify the existing ground level to generate the area-elevation curve which will help us understanding the surface shape. It also located the physical features existence. Digital elevation model and ground contour will be generated from the topographic survey for the 13 selected polders. The Topographical survey will be conducted using Digital Total Station/LiDAR system (Combination of LiDAR, Drone, and GPS). The LiDAR system and GPS is advised for Topographical survey instead of Total station. Topographic survey/Land level survey will be conducted at 50mx50mm interval

b) Embankment survey

Embankment cross section survey will be carried out at 13 polders only at 500 m intervals and 250 m where considered necessary. At the locations of breaches, damages, cross-sections will be taken at closer intervals to represent the correct configuration of the cross-section. Spot levels will be taken maximum 5m apart or less as necessary to represent the correct geometry of the section. Minimum three levels will be recorded at the top of the embankment, one at the crest and two at the edges for the existing embankment. The X-sections will be extended beyond 50m from the countryside toe of embankment whereas extension would be made up to the river bank at the river side. Cross-section and long sections will be plotted in AutoCAD or Civil3D and will be checked with design section for adequacy and computation of volume of earthwork.

4.4.4 Bathymetric and hydrometric surveys

a) Bathymetric surveys

River cross-sections at 1,000 m intervals surrounding the polders will be taken to update the model. About 800 nos. sections over 800 km length of surrounding rivers of selected 13 Polders. Digital Echo-sounder supported by DGPS and notebook computer installed with HydroPro survey software will be used for bathymetric survey. The survey work will be executed with direct connection of Echo-Sounder and DGPS. It is also mentioned that the cross-section at the land part and shallow depth part will be done Auto Level. The water level measurement during sounding also will be performed using RTK GPS at starting and ending of each section. The manual water level gauge for water level to check the RTK-GPS level. It will ensure comparative quality control between the gauge reading and RTK-GPS reading. The cross-section along the peripheral rivers of 13 polders @1000m interval extended up to high bank or up to the embankment will be conducted using Total station or Level equipment. The level will be transferred through fly levelling or through RTK GPS which is depending upon filed condition and environmental situation. But RTK-GPS system is easier, precise and quicker for a long distance. The cross-sections along the river bank protection for 10 km for Bank Protection Works @250m (total for 13 polders);

b) Drainage channel survey

Drainage channel sections will be carried out along 1000km length of the internal khals of the new polders only. will be conducted using Total station or Level equipment. The level will be transferred through fly levelling or through RTK GPS which is depending upon filed condition and environmental situation. But RTK-GPS system is easier, precise and quicker for a long distance. The sections will be made at an interval of 500 m along khals which were not surveyed during the previous study. Cross section to be extended at 15 m beyond the bank line and spot level to be taken maximum 5 m apart or less as necessary to represent the correct configuration of the cross section. Existing water levels, and historical HFL are also to be recorded.

c) Water levels

Water level data is important to know for assessment of the variation of water depth over the year, tidal characteristics and also to calibrate the water flow model. Tidal water levels are also required to design the hydraulic control structure by observing the upstream (drainage channel) and downstream (river network) water level data. Water level data will be collected at 26 locations around the all 13 polders (2 in each polder) for 6 months period during monsoon. The data will be collected at 30 minutes interval for 24 hours by installing pressure cell as well as by installing staff gauges for cross checking. The gauge reading will be taken by gauge readers. The gauges will be connected to the nearest TBM which will be connected again from the existing SOB Benchmark.

d) Discharge observation and velocity profiling

The tidal discharge is essential to know the water flow during flood and ebb tides, tidal prism and to calibrate the model. Discharge and velocity observations will be made at one location for each polder for spring and neap tide in monsoon. As such, a total of 26 measurements will be carried out in the 13 polders of all 2 packages. The observation will be made for 13 hours from early morning to evening near the installed water level gauges. The interval between successive measurements will be 1 or 1/2 hour depending on the location.

RD Instruments River Ray 600 Khz /Workhorse Rio Grande 600 KHz ADCP or similar will be deployed for the measurement. The velocity profiling range is from 2-meter depth up to 45 m depth. The measurement will be made following *WinRiver User Guide* supplied by the manufacturer of the instrument. The instrument is capable of measuring velocity without anchoring at measuring locations (moving boat condition). It measures flow velocity at each ensemble across the whole river. At each ensemble, velocity will be measured in 50 cm vertical intervals along the water column. Thus a series of velocity data will be recorded along the whole transect line. The interval between consecutive ensembles will be around 3 seconds depending on the configuration and depth of the river. The software estimates the discharge of unmeasured areas (the top of instrument face, near bottom part and at edges). The river flow is calculated online by the *WinRiver Software* by adding discharge of each ensemble as it moves along the transect line. As the discharge measurement will be conducted in coastal zone (brackish/ saline water), calibration will be made by using software in each station before starting the work.

e) Suspended sediment sampling and analysis

In order to know the sediment transport pattern and to calibrate the morphological model, sediment concentration measurement is needed. Samples will be collected once every hour to show the time variation and correlation the Total Concentration with velocity/discharge. The samplings for total concentration will be taken from 1 vertical along the discharge transect. At each vertical, samples will be collected from 0.2, 0.6 and 0.8 times the total depth from the surface. The sediment sampling will be made using pump-bottle technique. The water is withdrawn using JABSCO Pump operated by DC motor that has uniform speed and is operated by car battery. The pump is connected with a tube of required length. The tube is attached with a fish (normally used with traditional current meter) and lowered from a winch at the desired depth. The initial water pumped from the tube is allowed to drain before the sampling is made for total concentration. The samples will be tested for total concentration at a suitable laboratory typically by using filtration techniques.

f) Bed material samples

The bed samples are useful to know the river bed characteristics and calibration of the morphological modelling. To this end 3 bed samples will be collected for each polder and as such a total of 39 nos samples will be collected from the 13 polders. The sampling will be done by using Van Veen grab sampler. The sampler consists of cupped jaws that close to trap a sample of bed material. The grain size distribution of bed materials is usually estimated by sieve analysis. In the case of most cohesion less soils (gravel, sand and silt), distribution of grain size could be determined by sieve analysis. Cohesive soils (clay) cannot be separated by sieve analysis into size categories because no practical sieve can be made with openings so small; instead, particle size may be determined by observing settling velocities of the particles in the water mixture. Sieving through a 63 microns sieve separates samples for grain size analysis. The portion above 63 microns is analysed by dry sieving and the portion below 63 microns is analysed by observing settling velocity of the sediments in Andresen Settling Tube.

4.4.1 Supervision of technical surveys and investigations

Some of the work will be sub-contracted and to ensure the quality of the technical surveys and investigations supervised by Consultant in a manner described here below.

(i) **Field work**: To ensure high quality survey outputs and adherence of the surveyors to the required scope, support and supervision through the JV is required from the start of the survey, throughout the survey program and during post-processing.

a. Initiation of survey: The accuracy of topographic and bathymetric surveys largely depends on (i) the use and proper calibration of adequate survey equipment, (ii) incorporation of the surveys into a reference system, in this case the Survey of Bangladesh (SoB) system through linkage of survey equipment to established reference points such as benchmarks, and (iii) execution of surveys in a transparent and comprehensible manner to allow detection of errors and inaccuracies. To this purpose, the Consultant will, through the surveyor and the international survey supervisor, accompany the sub-contractors during the setup of temporary benchmarks and monitor the calibration of survey equipment. Similarly, the Consultant will check the equipment used for the geotechnical investigations as well as the locations of the boreholes.
b. Support and supervision during survey: Following the start of the survey, the Consultant will periodically visit the field to monitor topographic, bathymetric and geotechnical surveys. As an ongoing quality control of the surveys and to ensure the fulfillment of the technical specifications, collected data will be processed as soon as they are available, in parallel with the ongoing collection of data. The collected data will be checked for consistency, positioning to local and global coordinate system and errors. If necessary, re-surveys will be conducted to verify results or to close data gaps. In addition to checks of the collected data, these will also be used in initial model setups to confirm the suitability of the collected data for meaningful hydraulic modelling.

(ii) Data post processing and storage: Post-survey data processing will be done by the subcontractors as well as by team members. The latter is done to further refine the survey results to fit for the needs of the project and to cross-check the survey results for inconsistencies and errors. Outputs will include (but not limited to):

- Digital elevation models to be used for modelling and design of interventions such as embankments and slope protection,
- Bathymetric models to be used for modeling and design of underwater protection. This will further serve as a baseline for assessment of future erosion, and
- Soil strata profiles to be used for the assessment of bearing capacity of the soil for the construction of interventions and performance of protective works.

To ensure the availability of data for later use, in particular for the implementation of the proposed project, all survey data will be stored in raw and processed form. Main storage will be on a cloud-based storage system (such as BOX) and the data format will be generic (such as .xyz for bathymetric data) to provide low-barrier access for eventual users.

4.5 Hydrological, hydraulic and morphological studies and mathematical modelling

The objectives of the coastal embankments are to protect life and property in the polder areas from saline intrusion, cyclonic storm surge and monsoon high tides. Assessment of the vulnerability and risk of damage to the embankments, drainage systems and property at present and in the future, considering changing climate, is required for coastal embankment improvement.

The purpose of hydrological, hydraulic and morphological studies and mathematical modelling is to inform the design by providing the relevant hydraulic design conditions (including, but not limited to, water levels, current velocities and wave heights), erosion / accretion patterns, bankline migration, drainage capability etc for the selected polders.

The following activities will be performed within this project:

- Update the hydrological, hydraulic and drainage modelling framework
- Planform analysis and riverbank erosion forecasting
- Assessment of internal water management risk of the 13 polders

4.5.1 Update the hydrological, hydraulic and drainage modelling framework

CEGIS has recently developed and calibrated hydrodynamic, storm surge and regional models covering the entire project area: The Meghna Estuary, coastal zone and the delta of the South-West Region. These models will be enhanced with the data from the IWM's models and CEIP I modeling data and reports as well as the inputs from the Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone, and supplemented with the data from new surveys such as bathymetry survey, cross section survey, specification of cross drainage structures, topography survey, river connectivity survey and existing crest level of the for 13 selected polders. As the models will be used and updated for specific design of the 13 selected polders, the updated information will be focused on the river system in the direct vicinity of these polders. However, considering the highly dynamic nature of the river and delta system of Bangladesh, the regional models may also need to be updated.

Three models will be developed and updated as per necessity under the scope of the project:

1) Hydrodynamic model to assess the impact of future sea level rise
2) Storm surge model to assess the impact of storm surges considering climate change' '
3) Drainage model to assess the adequacy of existing drainage system of the 13 selected polders, considering future climate change.

4.5.2 Hydrodynamic model

CEGIS has a 2D hydrodynamic Bay of Bengal model, which is currently under development. The depth-integrated model is being developed using Delft3D. The model is capable of simulating flow pattern, tidal asymmetry, flow velocity, velocity pattern, in the Bay of Bengal which is highly affected by natural and anthropogenic activities. The model also has storm surge functionality, which means it has the capacity to assess the impact of storm surge along the coastal belt of Bangladesh. It also has the wave functionality to assess the wave For the purpose of this project the Bay of Bengal Model will be updated and enhanced with the data from the IWM's models and CEIP-1 modeling data and reports, and supplemented with the data from new surveys. The following datas will be required from field survey:

1) Survey of Peripheral River bank line
2) Bathymetry/Cross Sections Survey of River/Khals both peripheral river and rivers/khals inside selected 13 polders;
3) Existing alignment and crest level of embankment for the selected 13 polders;
4) Specification of existing cross drainage structures (e.g. opening size, sill level, no. of vent, et.)
5) Topography survey inside selected 13 polders;
6) Drainage Network Survey inside selected 13 polders.

Overall scheme of 2D hydrodynamic models showing the links and outputs are shown in Figure 4.3.

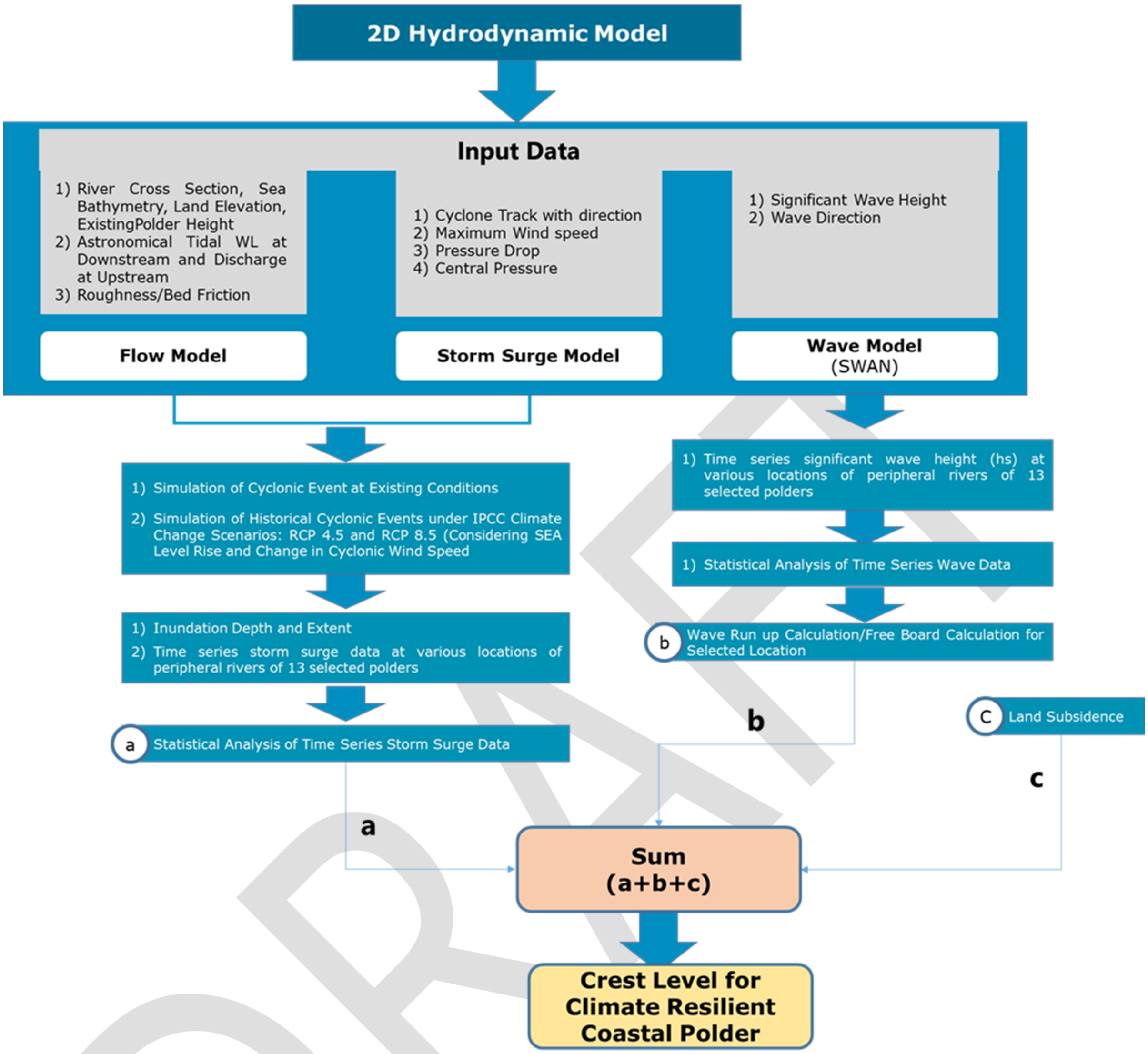

Figure 4.3: Scheme of 2D Hydrodynamic models

4.5.3 Flow model

The flow model is capable of translating hydrodynamic situation for existing and future climate change. It can simulated the Sea Level Rise scenarios and can translate the change in water level and also inundation depth and extent for future sea level rise. The overall approach of the flow model that will be followed is graphically represented in Figure 4.4.

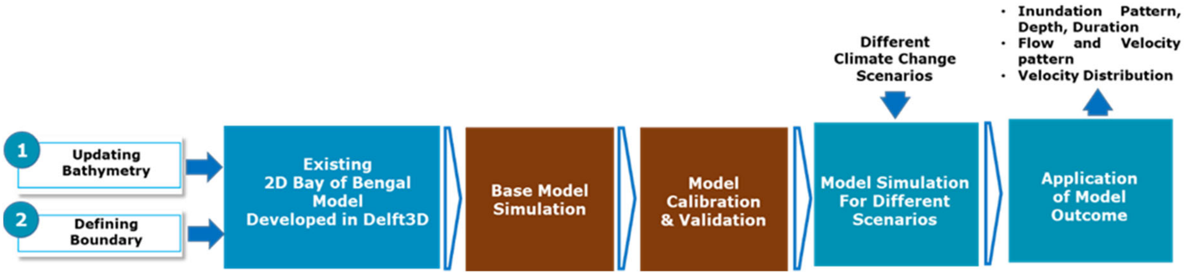

Figure 4.4: Overall Approach of Hydrodynamic Model

The model already has a generated grid (unstructured curvilinear) and specified boundary conditions. There are three upstream boundary conditions and one downstream boundary condition, as specified in Table 4-3.

Table 4-4: Boundary Conditions for the Hydrodynamic Model

SL	Boundary Type	Boundary Location	Type of Data	Source
1	Upstream	Hardinge at Ganges	Discharge	BWDB
2		Bahadurabad at Brhmaputra	Discharge	BWDB
3		Bhairab Bazar at Upper Meghna	Discharge	BWDB
4	Downstream	Deep Sea at Vishakapatnam	Astronomic Tidal Constituents	TPXO 8.0 Global Inverse Tidal model

Updating of bathymetry will be done based on the cross section survey, topography survey inside 13 selected polders and also with existing height of the 13 selected polders. Afterwards, the base model will be simulated for the purpose of calibration and validation. The calibration and validation will be done with observed water level data. Performance of the model will also be evaluated through statistical analysis.

Afterwards, the model will be simulated for different climate change scenarios based on IPCC Ar5 Report. The sea level rise rate will be adopted from IPCC 5th Assessment Report estimates for the Bay of Bengal. In this study, sea level rise scenario for the region will be based on projections for Haldia in West Bengal, India (22.0°N, 88.1°E), produced for the IPCC 5th Assessment Report (AR5). A Representative Concentration Pathway (RCP) is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC. Four pathways were used for climate modeling and research for the IPCC fifth Assessment Report (AR5) in 2014. The pathways describe different climate futures, all of which are considered possible depending on the volume of greenhouse gases (GHG) emitted in the years to come. The RCPs – originally RCP2.6, RCP4.5, RCP6, and RCP8.5 – are labelled after a possible range of radiative forcing values in the year 2100 (2.6, 4.5, 6, and 8.5 W/m2, respectively).

In Figure 4.5, Vertical Bars at the Right Side Represent the Ensemble Mean and Ensemble Spread (5 to 95%) of the Likely Sea Level Change at the Year 2100 Inferred from RCPs 2.6 (Dark Blue), 4.5 (Light Blue), 6.0 (Yellow) and 8.5 (Red).

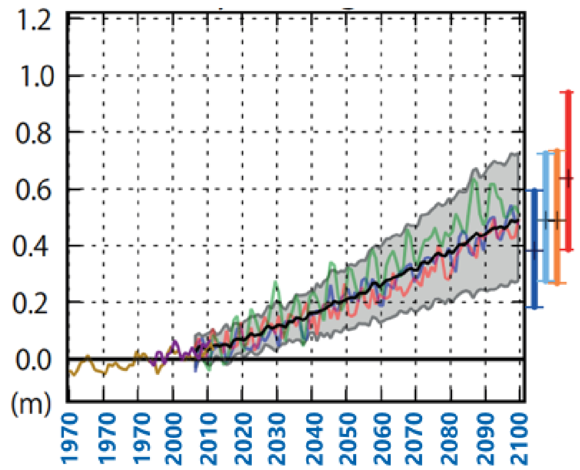

Figure 4.5: Observed and Projected Relative Sea Level Change Haldia Tide-gauge Station

This model will provide outputs such as:

- Inundation depths, extents and duration for different sea level rise scenarios and monsoon flood as well;
- Velocity and discharge distribution patterns

4.5.4 Storm surge model

CEGIS has a 2D Storm Surge model, which is currently under development. The depth-integrated model is being developed using Delft3D. It has the capacity to assess the impact of storm surges along the coastal belt of Bangladesh. The model will be applied to assess the impact of storm surges under future climate change conditions. The overall approach of the model that will be followed is graphically represented in Figure 4.6.

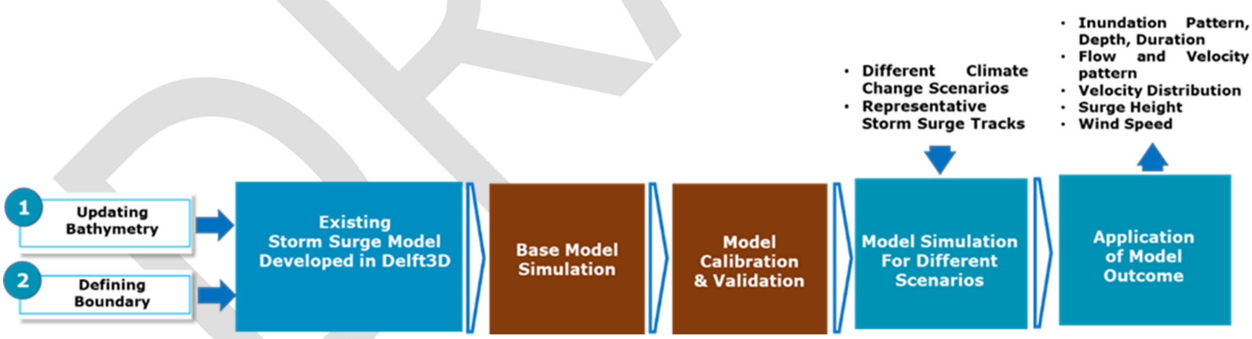

Figure 4.6: Overall Approach of Storm Surge Model

The model already has a generated grid (unstructured curvilinear) and specified boundary conditions. There are three upstream boundary conditions and one downstream boundary condition in the storm surge model just like the developed hydrodynamic model.

Updating of bathymetry will be done based on the cross section survey and the existing height of 13 selected polders. Historical storm surge data (1960-2020) will be collected from secondary sources like IMD, JTWC, BMD and UNISYS based on availability. The calibration and validation will be done with observed water level (surge height). The performance of the model will also be evaluated through graphically and statistically (e.g., RMS, PBIAS, R2, NSE, etc.).

In order to select this representative cyclonic event, numerous distributions have been suggested in the literature on the basis of their ability to "fit" various datasets from historic observations[13]. The first asymptotic distribution of extreme values (EV1); commonly called Gumbel Distribution is widely used and is recommended for Bangladesh coast and river related calculations[14]. Hence, from frequency distribution, representative cyclonic events will be selected for base model simulation and the model will be simulated considering that representative cyclonic events. Afterwards, the model will be simulated for different climate change scenarios. A synthetic storm surge track will be prepared. The approach of preparing synthetic surge track is shown in Figure 4.7.

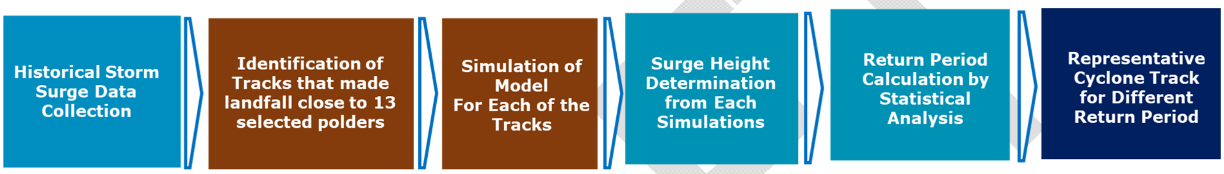

Figure 4.7: Overall Approach and Synthetic Surge Track Preparation

From the historical surge data, those tracks will be identified which made landfall close to the 13 selected polders. Subsequently, the model will be simulated for each of the identified tracks. Surge height will be determined from model outcome for each of the tracks. Then, statistical analysis will be performed based on the surge height to calculate the return period. Finally, representative cyclone track for different return periods will be selected.

The storm surge model will then be simulated for the selected tracks based on return period analysis of surge heights from model outcome. The combined effect of sea level rise and storm surge will be assessed via this model. The model will provide outcome such as: surge height, wind speed, velocity during landfall, flow pattern, inundation depth, extent and duration.

This model will provide outputs such as:

- Inundation depth, extent and duration;
- Velocity and discharge distribution patterns;
- Time Series Storm Surge Height at Various Location in Peripheral River;
- Statistical Analysis of Historical Storm Surge Heights.

The model outcome will assist in determining hydraulic design parameters for embankments such as:

- Crest level
- Slope

[13] FENNESSY MJ, KINTER III JL, FIRTMAN B, MARX L, NIGMAN S, SCHNEIDER E, SHUKLA J, STRAUSS D, VERNEKAR A, XUE Y and AZOUJ (1994). The simulated Indian monsoon: A GCM sensitivity study. *J. Clim.* **7** 33-43

[14] Saleque, M., G.. (1991). "Flood flows of the Jamuna: A study of magnitudes and frequencies." MSc. Project report, Bangladesh University of Engineering and Technology

- Set back distance
- Roughness etc.

The output and determined hydraulic design parameter of the model will be provided in tabular form, shown in Figure 4.4.

Table 4-5: Exemplary scheme for determining crest level

Sl	Location	LDL Crest Level (mPWD)	Existing Crest Level (mPWD)	Modelled Storm Surge Level (mWPD)	Standard Deviation	Simulated Storm Surge (mWPD)			Modelled Storm Surge Level (mWPD) Considering Sea Level Rise	Modelled Storm Surge Level (mWPD) Considering Sea Level Rise	Recommended Slope	Free Board for Grass or Smooth Slope	Free Board for Rough Slope	Allowance for Subsidence	Maximum WL in Monsoon Period	Maximum Wind Wave Height in Monsoon Period	Required Crest Level
									RCP 4.5 (2050)	RCP 8.5 (2050)							
						AILA	SIDR	Amphan	Representative Cyclone for Different Return Period	Representative Cyclone for Different Return Period							

4.5.5 Wave model

To simulate the evolution of wind-generated waves in coastal waters (which may include estuaries, tidal inlets, barrier islands with tidal flats, channels etc.) the third-generation SWAN model - SWAN is an acronym for Simulating WAves Nearshore – will be used. The model will be simulated coupled with the hydrodynamic model (flow model and storm surge model) to assess the impact of wave on tidal water level for any extreme event.

4.5.6 Drainage model

CEGIS is developing 1D hydrodynamic Regional Model for the South West (SW) and South Central (SC) region of Bangladesh. SOBEK is an integrated software package for river, urban or rural water management. The modeling suite comprises of Rainfall-runoff (RR), 1D and 2D Hydrodynamics modules.

A quasi 2D approach will be applied by using this regional model to assess the drainage condition inside the 13 selected polders. The upstream boundaries will consist of daily discharge data for the Hardinge Bridge point, Chapai Nawabganj Station at Mohananda, Bahadurabad Station on the Padma-Jamuna rivers and Bhairab Bazar Station on the Upper Meghna river. The five downstream tidal water level boundaries will include Arpangasia, Passur, Baleswar-Buriswar-Bishkhali, Tentulia and the lower Meghna.

Upon development and subsequent calibration & validation, the model will be updated using recent cross section data of the peripheral river and khals or other water bodies inside the polders. The model will be then re-calibrated with the latest bored data. After calibration and validation, the model will be used to simulate for climate change scenarios by changing the upstream discharge as per BDP 2100. The downstream boundary will be changed based on the simulation outcome of 2D Bay of Bengal Model for Sea Level Rise Scenarios as per IPCC Ar5 Report. The 1D model will also be used to simulate a small period of a storm surge event to see the tidal surge propagation along the peripheral rivers, which will be instrumental for fixing embankment crest level of dike, assessing adequacy of existing drainage system. It should be noted that the change in water level due to tidal surge will be applied in model downstream boundary.

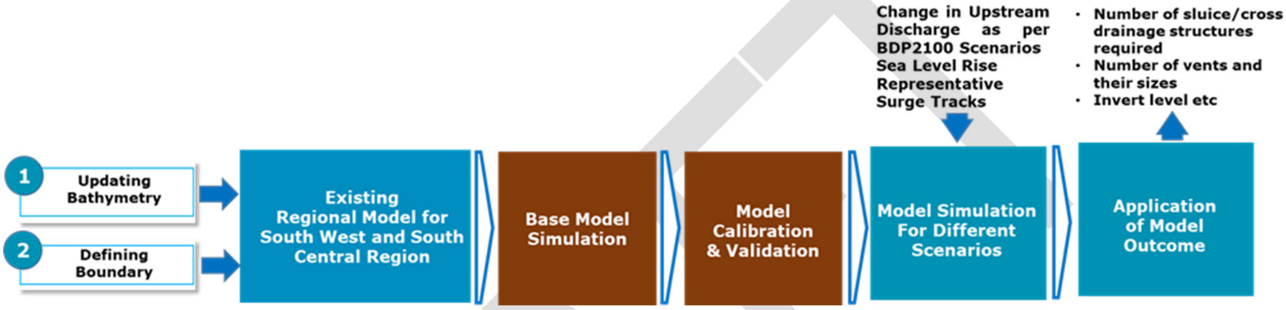

Figure 4.8: Overall Approach of Drainage Model

The model outcome will assist in determining hydraulic design parameter for cross drainage structures such as:

- Number of sluice/cross drainage structures required;
- Number of vents and their sizes;
- Invert level etc.

The proposed drainage parameters will be designed based on the outcome of drainage model. For example, the drainage volume may become higher due to climate change. The model will be used to check whether the existing design or number of cross drainage structures are adequate enough to pass the additional drainage volume. In addition, due to sea level rise there will be an increase in high tide for which drainage time will be reduced. Therefore, the size and number of sluices will be determined considering additional drainage volume and changed outfall river condition. on the other hand, if there is any waterlogged/ pocket area inside the polders, additional regulators might be recommended.

The output and determined hydraulic design parameter of the model will be provided in tabular form as shown in Table 4-6.

Table 4-6: Example of outputs from drainage modelling and analysis from CEIP-2

SL	Name of Khal on Which Sluice is Located	Chainage of Embankment Where Sluice is Located (km)	Design Crest Level (mPWD)	Side Slope		Existing				Proposed				Average Monsoon LWL at the Peripheral River/Channel (mPWD)	Average GWL for Specific Drainage Basin (mPWD)	Peak Discharge of Design Return Period (m3/s)	Catchment Area (sqkm)
				River Slope	Country Side	Sluice ID No.	No. of Vent	Size of Vent (mxm)	Invert Level (mPWD)	Sluice ID No.	No. of Vent	Size of Vent (mxm)	Invert Level (mPWD)				

4.5.7 Planform analysis and riverbank erosion forecasting

CEGIS has profound knowledge on the morphological assessment of the rivers not only in Bangladesh as well as abroad. CEGIS has rich database of historical maps and time series satellite images in the last two centuries which are essential for the precise morphological assessment and quantification of the rivers.

CEGIS is the only organization in the world who has developed unique tool for the prediction of the riverbank erosion in the major rivers (Jamuna, Padma and Ganges) in Bangladesh. The prediction is being made one-year ahead each year since 2004 to predict the erosion vulnerable locations along with prediction lines of different vulnerabilities (70%, 50% and 30%) and erosion vulnerability mapping of the vulnerable locations as well.

Moreover, CEGIS worked for 'Padma Bridge Detailed Study Phase' (Mawa) and predicted the Padma River for 50 years with and without project situation. In addition to that, during the last couple of years CEGIS have been engaged by Bangladesh Bridge Authority (BBA) to monitor and predict the behaviour of the Padma River for one to 10 year interval. CEGIS also worked in the Meghna Estuary Study where rivers in the estuaries were thoroughly investigated through planform analysis of the time series satellite images and historical maps. Additionally, CEGIS is continuously monitoring the dredging activities and different navigation routes in the coastal areas (especially in the Barishal and Khulna Divisions) where a dredging plan is being implemented through in-depth analysis of the morphological development of the rivers.

CEGIS is continuously updating their prediction methodology based on their accumulated knowledge and experiences. Rivers in the coastal areas have different characteristics than the fluvial system (in the northern part of Bangladesh). Enhanced knowledge and experiences gained from the previous studies along with the well established tool for erosion forecasting will help to in erosion forecasting in the study rivers of the 13 polders.

Morphological characteristics of a river are mainly determined by the historical development and changes of the morphological parameters like change in width and shifting of the banklines. Historical development of the rivers will be established using time series of satellite images while changes of the morphological characteristics over time will also be analyzed based on time series banklines delineated through the assistance of satellite images, Arc-GIS tool and Remote Sensing techniques. The methodology of processing and analyzing data is described in the following paragraphs and the different steps to conduct the study is given in Figure 4.9.

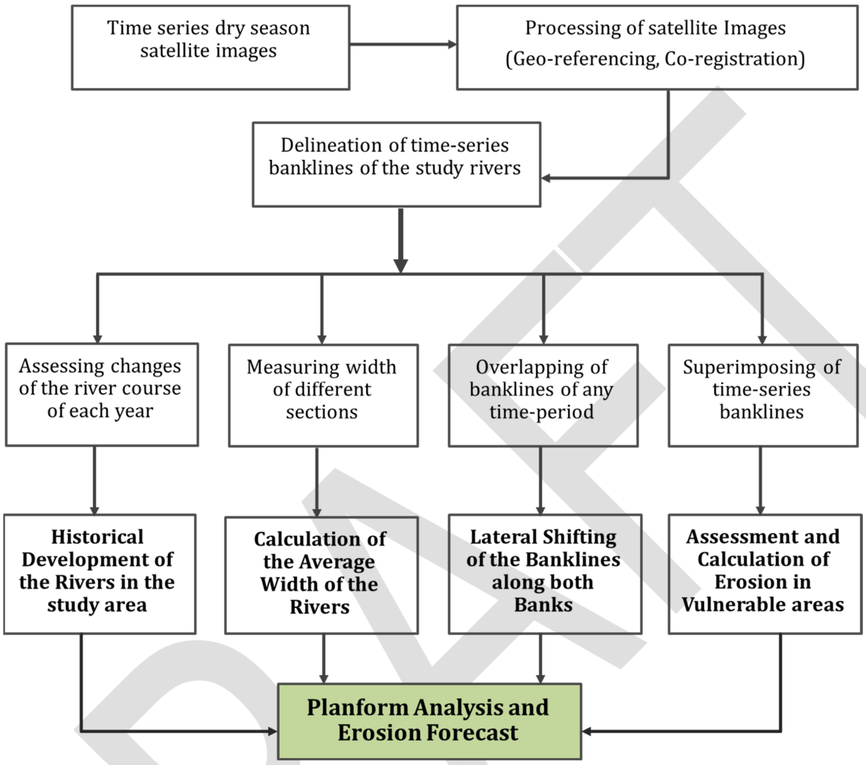

Figure 4.9: Flowchart showing the methodology of the morphological study

Processing of dry season satellite images

Satellite images are available in the CEGIS archives. Time-series satellite images since 1973 covering the study area will be collected. Afterwards, dry season satellite images will be geo-referenced into same projection system. Geo-referencing is the process performed on raw (i.e. layer stacked products) images to refer each pixel in the image to a real-world coordinate system. This enables the satellite image data to be viewed and analyzed along with other GIS data layers. After that, images will be co-registered to eliminate the offset distance within the images of different years.

Delineation of banklines

The bankline is defined as the line that separates the floodplain from the river. After processing of satellite images, banklines of each year will be delineated. These banklines will be used to assess historical development, change in width, the shifting of the channel as well as to analyze the riverbank erosion over time.

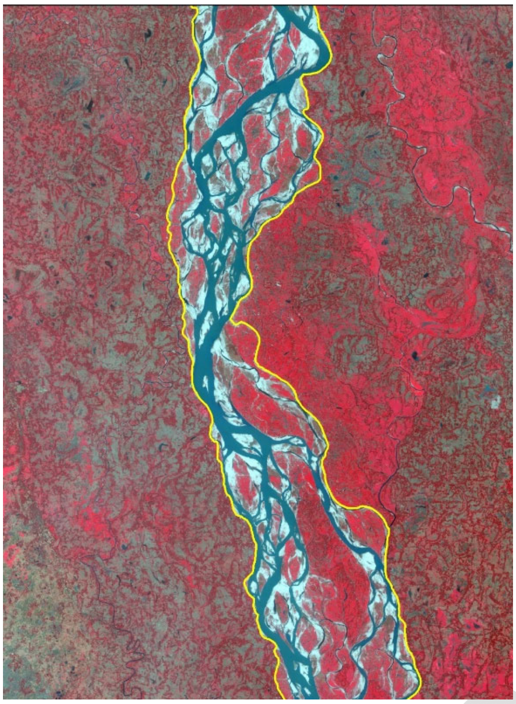

Figure 4.10: Examplery delineation of bankline using satellite images

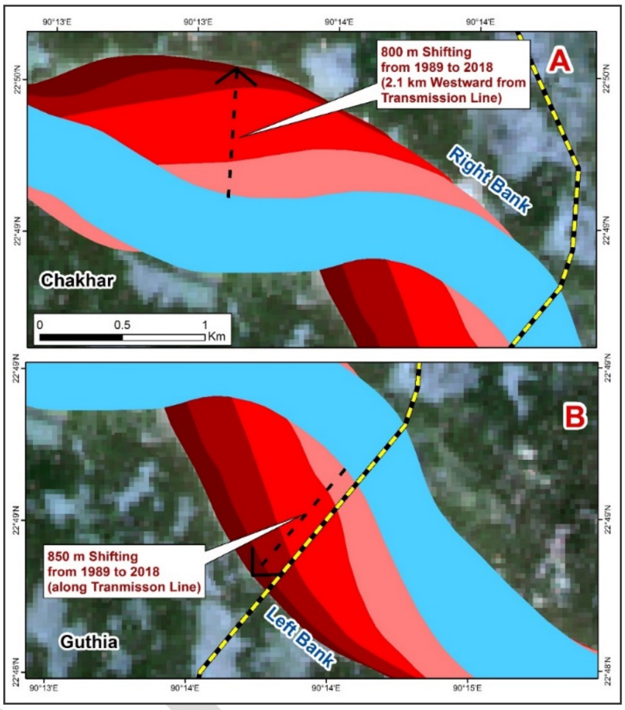

Figure 4.11: Examplery Lateral Shifting of the bank lines through bank line analysis

Planform analysis

For the assessment of the historical development of the rivers in the study area, time-series satellite images and bank lines of the study rivers in the 13 polders in different years will be overlapped with each other to assess the change of the course over time if any. This will help to assess the development of planform over time.

Furthermore, the width is defined as the distance between two banks in any section of a river. For the assessment of the average width of the river, it is essential to know the river corridor. Bankline of the river will provide that information. The width will be measured at different sections of the study rivers using the Arc-GIS tool for bank lines of different year which will be then averaged to calculate the average width over time. Comparison of average width of different years will provide the change in width over time.

Additionally, for the assessment of the lateral shifting of the rivers, banklines of different years will be delineated. After that, banklines will be overlapped with each other to assess the lateral shifting of the banklines over time. This analysis will be based on long-term and short term analysis depending on the changes of the migration of the channel within the study area.

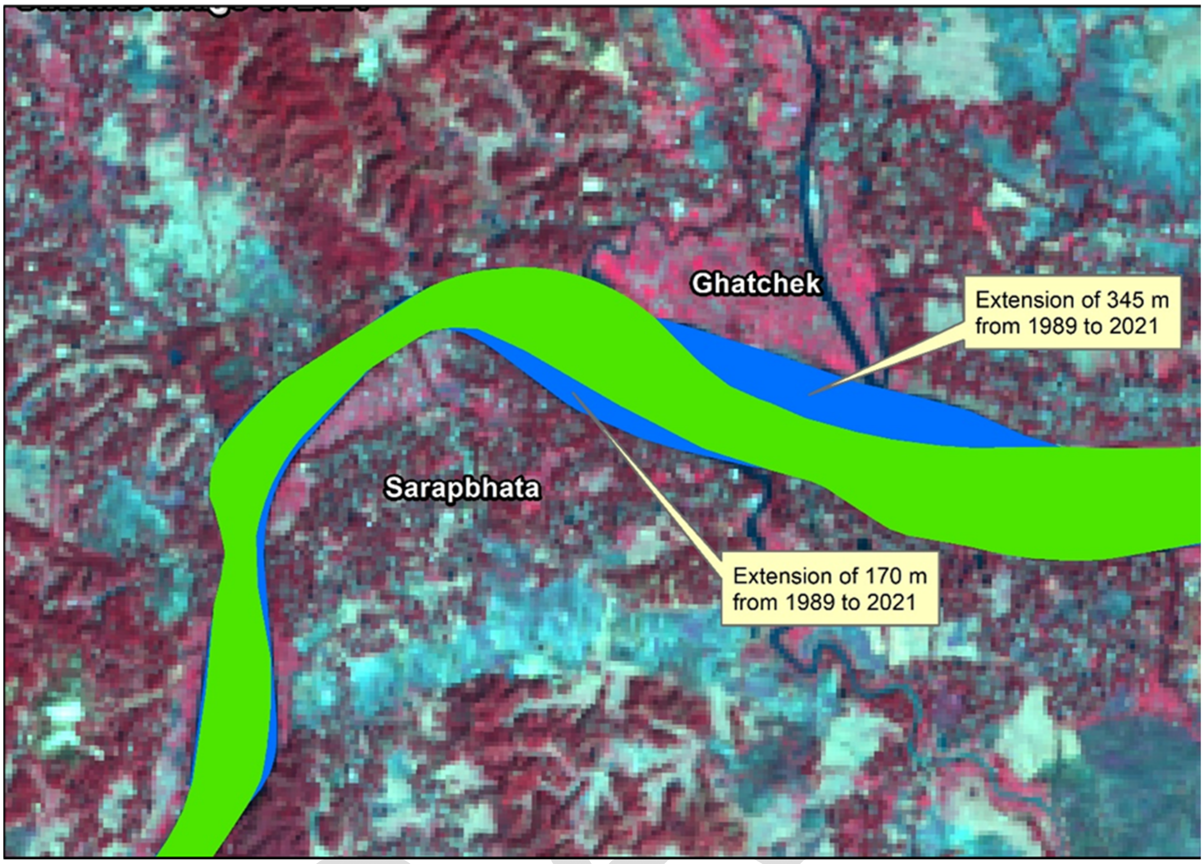

Figure 4.12: Examplery Planform Analysis Showing Bank Migration

<u>Assessment of the erosion-accretion and forecasting in future</u>

Assessment of the erosion-accretion pattern is the key feature for the proper planning, design and management of any river. In this study, it will be done using the time series banklines of the rivers in the selected 13 polders. Firstly, banklines will be superimposed with each other to identify the erosion vulnerable locations. After that, erosion and migration pattern of each bend will be assessed and then lateral erosion will be calculated of that particular portion/reach of the river over time using Arc-GIS tool and Remote Sensing Techniques. This will help to know the rate of erosion of a particular location of the rivers. Similarly, accretion will be calculated which will give insight about the deposited areas.

Finally, future development of the rivers will be forecasted in the study area for the next 15-20 years based on the planform development, shifting of the river course and erosion pattern in terms of the shifting of the particular bend.

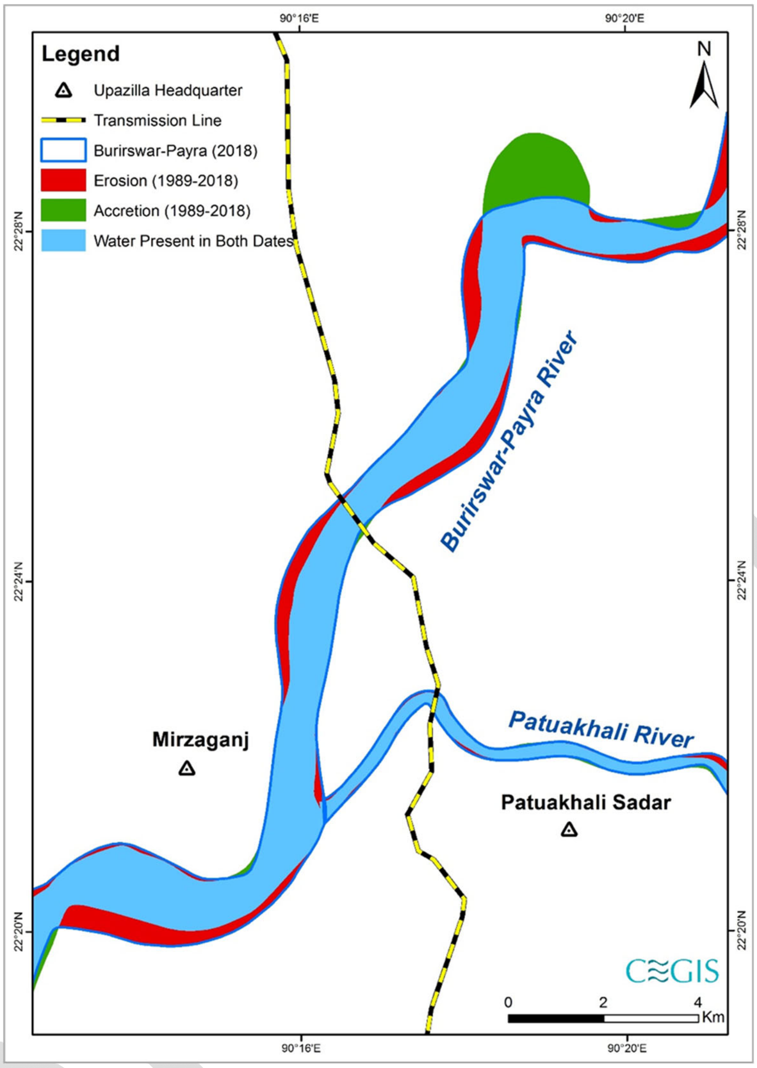

Figure 4.13: Exmplery Identification of erosion along both banks of the river

<u>Inputs from Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (LTM)</u>

The LTM project is focusing in development and application of many types of mathematical models for predicting the long-term processes (evolution) of the conditions in the Bengal Delta.

The macro models for the rivers Sibsa, Pussur, Baleswar, Bishkhali are 2D models including hydrodynamics, sediment transport, morphology, bank erosion, and as a result they give full feedback in the system. They include short-term calibration to water levels, discharges, concentrations. In principle, almost identical ”universal” bank erosion formula for all rivers considered thus far (Sibsa, Pussur, Baleswar, Bishkhali), slight variations in the parameters, which are defensible (Pussur is more shallow, Bishkhali more sandy).

The outputs from these LTM models are crucial for CEIP-2, and will be taken into account in this activity as well as other modelling works. It is expected that the outputs of LTM can be used as direct inputs to CEIP-2, as well as to calibrate and enhance accuracy of the models developed within CEIP-2.

4.5.8 Internal water management risk of the 13 polders

Assessment of risk of internal water management inside each of the 13 selected polders will be done based on mathematical model result analyses, secondary data and literature evaluation as well as extensive field work. The current water logged due to poor drainage areas will be identified by through a combination of interviewing local people reciprocated with drainage model outputs.

The first step is to assess he adequacy of current drainage system for future climate change (i.e. storm surge, sea level rise, excessive rainfall). This will rely on data availability of in-polder drainage infrastructure. For this, catchment and sub catchment will be delineated for 13 selected polders using Digital Elevation Model (DEM). Drainage volume needs to be determined considering future climate change. The drainage volume will assist in evaluating the capacity of existing channels.

Adequacy of existing cross drainage structures (i.e. sluice gates, regulators etc.) considering future climate change will also be assessed. Based on the outcome of the assessment, future requirement of drainage hence khal excavation requirement, additional drainage regulator requirement will be assessed. Required no., size and location of drainage structures for drainage improvement considering climate change impact will also be determined. Analysis of water demand inside the 13 selected polders will be done for effective water management. The current sedimentation scenario will be assessed by interviewing local people.

4.5.9 Geographical Information System

Consultant possesses ArcGIS Enterprise software and has ArcGIS Enterprise which is capable of managing huge size central Geodatabase (GDB) and with hundreds of users connected to the GDB. This software is different from commonly used GIS software, which cannot handle preparation of large volume geodatabase. ArcGIS enterprise supports mobile geodatabase and also web GIS comprising of large volume data.

For CEIP-2 project Consultant will conduct GIS services for following activities:

1) Use of GIS to gather data necessary for morphological and river engineering studies
2) Satellite image and morphological historical time-series maps analysis for the 13 selected polders
3) Generation of erosion-accretion maps for the coastal region for the 13 selected polders
4) Preparation of detailed polder maps for the 13 selected polders
5) Preparation of detailed land use map for the 13 selected polders
6) Existing and proposed cross drainage structures map
7) Social infrastructures and afforestation map
8) Preparation of Digital Elevation Model (DEM) from field survey (topographic survey)

Detailed activities have been listed out in Table 4-7.

Table 4-7: Enisaged GIS activities

SL No	Activities	Data Sources	GIS database/GIS layers	Mapping
1	Pre-selection of polder	CEGIS archive	✓ 122 polder boundary layers ✓ Admin boundary up to Mouza level & all headquarters ✓ Detailed rivers, Roads, Social structures and other relevant GIS layers	✓ Polder Prioritization mapping ✓ Base maps for selected polders
2	Hydrological & hydraulic modelling	Modelling outputs	✓ Catchment boundary & Flow direction ✓ Inundation depth & extend ✓ Waterlogged/drainage congested Area ✓ Salinity intrusion area ✓ Modelling output for different Scenario	✓ Detailed catchment mapping ✓ Inundation & Flood extend map ✓ Waterlogged and drainage mapping ✓ Salinity mapping ✓ Modelling output mapping
3	Erosion accretion assessment and future bankline forecasting	Morphological analysis	✓ Bankline of different year ✓ Erosion Accretion Area ✓ Future bankline ✓ Proposed location for bank protection work (if any)	✓ Bankline mapping ✓ Erosion Accretion mapping ✓ Future erosion vulnerable area mapping
4	Land use	Satellite images	Detail land use class (Settlement, Road, rivers & khals, waterbodies, Agricultural land etc.)	Land use mapping
5	DEM preparation	FINNMAP, BWDB Irrigation Map and Topographic Survey	✓ Spot heights ✓ Elevation from topographic survey ✓ Digital Elevation Model (DEM) ✓ Land class (F_0, F_1, F_2)	✓ DEM Map ✓ Topographic survey map ✓ Land class map
6	Existing Intervention Map	Existing maps & GPS survey for detailed intervention	✓ Existing intervention from secondary sources (hard copy maps, documents etc.) ✓ Detailed information of existing interventions through GPS survey	Existing intervention maps
7	Social infrastructures & afforestation Map	Secondary sources and GPS survey	✓ Social infrastructures from secondary sources ✓ GPS survey for afforestation area	Afforestation area mapping
8	Proposed intervention Mapping	Study Outputs	✓ Proposed drainage structures & Embankment ✓ Proposed drainage network (Re-excavation work) ✓ Proposed Bank protection work ✓ Proposed water retention Area ✓ Other proposed interventions	✓ Proposed intervention mapping ✓ Proposed re-excavation mapping

4.6 Detailed designs

4.6.1 Introduction

As mentioned earlier, n view of the limited time of the studies, the preparation of detailed designs and bidding documents will follow the same procedure as is followed in CEIP-1 and will be elaborated upon in the next section.

As per ToR, Consultant will also look how innovations can be applied and section 4.6.3 is elaborating on possible innovations which could be applied for the next phase of CEIP. Application of these innovations will very much depend on the local circumstances and thus of the selection of the 13 polders to be included in the invest plan. Once the preparation of the detailed designs commence, application of these innovations will be considered and run in parallel to the detailed design. Where applicable, they will then directly be incorporated into the detailed designs and thus resulting in quick wins and a first step in a process of introducing design innovations in Bangladesh.

4.6.2 Preparation of detailed designs

Detailed design will be prepared for each new drainage sluice/flushing regulators/other structures and retired embankment. Detailed design will also be prepared for rehabilitation/ repair works. Detail design will be carried out following the guide lines of CEIP-1, approved design manual of BWDB and methodology describe below.

4.6.2.1 Development of typical design methodology

Design methodology is common for every water control structures. The design methodology has already been developed during preparation of detailed design of 4 Polders (32,33,35/1&35/3) of CEIP-1 which have already been approved by BWDB. That will be updated consulting with Design office of BWDB if required. The salient design criteria and design methodology are given below:

a) Hydrological Design Criteria of Drainage cum flushing sluice:

The purpose of hydraulic design is to derive the waterway opening of drainage sluice/ drainage cum flushing regulator/flushing regulator as well as to generate design discharge and corresponding water levels required for hydraulic design. Hydrologic design will be carried out on the basis of a drainage model will be developed for draining the polder area with a set of drainage sluice/drainage cum flushing regulator that may work together in cluster in climatic change conditions.

For obtaining the waterway opening of drainage sluice considering a design storm of 5–day duration of 10year return period expected over the catchment area will be considered. The drainage performance of regulator will be evaluated considering that the design storm shall not cause submergence of more than 5% of the incremental area in addition to the area that cannot be drained by gravity to a depth not more than 0.30 m for a period of 3 days. The flood inundation area of the polder for different land classification (Flood Free, F0, F1, F2, F3) will be derived based on model result. Said 3 days will have to be discussed with the BWDB in view of recent water logging in Polder 35/1 where intense pluvial flooding challenged the design requirements set forward at the start of CEIP-1.

b) Hydraulic Design Criteria of Drainage Sluice:

The purpose of hydraulic design is to provide necessary measures which will ensure safety of structures against failure caused by excessive velocity, seepage, uplift and scour. The following measures would be taken to counter the hydraulic failure phenomenon:

Stilling basin: A stilling basin which allows dissipation of excess energy of flow by formation of hydraulic jump within the basin and release non-eroding velocity to the earthen channel will be provided.

Cut-off wall: Cut-off wall of adequate depth will be provided to protect the end of floor from collapsing due to scour hole and by retaining earth behind the same.

Adequate Floor length and Cut-off wall: Adequate floor length and cut-off wall depth which reduce the seepage pressure and allows a safe exit gradient will be provided.

Adequate floor thickness for weight of structure: Adequate floor thickness will be provided so that weight of structure helps to remain in position by counter balancing uplift pressure.

Protection Works: Apart from scour cut-off wall, protection in the form of inverted filter and loose apron with C.C. blocks will be provided at the end of RCC floor.

The following criteria will be followed for the hydraulic design:

c) Energy Dissipation for drainage sluice/flushing regulator:

The excess energy of flow through hydraulic structure may be dissipated through the formation of a hydraulic jump within a designed stilling basin. The design elements of stilling basin are as follows:

- Width of stilling basin;
- Floor level of stilling basin;
- Length of stilling basin and;
- Dimension and details of stilling basin appurtenances such as chute block, baffle block and end sill.

The design parameters will be based on generalized stilling basin design approach which is developed by USBR. The type of stilling basin may be determined as follows based on the range of Froude Numbers of incoming flows to the basin.

- Froude Number between 2.5 and 4.5 : USBR Type-IV, generally called ERC type stilling basin.
- Froude Number between 2.0 and 4.5 : Indian Standard Stilling basin, Type-1.
- Froude Number less than 2.5 : USBR Type- 1.
- Froude Number greater than 4.5 : USBR Type –II stilling basin

Seepage or Piping:

The Khosla's theory of exit gradient is used for determination of measures to prevent piping underneath the structures. Safety against piping can be ensured by providing sufficient floor length and reasonably deep vertical cut-off walls at the ends of the floor of the structure. These can be obtained by keeping the exit gradient (as per Khosla's theory) well below the critical values. Values of safe exit gradient for fine sand may be considered as 1/6 to 1/7.

d) Uplift pressure under the floor of sluice/flushing regulator:

Excessive hydrostatic head difference across a structure causes seepage of water through the underlying sub-soil. The seepage water causes uplift pressure underneath the structure. The net residual uplift pressure may uplift part or hole of a structure if sufficient counterbalance weight is not provided. A factor of safety of 1.10 against uplift may be used. The uplift pressure may be determined by Khosla's theory. Khosla has given a simple, quick and accurate approach, called the Method of Independent Variables to compute uplift pressures under a hydraulic structure.

e) Protection works in both side of sluice/ flushing regulator:

Cut-off walls at either end of a rigid apron will be provided to protect the structure against failure by scour in the channel. In addition, the protection works are required at u/s as well as d/s of rigid apron in order to repel the possibility of a scour hole from travelling close to the apron and to relieve any residual uplift pressure through the filter. The respective protection arrangement consists of (a) loose flexible apron (consisting of inverted filter) and(b) launching apron.

The design of protection works depends on scour depth. The regime scour depth (R) with respect to unit discharge (per metre width) and silt factor is computed by Lacey's formula.

The following minimum cut-off wall depth shall be provided at u/s and d/s ends of structures in consideration of regime scour depth D:

U/S cut-off wall depth: $D_{u/s}$ = 1.25 R – water depth
D/S cut-off wall depth: $D_{d/s}$ = 1.50 R – water depth

Where

R = regime scour depth [m]
D = design depth of scour [m]

Adjacent to the rigid apron, protection works in the form of loose flexible apron, is provided by concrete or brick blocks apron or stone riprap over inverted filter. The design requirements of protection works are as follows:

The length of loose flexible apron shall be as follows:

Upstream : 1.25 $D_{u/s}$
Downstream : 1.50 $D_{d/s}$

Beyond the loose flexible apron, launching apron consisting of either assorted CC blocks or stone/bolder shall be provided with following lengths:

Upstream Apron : 1.50 $D_{u/s}$
Downstream Apron : 2.00 $D_{d/s}$.

f) Design of Drainage Channel:

The main function of drainage channel system is to drain out the excess rainfall-runoff from agricultural land to avoid inundation and for satisfactory growth of crops. A 5-day storm of 1 in 10 years frequency rainfall will be considered for design of drainage system. The hydraulic design computation with respect to design section of drainage channel shall be carried out using the Manning's equation based on design discharge, longitudinal bed slope, side slope and Manning's roughness coefficient.

g) Design Criteria for Embankment Crest Level:

The 25-year storm surge level with climate change assumption will be the basis of obtaining design crest level of embankment. However, the following heights are added to 25-year surge level to obtain the minimum design level.

- Freeboard necessary to limit the wave overtopping to the embankment. The wave overtopping will be computed from the 25-year return period incident wave height and period. This is a function of river side slope and roughness element.
- An additional margin to allow for any uncertainty in the statistical curve fit in obtaining the 25-year surge levels. (Computed standard deviation will be used).
- A margin of 30 cm will be added to crest level to allow for subsidence.

g) Design criteria for river bank and embankment slope protection works:

- The above water revetment consists of cover layer material, bedding layer and filter layer;
- The above water cover layer materials will be cement concrete block;
- The underwater materials may be cement concrete block and sand filled geo-bag;
- The above water filter layer consists of geotextile, khoa and sand. The underwater filter may be laid by sinking of fascine mattress consists of geo textile and bamboo;
- A khoa bedding layer in between cover layer and geotextile shall be provided to prevent damages of geotextile during placement of blocks, to prevent flapping of geotextile which may cause loss of base material and also to prevent damage by ultra-violet ray of sun;
- Size of cover layer material shall be determined considering stability against design flow velocity using widely used Pilarczyk and other formula;
- Size of cover layer material shall be determined considering stability against design wave height using widely used Pilarczyk and Hudson formula;
- Thickness of riprap material shall be at least two times the size of armour material;
- The size of launching apron as toe protection measures, shall be determined using the recommendation of T.S.N. Rao and in consideration to design depth of scour;
- The scour depth will be computed by both Lacey's formula and Ahmed's formula; and
- It is considered that the placed apron will be launched at 1:2 slope.

4.6.2.2 Detailed design of preferred alternatives including technical specifications

Some 7 polders of package-3 of ongoing CEIP-1 will be a part of following phase (CEIP-2). The detailed design of all the infrastructures under this Package-3 was completed by the Consultant of CEIP-1 and those were approved by the competent authority of BWDB and technical specifications of it were also prepared accordingly during conducting the Feasibility studies and detailed design of CEIP-1. Under this study, Consultant will prepare the detailed design and specifications of all the infrastructures of the polders which will be selected for improvement under the following phase of CEIP-1 i.e. the CEIP-2. During review and update of detailed design, those prepared for the polders of Package-3 will also be reviewed. During review detail design of the infrastructures of package-3 of CEIP-1 and preparation of the detailed design of the structures of the polders of the CEIP-2, BWDB's latest technical specifications will be included in the drawings and the Consultant will explore the possibilities to identify any alternatives further can be adopted for betterment of the project other than it is existing now.

4.6.2.3 Preparation of Engineering Drawings for new construction works

All drawings including the drawings of new construction works will be prepared by Auto-CAD. The working drawing sets will compose the following features:

Embankment:

- Project map/Polder map showing alignment of embankment;
- Longitudinal profile of base of embankment showing existing ground profile and design crest profile;
- Design cross section of embankment;
- General notes and specifications.

Drainage channel:

- Project map/Polder map showing alignment of drainage channel;
- Longitudinal profile of drainage channel showing existing bed profile and design bed profile;
- Existing and design cross section of drainage channel;General notes and specifications;

Structures:

- Project map /Polder map;
- Site plan;
- Bore logs;
- Plan, profile and sections of structure;
- Concrete outline of structure;
- Details of reinforcement;
- Details of foundation treatment, if required;
- General notes and specifications;

Preparation of Engineering Drawings showing Rehabilitation works:

All drawings of repair/rehabilitation works will be prepared by Auto-CAD. The working drawing sets for all rehabilitation works of existing damaged structures (partial) will compose the following features:

Embankment:

- Project map/Polder map showing alignment of embankment and position of structures;

- Longitudinal profile of embankment showing existing ground profile (top and base) and design crest profile;
- Existing and design cross section of embankment;
- General notes and specifications.

Structures:

- Project map/Polder map showing alignment of embankment and position of structures;
- Site plan;
- Plan of existing structure with marked damaged area on the drawing;
- Profile and original Design sections of structure combine with present situation;
- Repair/rehabilitation works with dimensions;
- Details of reinforcement if added/used;
- Details of foundation treatment, if required;
- General notes and specifications.

4.6.3 Innovations in design

4.6.3.1 Introduction

Consultant considers innovations in the Bangladesh design practice of polder rehabilitation on three levels. Applying these innovations can lead to considerations to change the design criteria for embankments and sluices in the polder system. Innovations can be applied in various ways and to distinguish them, Consultant has identified three levels of innovations as follows:

4.6.3.2 Level 1: Innovation on the level of methodology introducing probabilistic techniques

Risked based design approach: probabilistic techniques to look at failure of the entire system, i.e. total acceptable probability of flooding. On a functional level this determines the design criteria for the embankments and structures in terms of tolerable probability of failure factors for geotechnical stability and other failure mechanisms as piping, erosion. This risk based design approach is based on Dutch high water protection programme[93]. The methodology is explained in Appendix 12. Another consideration can be to apply different protection levels for different areas or leave certain areas unprotected and give more room for rivers.

Within the scope of this Feasibility Study, the above approach may be a step to far in the Bangladesh context, but will be explored during the course of the Study if and when sufficient data become available.

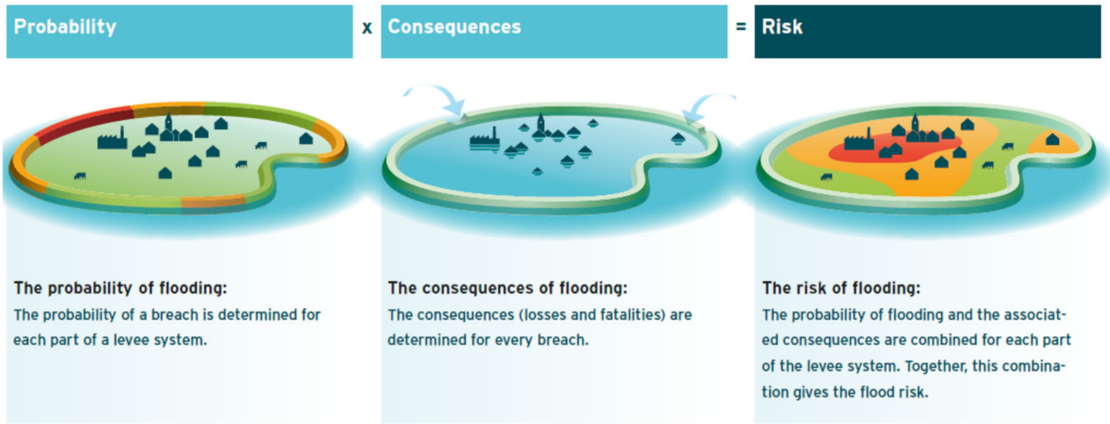

Figure 4.14: Flood risk visualized
(source: report The National Flood Risk Analysis for the Netherlands)

4.6.3.3 Level 2: Innovations on the level of conceptual design

Combining various functions of are here defined as innovations on conceptual design level and some examples are shown in the following:

- Multipurpose/ multifunctional designs of embankments/ coastal protections.
    - Road combined with embankment. The road can be positioned on a lower level at a berm at the inland side of the polder. This a flexible concept which allows us to easily heighten up the structure in future (see Figure 4.15).

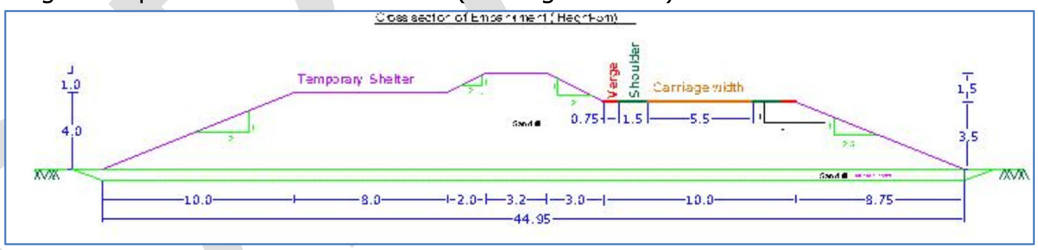

Figure 4.15: Example of road at landside and temporary shelter at riverside

    - Creating areas for temporary shelter.
    - Beach building for recreational purposes, which forms protection of the embankment. Example groynes in combination with sand suppletion and beach nourishing to restore the transport along the coast. Some examples of the Netherlands are shown in Figure 4.16 and Figure 4.17.

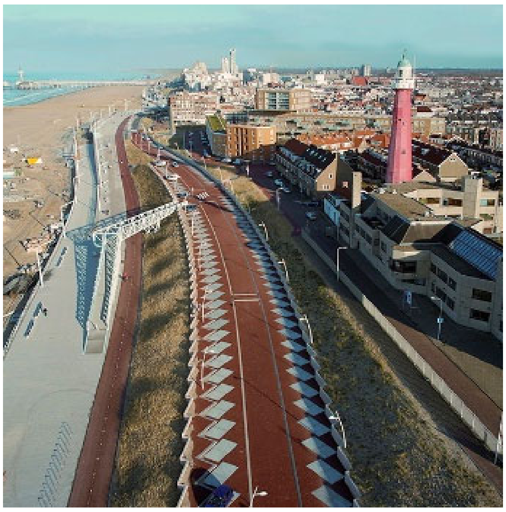

Figure 4.16: Integrated solutions coping with coastal erosion in The Netherlands

Figure 4.17: Nature based sand engine in The Netherlands

- Combining polders by making retaining sluices in the rivers. It is expected that this only effective when crossing river is not too wide. Quantify: up to several 100 m.
- New concepts of building in which relation between investment and operation and maintenance is considered. When damage to structures and levees to a certain level is accepted and is not leading to collapse or failure, you must consider a proper maintenance plan and budget. The extra maintenance budget is profitable when the investment in the structural elements can be minimized. E.g., leaving out hard cc blocks as revetment and construct a more robust structure with gentle slopes and plantation. Another possibility is to count on natural processes (e.g., sedimentation) with the knowledge of these processes can be used to optimized. This can be interesting from ecological and sustainable point of view (building with nature!). Counting on natural processes give a little bit more uncertainty which can be caught up with a proper operation and maintenance plan. This requires sound governance and management and another division of the available budget. This means less investment, probably more maintenance/ adaption. Another point which must be considered that these kind of solutions (allowing damage and building with nature) generally take more space, so in this respect also social and environmental effects must be considered.

Analytical work recently done under a Technical Assistance Programme of the World Bank on concept solutions for combatting coastal erosion in Bangladesh may provide a good starting point in a transformation process of introducing innovations in Bangladesh. of to considered under the current Feasibility Studies. In this respect also reference is made to a recent visit[15] to the Netherlands, where Government Officials from various Ministries visited innovative projects from a perspective how to adapt these to the specific Bangladesh physical, cultural and institutional setting.

Above Level 2 innovations can be considered when the 13 polders have been selected.

[15] BANGLADESH, COASTAL RESILIENCE AND DELTA PLAN KNOWLEDGE EXCHANGE TO THE NETHERLANDS, SEPTEMBER 27, 2019 TO OCTOBER 6, 2019

4.6.3.4 Level 3: Technical innovations in design of embankments and associated interventions

Level 3 innovations are of a smaller scale and can most likely be implemented relatively easy during the course of the studies and will be further elaborated when the 13 polders are known. Some Level 3 innovations which could be very useful are listed hereunder.

Application of geosynthetics in a proper manner in coastal areas

While sand-filled geotextile bags (geobags) are well established for riverbank protection, ranging from low-cost, sustainable revetments consisting solely of geobags for the protection of agricultural land, to their application as filter layer under riprap in the critical part of the river training works of Padma Multipurpose Bridge Project. In coastal areas there are several issues:

- Use above water level: geotextile bags above water level are prone to UV degradation, faster oxidization (if PP is used), and vandalism. These problems have been addressed successfully in other places in the world, for example Australia. A suitable means is to provide a 'vandal protection layer', basically a two layer geotextile, the inner part of which fulfils the criteria of filtration and retention, while the outer part is designed to store additional sand, thereby protecting the outer layer against UV and vandalism. While these geotextiles are more expensive, they still have potential to remain more cost effective than the commonly used concrete blocks, the more so as the typically low specified strength results in fast degradation and compromises the lifetime of the blocks.
- Retention of silt: Typically non-woven geotextile filter cloth is specified as it provides a three-dimensional filter layer. This layer is also applicable against silty soils or able to retain silty fill material. The retention depends on the thickness, and can be addressed by specifying thicker material than the typically 400 g/m² used for smaller geobags (up to 250 kg) in rivers.
- Size of geobags: The BWDB typically specifies 250 kg geobags as standard size for flow velocities up to 3.5 m/s. latest geotextile research indicates that well filled bags of smaller and more manageable dimensions are equally stable, than the somewhat oversized and consequently underfilled 250 kg geobags. This provides room for improvements in two ways: first reduce the dimensions of the 250 kg bags, to arrive at well filled bags, and second reduce the overall size of the bags to the more manageable dimensions of for example 125 kg, which can be carried by two persons instead of four.

As recently as 2018, the BWDB has implemented wave protection layers on river embankments made of grout-filled jute mattresses. The mattresses are produced from local jute material and filled with grout, providing a porous and interconnected wave protection layer on embankment slopes. Their advantage is the overall thinner and therefore more cost-effective protection, as well as fast implementation within few months, as opposed to typically two years for concrete blocks. While river embankments do not have a high wave load, the grout-filled jute mattresses could be adjusted to the more aggressive wave climate along the coast. This involves not only the thickness of the mattress, but also the filtration under the mattress, which needs to be stable over long periods of time.

Joint probabilities of events like storm surge and tides

The design of an embankment and more specifically the crest level is currently obtained by adding the design parameters storm surge, inundation, water level, wave run-up and sea level rise. Such a deterministic approach can lead to conservative designs and a probabilsitic approach where joint probabilities of events like storm surge and tides are considered (see Figure 4.18), could lead to more optimised designs. Section A12.2 elaborates on this.

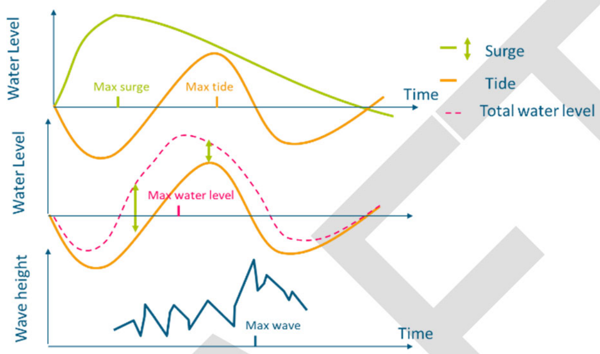

Figure 4.18: Joint probability of storm surge and tides

In this respect, Consultant will also critically review the hydraulic boundary conditions of the CEIP-1 design. An important question here is, if the 18 storms and cyclones considered in the modelling for CEIP-1 is sufficient to characterise the complex geometry of the Bangladesh coast. The actual tide was used running these 18 historic storms whereby 18 additional runs were made with the tide mirrored. So also here the question is whether this sufficiently captures combined probabilistic of storm surges and tides. As said, Consultant will review these aspects and see if design optimisations can be made, however, Consultant will not set-up a complete additional modelling campaign.

Other technical innovations to be considered

- Gentle slopes and plantation like mangroves and use of vetiver grass. The latter has been applied in the Flood and Riverbank Erosion Risk Management Investment Program (FREMIP)[16].
- Differentiation in dimensions of revetment, in relation to different loads at different vertical levels. Higher blocks/ lower blocks. In coastal area this new, as normally only one size of a cc-block layer is applied.
- Continuous surface of structures, no transitions in different type of structures, which causes a different roughness and introduces possible risk of local erosion. These risk spots which has to be protected with rather heavy stone.
- Transition protected area – non protected area.

[16] Flood and Riverbank Erosion Risk Management Investment Program, Bangladesh Water Development Board and Asian Development Bank, 2016

- Taking into account features for people in the design like stairs and recreational areas.
- Civil 3D application for integrated design of interventions.

Mangroves as part of an integrated coastal protection system

The currently applied protection systems in Bangladesh are mainly using hard materials like rock and CC-blocks. Recent research by the World Bank has shown that integration of hard structures and mangroves can enhance coastal resilience and address introduction of nature based solutions in Bangladesh. Said research showed that mangrove can attenuate waves and trap sediment, and they could consequently decrease the loads acting on the embankments, reducing their cost, and provide coastal protection.

Mangroves cannot grow everywhere since they only thrive under specific conditions. Knowledge of the favourable conditions for growing and restoring mangroves is therefore very important. Suitable conditions for mangrove afforestation are coastal mudflats at or above the average highwater mark that are not exposed to high flow velocities or waves. These types of environments can be created by means of dams, among others.

If and when the natural conditions of the selected polders allow for implementation of mangroves as part of an integrated protection system, Consultant will explore this and discuss this with the Chief Engineer Design. It is noted that this could potentially be a "quick win".

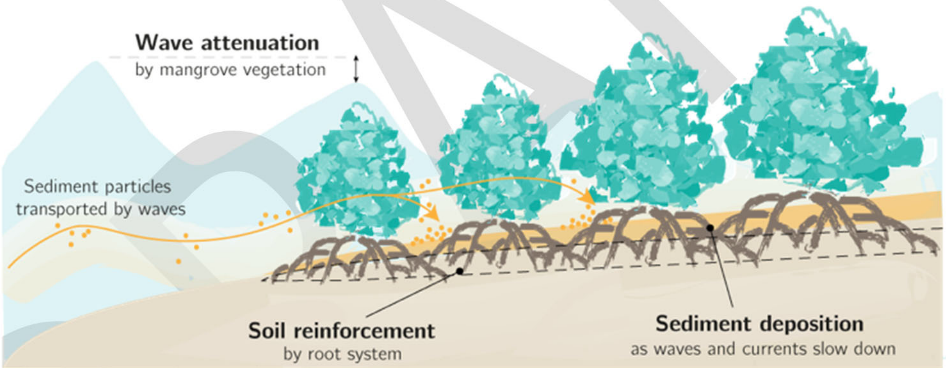

Figure 4.19: Coastal protection functions provided by mangrove vegetation

Optimisation of selection of locations for bank protection works in a morpho-dynamic environment

Bank protection works safeguarding embankments against the threats of erosion are very expensive and thus an important element where cost savings can be achieved. Apart from optimizing the design of these works it would also be innovative to plan these works within the context of the high morpho-dynamic character of the coastal zone of Bangladesh. Under CEIP-1, the locations and extend of these bank protection works have been identified well ahead of actual implementation of these works. A typical period between planning, and approval, and implementation is some 3 to 4 years, which is, in view of the morpho-dynamic time scale relatively long. Analytical work conducted under a World Bank funded Technical Assistance also shows that future erosion trends are, with the current state of art of mathematical models, difficult to predict.

Apart from said challenges in the prediction of erosion, cyclones can also significantly change the morpho-dynamic setting and thus the need for bank protection works. The following illustrates the impact of cyclone Amphan in May 2020 on the morpho-dynamics system near Polder 32.

The current erosion, not a treat before May 2020, is at location 43.00 at Polder 32 and is mainly caused by a change in hydraulic conditions due to the breach of a land strip some 300 m upstream caused by cyclone Amphan in May 2020 (see Figure 4.20 and Figure 4.21). Due to this breach, the flow pattern changed and the currents and waves at this location km 43.00 have significantly increased the eroding. The fact that cyclone Amphan caused this, is also reason why this location was initially not included in the proposed bank protection works. It is recommended to make a proper assessment of this impact of cyclone Amphan and not only limited to location km 43.00.

Figure 4.20: Erosion of land strip upstream of location km 43.0

Figure 4.21: Area impacted by cyclone Amphan in May 2020

In view of the above Consultant will identify those areas where urgent implementation of bank protection works are needed and allocate budget provisions and typical designs for implementation of bank protection works for those locations where the need for these works come up in, say next 5 years. In this respect also re-alignment of embankments could be considered which could turn out to be a more cost effective solution.

4.6.4 Taking Operations and Maintenance into the design process

O&M needs to be carefully balanced with design and construction. It requires debate between those responsible for design and construction and those that play a role in the use, operation and management of a project. This debate, which involves different stakeholder groups, will often be about the allocation of costs, since designs bringing less lifecycle costs may be more costly to construct. It is also a debate between a fixed design with well-defined objectives and reasonably certain behaviour and benefits, and a more flexible design which may bring larger, but also less certain benefits.

The past and present O&M model, including the main actors, decision making procedure and funding has, to a certain extent, been already assessed by the Consultant, within the CEIP-1 project as well as in recently conducted World Bank funded Technical Assistance Programme with specific focus on the existing structure and provision of suggestion on improvement of the existing monitoring system in relation to routine, periodic and emergency maintenance.

To become more specific, operation of the structures is the efforts to manage and distribute the water resources of the management scheme, in order to fulfill respective functions of the structures. Maintenance of the structures is the efforts to secure the conservation of the function of structures in good conditions, including rehabilitation works that recover the structure condition to the required condition in the water resources management scheme. The maintenance works of BWDB are classified into three categories; preventive/routine, corrective/periodic and emergency maintenance. The existing structure of O&M activities on the field are given below:

- The O&M division office is conducting the periodical O&M activities. The sub divisional engineers and the sectional officer conduct the patrol/inspection periodically, mostly once a month, and report to the executive engineer of the O&M division office;
- The executive engineer judges the necessity of the maintenance works considering the condition of the infrastructures and the required budget for maintenance works;
- According to the information from the office of Director of O&M, the works more than BDT 10 Crore are recognized as the rehabilitation works in the development budget;
- In some cases, small scale and small budget maintenance works are implemented by the water management organizations (WMO). Coordination with the WMOs is required;
- Technical aspect of the maintenance works are assisted by the office of the Design Circle in charge of respective O&M division offices and the mechanical O&M division office in the Zone;
- Location of the hydraulic structures in the jurisdictional area was known by the executive engineer, sub-divisional engineers and the sectional officers in the O&M division office. However, there is no location map of the all managed structures, except the location maps of the structures for the completed projects. In addition, there are few ledgers of the managed structures in the offices;
- Survey of the maintenance works is done by the staff in the O&M division office. On the other hand, soil mechanics investigation is done by the Ground Water Circle of BWDB/sub-soil test contractor. Hydrological observation in the jurisdictional area is done by the Hydrology Department of BWDB.

Consultant will further review the past/present O&M model and will propose effective institutional and technical arrangements in the design such as required manpower, frequency and parameters of surveys needed for monitoring, manpower designated for operation of sluices and embankments (the latter is also related to the existing WMOs which should be further enhanced). Here also use will be made of the findings and recommendations on water management of the Dutch funded Blue Gold Programme[17] will be taken into account.

[17] Blue Gold Programme, Polder Development Plan, Bangladesh Water Development Board and Dutch Government, 2016

O&M activities in Bangladesh leave room for improvement in terms of monitoring and prioritization of maintenance investments. More systematic activities, performed in a timely manner are often limited due to budgetary constraints. It should be noted that currently, only some 25%-30% of the total budget allocated for O&M can be actually used for that purpose. This insufficient funding for operations and maintenance constitutes a major concern and has complex social, institutional and financial dimensions, and is often site-specific. Poor operations and maintenance have led to damaged hydraulic structures, poor condition of the embankments and silting up of drainage canals[18].

The lack of funding for operation and maintenance lead to the common approach of application of temporary and emergency protection works in the locations where a failure/breach is identified. The impact of the super-cyclone Amphan to Polder 35/1 is a recent example of application of such emergency protection works in locations were the impacts of erosion were significant and the stability of the previously implemented emergency work has failed. The cost of emergency protection works is in the order of 200,000 USD/km annually. Reduced required O&M funds making the allocation of required funding more feasible. The latter could be achieved through incorporation of such costs in the DPP.

- To allow for proper prioritization and allocation of O&M funds, sufficient manpower is needed to perform monitoring in the field. That would facilitate the prioritization process via classification of vulnerable locations in a basis of an urgency timescale;
- New initiatives are being developed and should be encouraged taken forward;
- Central storage of data is recommended where assets, condition levels and land use are brought together; currently there are GIS based systems, however, not properly linked;
- It is recommended to have a monitoring approach which is based on a Risk Based Program as e.g. in the Netherlands; this would also nicely fit into BDP 2100 strategies;
- Definition of thresholds over which there is need for interference would go in hand with
- the aforementioned systematic monitoring system;
- Application of a Early Erosion Warning System (EEWS), will allow interfering in a cheaper manner by anticipating eventual changes and identifying the vulnerable stretches in advance. In other words, the O&M costs will be reduced significantly by monitoring the integrity of the embankment. Additionally, the large costs resulting from the application of the non-sustainable emergency and temporary works will be avoided.

4.7 Preparation of bidding documents

Preparation of cost estimates

After completion of detail design of drainage sluices/flushing regulators, embankments, drainage canals, bank protection works, repair/renovation of existing structures and approval of drawings of those by the competent authority, Consultant will calculate the quantities of each new and rehabilitation works separately first. If any item of work is required for any specific work due to site condition, quantity of that item will also be calculated and will be added.

BWDB has circle wise separate approved rate schedule (Market Price) in this project area but those rates of the schedule are not suitable for invitation of international tender. There, before preparation of cost estimate, Consultant will have to prepare a rate schedule of special rates as

[18] Water Management Bhola Island, ORIO Development Phase, Royal HaskoningDHV and partners, 2014

that of CEIP-1. Consultant, has prepared a special rate schedule but the rates of it is not matched with the present market rates/price. Consultant will review the special rate (analysis rate) schedule and including present market rates and new items if required, an updated schedule of rate will be prepared. Using the updated rate and quantity calculated Consultant will prepare estimates for each work and a combined estimate combining some individual estimates with a combined Bill of Quantities (BOQ) for each proposed package.

The prepared estimated cost will be used for financial analysis of the study of CEIP-2 and preparation of Tender documents. Before start the tendering process, the estimates will be approved by competent authority following the Delegation of Financial Power (DoFP) of BWDB. Consultant will have to find out the quantities of each construction materials and type and nos./quantities of plants, equipment, vehicle etc. for each package.

Preparation of Bill of Quantities (BoQ)

Consultant will prepare combined BoQ for each package by combining the quantities of individual BoQ of the estimates of each work under every package. This combined BoQ will be used to prepare the bidding documents of each package.

Preparation of bidding documents

After preparation of BoQ for each package, Consultant will prepare both for Prequalification and bidding document for international Competitive Bidding (ICB). ICB bidding documents has already been prepared for package-1, 2 and 3 under CEIP-1 following the guidelines of World Bank. Consultant will review those bidding documents before preparation of bid document for the subsequent packages of CEIP-2. If any modification or needs anything to add, Consultant will do that before use those to prepare bid document for packages of CEIP-2. On completion of preparation of detailed design/drawings, BOQ, finalized technical specifications, Consultant will finalize the bidding documents and will send them to WB and BWDB through PD, CEIP for approval.

For the process of tendering, a list of number of qualified contractors will be prepared by inviting proposal/tender by issuing prequalification documents. Prequalification document was prepared in CEIP-1 for 3 packages. Consultant will review that document and up-date/modified if necessary. The contractor who wants to be a pre-qualified contractor shall have to fulfil the requirements of the technical experience, financial capabilities, required qualified and experienced professionals, types and nos. of equipment under his/her possession which will be included in the bid document as the pre-qualification criterion. The following information will be included in the Prequalification and Standard Bidding Documents:

Information which will be included in the Prequalification Document for Procurement of Works are:

PART 1 – PREQUALIFICATION PROCEDURES

Section I. Instructions to Applicants (ITA)

This Section provides information to help the Applicants in preparing and submitting their Applications for Prequalification ("Applications"). Information is also provided on opening and evaluation of Applications. This Section I contains provisions that are to be used without modification.

Section II. Prequalification Data Sheet (PDS)
This Section includes provisions that are specific to each prequalification and supplement Section I, Instructions to Applicants.

Section III. Qualification Criteria and Requirements
This Section specifies the methods, criteria, and requirements to be used to determine how Applicants shall be prequalified and later invited to bid.

Section IV. Application Forms
This Section includes the Application Submission Form and other forms required to be submitted with the Application.

Section V. Eligible Countries
This Section contains information regarding eligible countries.

Section VI. Bank Policy – Corrupt and Fraudulent Practices
This Section provides the Applicants with the reference to the World Bank's policy in regard to corrupt and fraudulent practices applicable to the prequalification process.

PART 2 - WORKS REQUIREMENTS

Section VII. Scope of Works
This Section includes a summary description, delivery and completion schedules, and Site and other Data of the Works subject of this prequalification. The Scope of Works may also include a summary of the environmental and social (ES) requirements (including requirements relating to Sexual Exploitation and Abuse (SEA) and Sexual Harassment (SH)) which are to be satisfied by the Contractor in executing the Works.

a) The information which will be included In the Standard Bidding Documents for Procurement of Works are:

Summary Description

Invitation for Bids
Two templates for Invitation for Bids are attached for inviting Bids either after prequalification or without prequalification.

SBD for Procurement of Works
These Standard Bidding Documents (SBD) for Procurement of Works apply either when a prequalification process has taken place before bidding or when a requalification process has not taken place before bidding (provided alternative documents should be selected as applicable).

A brief description of these documents is given below.

PART 1 – BIDDING PROCEDURES

Section I: Instructions to Bidders (ITB)

This Section provides relevant information to help Bidders prepare their bids. Information is also provided on the submission, opening evaluation of bidsand on the award of Contracts. This Section I contains provisions that are to be used without modification.

Section II. Bid Data Sheet (BDS)

This Section includes provisions that are specific to each procurement and that supplement Section I, Instructions to Bidders.

Section III. Evaluation and Qualification Criteria *(alternative Section III to be used when Prequalification has taken place before bidding)* his Section specifies the criteria to determine the lowest evaluated bid and to ascertain the continued qualification of the Bidder to perform the contract.

Section III. Evaluation and Qualification Criteria *(alternative Section III to be used when Prequalification has not taken place before bidding)*

*T*his Section includes the criteria to determine the lowest evaluated bid and the qualifications of the Bidder to perform the contract.

Section IV: Bidding Forms

This Section includes the forms which are to be completed by the Bidder and submitted as part of his Bid.

Section V. Eligible Countries

This Section contains information regarding eligible countries.

Section VI. Bank Policy – Corrupt and Fraudulent Practices

This Section provides the Bidders with the reference to the Bank's policy in regard to corrupt and fraudulent practices applicable to this process.

PART 2 – WORKS REQUIREMENTS

Section VII. Works Requirements

This Section contains the Specification, the Drawings, and supplementary information that describe the Works to be procured. The Works Requirements shall also include the environmental and social (ES) requirements (including requirements relating to Sexual Exploitation and Abuse (SEA) and Sexual Harassment (SH) which are to be satisfied by the Contractor in executing the Works.

<u>PART 3 – CONDITIONS OF CONTRACT AND CONTRACT FORMS</u>

Section VIII. General Conditions (GC)

This Section refers to the "General Conditions" which form part of the Conditions of Contract for Construction (Second Edition 2017) published by the Federation Internationale Des Ingénieurs – Conseils (FIDIC).

Section IX. Particular Conditions (PC)

This Section includes particular conditions of the contract consisting of: Part A- Contract Data; Part B -Special Provisions, PART C – Bank's Policy- Corrupt and Fraudulent Practices; and PART D – Environmental and Social (ES) Reporting Metrics for Progress Reports. The contents of this Section supplement the General Conditions and shall be completed by the Employer.

Section X: Contract Forms

This Section contains the Letter of Acceptance, Contract Agreement and other relevant forms.

4.7.1 Preparation of cost estimates

The typical steps to be taken would be:

- Receive and review drawings and EMP
- Decide on appropriate format and sections for the Bill of Quantities
- Obtain feedback on BoQ prepared for previous packages of work – identify "lessons learnt" for inclusion in current and future BoQ
- Review programme allocation for preparation of BoQ and allocate appropriate resources
- Measure and draft BoQ items
- Edit and update Preamble (specifying the measurements and payment modalities) and Day works Schedules as necessary
- Check, review and finalise BoQ, and submit for BWDB approval
- Use newly drafted BoQ for Packages 3,4 and 5 plus priced BoQ from Package-1 plus feedback from construction team on Package-1 to produce a cost estimate for Packages 3,4 and 5

4.7.2 Preparation of Bill of Quantities (BoQ)

The Bill of Quantities (BoQ) and bidding documents would be prepared in accordance with the formats and standards defined in the Bank guidelines for procurement of such work. For large contract to be procured under International Competitive Bidding (ICB) procedure, the bidding documents would be prepared using World Bank Standard Bidding Documents for ICB.

4.7.3 Preparation of bidding documents

The typical steps would be:

- Receive guidance from Client on procurement strategy and will be finalised through discussion.
- Review Bidding Document produced for Package 1
- Receive and review drawings, EMP and BQ

- Obtain feedback from procurement team and construction team for Package-1 – identify "lessons learnt" for inclusion in current and future Bidding Documents
- Draft Bidding Document
- Check, review and finalise Bidding Document, including approvals from PD, BWDB

4.8 Preparation of LAP and RAP

4.8.1 Introduction

As per scope of work described in the ToR of the safeguard team, KMC will carry out the following necessary surveys to able to prepare RPFs, LAPs, RAPs and other associated documents:

- Carry out quantitative and qualitative surveys to collect primary data;
- Consult secondary information from BBS and other government sources;
- Preparation of RPF;
- Preparation of LAP;
- Preparation of RAP.

The preparation of social safeguard document and major activities to carry out surveys and are presented in *Table 4-8*:

Table 4-8: Activities for the preparation of LAP and RAP

Activities	Description	Tools & Techniques
a. Develop objectives and scope	Develop objectives and scope of social assessment and methodology	Review and analysis of existing documents
b. Beneficiaries and stakeholders mapping and analysis	Beneficiary mapping will be carried out on available secondary data supplemented with community consultation in the project area	Community consultation (*disaggregated and ethnicity*)
c. Social participation	Develop approach for social mobilization and other related issues	Focus Group Discussion with targeted population
d. Information sharing	Share information on proposed project activities to all relevant persons.	Workshop with relevant persons
e. Minimizing social risks and impacts	Identify potential social risks and impact of the proposed project	Focus Group Discussion with targeted population, and social assessment with a representable sample
f. Institutional Capacity Assessment	Conduct an institutional capacity assessment of the BWDB	Capacity assessment and identify enhancement need
g. Resettlement Policy Framework (RPF)	Develop a Resettlement Policy Framework (RPF)	Consult primary and secondary data including CEIP-1 SMRPF
h. Land Acquisition Plan (LAP)	Prepare Polder-wise Land Acquisition Plan for 13 selected polders	Prepare as per requirement of the DC office following ARIPA 2017
i. Resettlement Action Plan (RAP)	Required number of RAP will be prepared by clustering the 13 selected polders as per discussion with the PMO and World Bank	Primary data will be collected through consultation and census & IOL survey
j. Small Ethnic Community Policy Framework (SECPF)	Develop small ethnic community policy framework for identified ethnic communities in the polder	Focus Group Discussion with ethnic minorities

Activities	Description	Tools & Techniques
k. Gender analysis and disability assessment	Carry out gender analysis and assessment of persons with disabilities in the project area	Stakeholder's consultation and lessons learned from best practices
l. Preparation of Gender Based Violence (GBV) Action Plan	Assess the risk of Gender Based Violence (GBV) and Sexual Exploitation and Assault (SEA) and prepare a GBV Action Plan	Risk assessment and prepare GBV Action Plan

Detail approach and necessary participatory tools will be developed to accomplish all above-mentioned activities including a checklist for FGDs, KII's and agenda for workshops and stakeholder's consultation to obtain broader community support from the affected /impacted community.

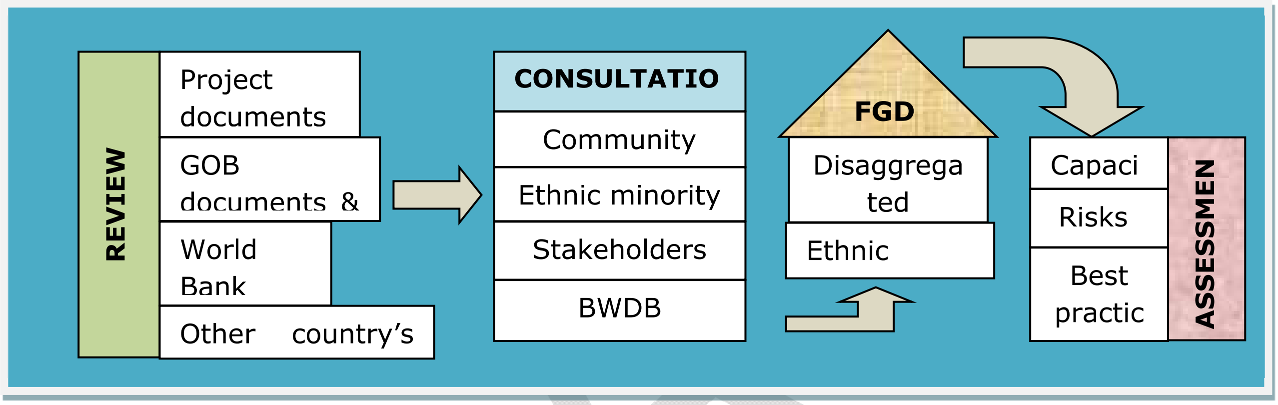

Figure 4.22: Process flow chart -Social assessment and community participation aspects

Gender Analysis and Disability Assessment:

Based on consultations with stakeholders and individual interviews during the study with various occupational groups, particularly women and persons with specially-abled, a Gender Analysis and Disability Action Plan will be prepared. Data will also be collected from secondary sources (WB guidelines and policies, GOB gender policy) and other national and international best practices. The analysis will help the development of a gender-and disability action plan for the project to provide guidance on detailed polder-wise designs and implementation methods.

Preparation of Gender Based Violence (GBV) Action Plan:

GBV and Sexual Exploitation and Assault (SEAA) affects women and girls across their lifespan and takes many forms, including sexual, physical, and psychological abuse. To minimize the risk of GBV and SEAA, and to put in place an effective response mechanism, GBV/SEAA risk assessment will be carried out during the study and a GBV action plan as a part of the Gender and Disability Action Plan will be prepared following the World Bank ESF. A separate Grievance Redress Mechanism (GRM) for dealing with sexual exploitation and abuse will be proposed in the RAP. This GRM will deal with lack of protection against (GBV/SEAA) of female workers by labourer suppliers / sardars, supervisors, and others who also deal with workers. The contractor will have independent GRM for the GBV issue among the workers.

In case of minor GBV (eve teasing, bad touching, etc.) the complaints can be resolved under the contractor's GRM but in case of major GBV (rape, acid throw, etc.) the issue will be brought to the one-stop crisis cell (OCC) or police station. The service provider will facilitate the GBV victims. In case of both minor and major GBV, the service provider will provide support to the victim to get justice (compensation, treatment, legal support, etc.) as per laws. The PMO will assign a grievance focal person (female) at PMO level with whom the victim can communicate for further advice.

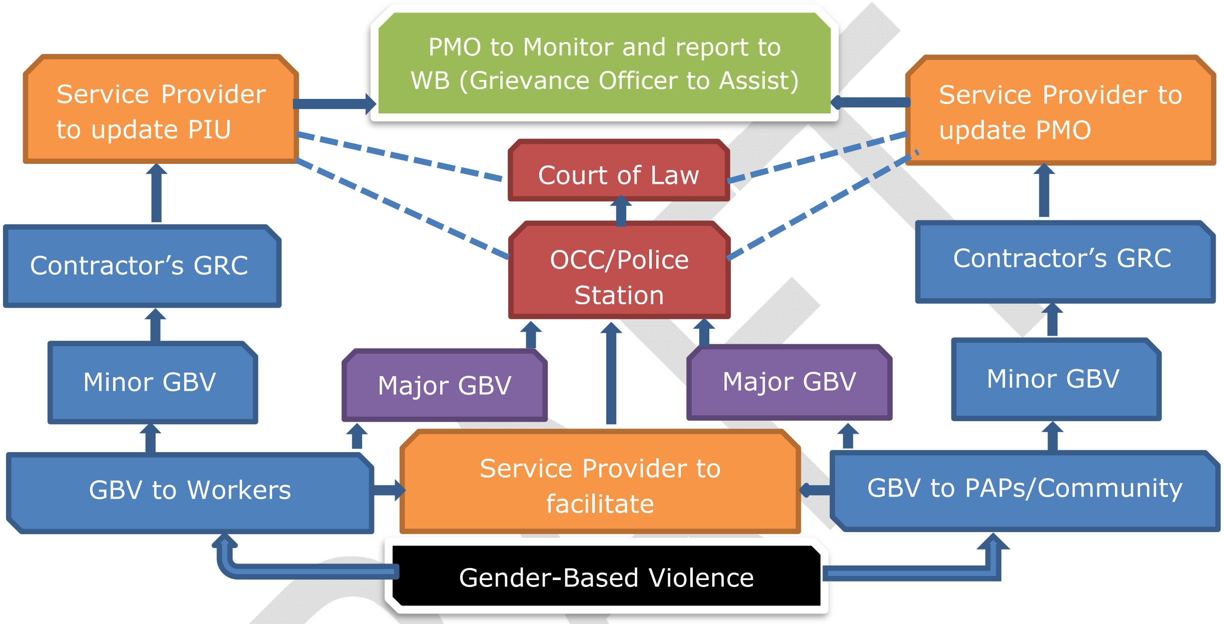

Figure 4.23: GRM for the Gender-Based Violence

The activities for addressing the risks of GBV and SEAA to be outlined in the GBV Action Plan will be included in the contractor's CESMP. The codes of conduct, community engagement and GBV roadmap will be tailored to the level of risks assessed for the project.

4.8.2 Preparation of RAP

Approach

A RAP will be prepared on the newly selected 13 polders for which detailed design will be prepared. The safeguard Consultant will review the RAPs prepared for work packages under the CEIP- I and other projects such as the Coastal Embankment Rehabilitation Project and River Bank Protection Project.

Methodology

The methodology for implementing task are but not limited to the following:

Review project documents

The safeguard Consultant will review project interventions and design including requirement of additional lands in 13 polders following Acquisition and Requisition of Immoveable property Act 2017, the World Bank operational policies on social safeguards (ESS5, ESS7) and the Resettlement Policy Framework.

Carry out Social Screening

The social safeguard Consultant will carry out social screening of each polder, and design and carry out a Social Assessment (SA) in respect to the impacts of the project interventions by means of stakeholders' consultation and participation process and a socioeconomic survey of beneficiary and affected households of representative sample. A screening checklist will be administered to obtain information from the stakeholders. At least 100 screening checklists will be filled up from each polder among which 30% are inside the polder, 60% on the embankment and 10% outside the polder. Social inclusion, participation, gender issues and public health implication due to project interventions, tidal effect, gender-based violence risks, etc. will be analysed in the screening as well for the SA.

SCM

Mass consultation meetings will be held with various stakeholders to disclose the objectives of the project and seek broader community support to ensure stakeholders engagement in project planning and implementation stage. The meeting will also confirm the cut-off-date of the affected properties. The meeting will hold prior to census and IOL. The consultation meetings will be conducted in local languages (Bengali) familiar to the affected people for easy understanding. The public consultation meetings will be organized in easy accessible place (Market, School, Union Parishad Office, etc.) with prior notice to the affected people and relevant officials/agencies and other stakeholders. People will be informed about the venue, time and topic of discussion of the meeting through personal contact, public announcement in the mosque and bazar, Union Parishad Chairman and Members and written notice to the community leaders.

Census and detailed measurement of Losses

100% of the census will be carried out for PAPs affected with their housing, income and livelihood resources and the current users of the agricultural lands to be acquired. Following the RPF and the SIA, detailed measurement of losses will be designed and carried out including affected land, structure, trees, crops, and employment, income, business and industry and will identify PAP including title holders, non- titled owners and users of affected property (squatters, encroachers and tenants), and affected income earners as follows:

- Landowners (residential and non-residential);
- Owners of physical assets (structures, crops, productive trees);
- Owners of business and industry;
- Household/person with potential impact of loss on income and livelihoods associated with businesses, industry and rental or productive assets;
- Community or group affected with their common property structures (sociocultural, religious, educational and cultural resources)
- Any other person or group

The inventory of losses (IOL) data will be supplemented with onsite still and video imaging for cut-off date of recognizing losses for compensation and assistance.

A more extensive description about the data collection process can be found in Appendix 8.

Identify alternatives

The social safeguard consultant will identify alternatives to minimize land acquisition, resettlement, and population displacement those were considered in engineering design and involve communities for identification and selection of relocation options, alternatives and sites suitable and acceptable to the communities.

Drafting the RAP

The RAP will be drafted based on the census and detailed measure of losses survey and following the guideline of RPF. The RAP will also contain the polder wise summary impacts and measure taken for resettlement and land acquisition management. The following activities will be done for drafting the RAP including other resettlement management activities as per instruction of RFP:

- Design and implement a program of disclosure and of consultation and participation of beneficiaries and affected persons in identification, design and implementation of project interventions and the resettlement policy of each polder;
- Describe legal framework for RAP, relevant local laws, customs that apply to land acquisition; describe entitlement policies for each category of impact and specify that resettlement of PAPs will be based on specific provisions of agreed RAP:
    - Describe methods of valuation used for affected property;
    - Prepare compensation and entitlement matrix;
    - Describe grievance redress procedures for registering complaints and management of complaints;
- Prepare institutional arrangement and capacity development of the social unit under the PMU for implementation of RAP including linkages with the PMU, BWDB field offices, local administration, NGOs and other stakeholders;
- Prepare cost estimates of RAP implementation separately identifying the administrative costs, consulting services, equipment, and compensation under each impact categories, such as land, houses, trees, other property, cost of basic facilities for relocation sites, etc.;
- Prepare implementation schedule including timelines for land acquisition milestones, relocation and livelihood restoration of PAPs and handing over lands for civil works construction, and monitoring and supervision mechanism with pre-set indicators.

Public disclosure on the draft/updated draft RAPs

In the meantime, the updated draft/draft RAP will be disclosed for any comments from the PAPs and other stakeholders. Feedbacks from the stakeholders will be taken into consideration for the finalization of RAPs in consultation with BWDB and WB.

Finalization of RAP

The draft RAP will be finalized incorporating all comments and submitted the final RAP to BWDB. The executive summary of the final RAP will be translated in Bangla.

A guideline for RAP management and IOL service module can be found in Appendix 8.

Public Disclosure on the Draft/Updated draft RAPs

In the meantime, the updated draft/draft RAP will be disclosed for any comments from the PAPs and other stakeholders. Feedbacks from the stakeholders will be taken into consideration for the finalization of RAPs in consultation with BWDB and WB.

Finalization of RAP

The draft RAP will be finalized incorporating all comments and submitted the final RAP to BWDB. The Executive summary of the final RAP will be translated in Bangla.

4.8.3 Preparation of LAP

Approach

The LAPs and LA proposals will be prepared during this feasibility phase. The Consultant will prepare the LAPs and LA proposals of embankment and hydraulic structures drainage and flushing sluice) following the ARIPA 2017.

Legal Framework

The principal legal instrument governing land acquisition in Bangladesh is the ARIPA 2017. LAs for the CEIP-2 will be carried out in accordance with the ARIPA 2017. It detailed the land acquisition process from section 4 to section 19 and land requisition process from section 20 to section 28. The ARIPA 2017 requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, trees, houses); and (ii) any other damages caused by such acquisition. The Act also provides for the acquisition of properties belonging to religious organizations like mosques, temples, pagodas, and graveyards if they are acquired for public interest. The Act stipulates certain safeguards for the landowners and provides for payment of "fair value" for the properties acquired. The DCs there after enhancing the assessed value by 200% and another 100% premium for loss of standing crops, structures, and income due to compulsory nature of the acquisition. It means the premium for land is 200%, thus 3 times of the mouza value in case of government requiring body and 300% (meaning 4 times) in case of private requiring body for the affected land is provided as compensation. In addition, if there are other asset and income/livelihood losses caused by the land acquisition, 100% as premium to reach market rate for these items is provided as compensation. The compensation such determined is called the Cash Compensation under Law (CCL). If the land acquired has standing crops cultivated by a tenant (bargadar) under a legally constituted written agreement, the law requires that compensation money be paid in cash to the tenants as per the agreement. Households and assets moved from land already acquired in the past for project purposes, and/or government has land are not included in the acquisition proposal, and therefore, excluded for considerations for compensation under the law. Lands acquired for a public purpose cannot be used for any other purpose. The new Act under section 4 (2) also facilitates the private organizations to request from the government to acquire the land for their development activities. Furthermore, the new Act under its section 15 provides for the acquisition of entire houses/buildings if their owners request to acquire the entire house or building against partial acquisition.

The Ministry of Land (MOL) has overall responsibility to enforce land acquisition. The MOL delegates some of its authority to the commissioner at the divisional level and to the deputy commissioner at the district level. The deputy commissioners are empowered by the MOL to process land acquisition and pay compensation to the legal owners of the acquired property. The burden to establish his/her legal rights to the acquired property in order to be eligible for compensation under the law is on the landowner.

The deputy commissioner is empowered to acquire a maximum of 50 standard bigha (16.50 acres) of land without any litigation for which he/she would obtain the approval of the divisional commissioner. Acquisition of land exceeding 16.50 acres must be approved from the central land allocation committee (CLAC) headed by the prime minister of the GOB. In the case of acquiring Khas land (government owned land), the land will be transferred through an inter-ministerial meeting following an acquisition proposal submitted to DC or MOL.

The government is obliged to pay compensation for the assets acquired. The ARIPA 2017 has incorporated provisions to address the above gaps, and therefore, it reduces the gaps between the national legislative framework of the government and WB policies.

Table 4-9 describes the land acquisition process under ARIPA 2017. The process generally takes minimum of 13 months for a priority project and minimum 16 months for a non-priority general project. This includes the time taken by DC to award compensation for affected persons which is stipulated as 2 months.

Table 4-9: LAP under ARIPA 2017

Relevant Section under ARIPA, 2017	Steps in the Process	Responsibility
Section 4 (1)	Publication of preliminary notice of acquisition of property for a public purpose	Deputy Commissioner
Section 4 (3) (1)	Prior to the publication of section 4(1) notice; Identify the present status of the land, structures and trees through videography, still pictures or appropriate technology.	Deputy Commissioner
Section 4 (3) (2)	After the publication of the section 4(1) notice, a joint verification is conducted with potentially affected households and relevant organizations.	Deputy Commissioner
Section 4 (7)	After publication of preliminary notice under the section 4(1), if any household has changed the status of the land for beneficial purposes, changed status will not be added to the joint verification notice.	Deputy Commissioner
Section 4 (8)	If the affected person is not happy with the joint verification assessment, he/she can complain to Deputy Commissioner within seven days of issuing sec 4(1) notice.	Affected Person

Relevant Section under ARIPA, 2017	Steps in the Process	Responsibility
Section 4 (9)	Hearing by Deputy Commissioner within 15 working days after receiving the complaints. In case of government priority projects, hearing will be within 10 working days.	Deputy Commissioner
Section 5 (1)	Objections to acquisition by interested parties, within 15 days of the issue of section 4 (1) Notice	Affected Person
Section 5 (2)	Deputy Commissioner submits hearing report within 30 working days after the date of the section 5(1) notice. In the case of government priority projects, it will be within 15 working days.	Deputy Commissioner
Section 5 (3)	DC submits his report to the (i) government (for properties that exceed 16.50 acres; (ii) Divisional Commissioner for properties that do not exceed 16.50 acres. Deputy Commissioner makes the final decision, if no objections were raised within 30 days of inquiry. In case of government priority project, it will be 15 days	Deputy Commissioner
Section 6 (1) (1)	Government makes the final decision on acquisition within 60 working days after receiving report from the Deputy Commissioner under section 5(3) notice.	Divisional Commissioner
Section 6 (1) (2)	Divisional Commissioner makes the decision within 15 days or with reasons within 30 days since the submission of the report by Deputy Commissioner under section 5(3) notice.	Divisional Commissioner
Section 7 (1)	Publication of the Notice of final decision to acquire the property and notifying the interested parties to submit their claims for compensation.	Deputy Commissioner
Section 7 (2)	Interested parties submit their interests in the property and claims for compensation within 15 working days (in case of priority project 7 days).	Affected Person
Section 7 (3)	Individual notices have to be served to all interested persons including the shareholders within 15 days of issuing Section 7(1) notice	Deputy Commissioner
Section 8 (1)	Deputy Commissioner makes a valuation of the property to be acquired as at the date of issuing Section 4 Notice; determine the compensation; and apportionment of compensation among parties interested.	Deputy Commissioner
Section 8 (3)	Deputy Commissioner informs the award of compensation to the interested parties and sends the estimate of compensation to the requiring agency/person within 7 days of making the compensation decision.	Deputy Commissioner
Section 8 (4)	The requiring agency deposits the estimated award of compensation with the Deputy Commissioner within 120 days of receiving the estimate.	Requiring Agency

Relevant Section under ARIPA, 2017	Steps in the Process	Responsibility
Section 9 (1)	During valuation of assets, Deputy Commissioner will consider the following: (i) Average market price of land of the same category in the last 12 months; (ii) Impact on existing crops and trees; (iii) Impact on other remaining adjacent properties; (iv) Impact on properties and income; and (v) Relocation cost for businesses, residential dwellings etc.	Deputy Commissioner
Section 9 (2)	Additional 200% premium on transacted deeds collected from Sub-Registrar's office is added to the estimated value. If land is acquired for private organizations, added premium will be 300%.	Deputy Commissioner
Section 9 (3)	Additional 100% compensation on top of the market price for impacts mentioned under sections 9(1) and (2)	Deputy Commissioner
Section 9 (4)	Appropriate action will be taken for relocation on top of the above-mentioned subsections.	
Section 11 (1)	Deputy Commissioner awards the compensation to entitled parties within 60 days of receiving the deposit from the requiring agency/person.	Deputy Commissioner
Section 11 (2)	If an entitled person does not consent to receive compensation, or if there is no competent person to receive compensation, or in the case of any dispute with the title to receive compensation, Deputy Commissioner deposits the compensation amount in a deposit account in the Public Account of the Republic. Thereafter, Deputy Commissioner acquires the land. (Landowners can obtain such deposited money at any time, having appealed to the Deputy Commissioner, and providing evidence in support of his/her claim.	Deputy Commissioner Affected Persons
Section 12	When the property acquired contains, standing crops cultivated by Bargadar, the apportion of compensation due to him will be determined by the Deputy Commissioner and will be paid to the bargadar in cash.	Deputy Commissioner

In addition to ARIPA 2017, another relevant law that applies to the project due to acquisition of bank line for riverbank protection works and shifting of embankment towards the river on naturally accreted land, is the State Acquisition and Tenancy Act 1950 (East Bengal Act No. XXVIII of 1951, Section 86 and 87) that defines the ownership and use right of alluvion (payosti) and diluvion (sikosti) land, and of land gained by accession from recess of river or sea in the country. Legally, GoB owns the bank line and eroded land in the river and any land accessed from recess of river. However, the "original" owner(s) of private land eroded into rivers can claim the land if it reappears in a natural process within 30 years from the date of erosion. Due to river training and other protection measures, landowners might lose access to new land in situ or original site. Therefore, land acquired for the seven polders under package 3, which includes bank line and newly accreted land, would be considered for compensation after a joint review of the alluvion and diluvion line established by the DCs of the three districts –Khulna, Satkhira and Bagerhat.

The DCs in all the cases, determine market value of acquired assets on the date of notice of acquisition (notice under section 4 of the ordinance). The DCs then add 200% premium of the assessed value for Compensation under Law (CUL) of all acquired assets except standing crops due to compulsory acquisition. The CUL determined for the affected land is generally less than the market value as owners customarily report undervalued land transaction prices in order to pay lower stamp duty and registration fees. If land to be acquired has standing crops cultivated by tenant (bharate/bhagchasi/bargadar) under a legally constituted written agreement, the law requires that part of the compensation money be paid in cash through cheque to the tenants as per the agreement. Places of prayer and worship, graveyard, cemetery and cremation grounds are not to be acquired for any purpose. The law requires that the salvaged materials upon payment of compensation will be auctioned out by the government. Households and assets moved from existing land (acquired already) of the executing agencies for project purpose are not included in the acquisition proposal and therefore considered for CUL. Lands to be acquired for improvement of polders cannot be used for any other purpose by BWDB.

A more extensive description about the data collection methodology can be found in Appendix 8.

Challenges and recommendation for Safeguard Management

In the coastal area, tidal surges, river erosion, shifting of embankment & population displacement, salinity intrusion, etc. are the major challenges of safeguard planning and implementation. In every year people become displaced from their homestead due to tidal surge and river erosion and take shelter on the embankment. Cyclone SIDR (15th November - 2007) and AILA (25th May 2009) damaged the embankment infrastructure drastically in the coastal area that required reconstruction and rehabilitation. In order to achieve the mitigation of natural calamities BWDB undertook many projects for constructing and reconstructing the embankment over the last several decades. Construction of embankment on emergency basis enforces people to offer land and get displaced. Over the decades, people lost their land for construction of retired embankment inside the polder due to river erosion threat. But in many cases land was not acquired following the GoB land acquisition law and payment of compensation was not paid. Taking into account of the land legacy issues, displacement of people, loss of livelihood, and environmental risks and challenges, safeguard planning and implementation mechanism has been developed.

Table 4-10: Challenges in safeguard planning and implementation

Issues and potential challenges in safeguard planning and implementation	Suggestion to overcome the challenges
Land Legacy issue	
Embankment has been constructed on emergency basis couple of years or even decades back but land acquisition proposal is not given as of now. The land owners are still paying revenues of the land under embankment	A complete census of the land owners who provided land for emergency embankment will need to be prepared and shared with the BWDB for necessary decision. BWDB can make payment to the land owners based on valid land ownership documents.
• It is evident that in spite of proper acquisition of land by the BWDB before construction and placement of fund with DC office, many of the land owners could receive compensation due to ownership problem among co-sharers • Civil suits pending in court • Lack of updated record of rights	Land Acquisition Proposals are to be submitted to DC offices well ahead of civil contract award. A team of specialists (Consultant) can be recruited for implementation of land acquisition plan prior to submit to DC offices. The Consulatnt will assist the BWDB to properly submit the LA Proposal, affected land owners to update their record of

Issues and potential challenges in safeguard planning and implementation	Suggestion to overcome the challenges
• Complexity in payment modality in DC's office • Amount of compensation is minimum compared to current market price	rights and getting compensation from DC offices. They will also assist the DC offices to serve notices and expedite LA process. Consultant will regularly conduct focus group meetings to resolve issues relating to record of rights, ownership problems, etc.
Resettlement and Livelihood restoration	
• Due to tidal surges and other natural disasters, people loss their shelters, cropping field and livelihood and take shelter on the embankment. In some cases, poor and vulnerable people permanently take shelter on the embankment since they have no alternative place of residence. They are mostly dependent on the agriculture, fishing, Rickshaw/ Van pulling, petty business, etc. • Apart from these, construction of retired embankment displaces people from their own land. • Compensation for their lost assets and relocation in cluster manner with alternative livelihood option are big challenges in linear type projects. • People from different villages/communities and various cultures take shelter on the embankment. Relocation in cluster of such heterogeneous groups became unsuccessful in many projects, including CEIP-1. • After temporary displacement during construction of the project, many of households and shops come back on the embankment.	• A comprehensive resettlement action plan including scope of relocation in cluster manner and livelihood restoration plan (LRP) to be prepared and agreed by the BWDB and World Bank. • This effort is being taken in many of the infrastructure projects in the Country including JMREMP (PIRDP). It was a successful project and model of Resettlement in the country particularly in rural settings. Such relocation planning was carried out in RMIP also. • If, relocation is agreed by the BWDB and World Bank, potential sites for relocation inside the polders would be selected and land acquisition process for the relocation sites would be started in advance for land filling and other civic amenities for facilitating displaced people to relocate prior to civil construction. • Resettlement sites can be designed for maximum 100 HHs taking into account of the social hierarchy. • It is to be ensured by the BWDB that people will not be allowed to take shelter permanently on the embankment.

4.9 Preparation of EIA

4.9.1 Background

Environmental impact assessment (EIA) is one of the environmental assessment tools being used worldwide to provide decision-makers and the concerned public with essential information to plan for environmentally sustainable economic development. It is a systematic analysis of projects to determine their potential environmental impacts and the significance of such impacts and to propose measures to mitigate the negative impacts.

EIA is both a planning tool and a decision-making tool. As a planning tool, EIA presents methodologies and techniques for identifying, predicting, and evaluating potential environmental impacts of projects as per the project cycle. As a decision-making tool, it provides information that promotes policymaking and actions that ensure sustainability in the implemented projects. Best-practice EIA identifies environmental risks, lessens conflicts by promoting community participation, minimizes adverse environmental effects, informs decision-makers, and helps lay the base for environmentally sound projects. Benefits of integrating EIA have been observed in all stages of a project, from exploration and planning through construction, operations, decommissioning, and beyond site closure (Sinha, 1998).

EIA has several strengths. Firstly, it can be a flexible process and employ a large number of evaluation methods and techniques. Secondly, EIA is increasingly viewed as a process, not as a mandated document. Thirdly, EIA is becoming more as a part of standard pre-feasibility engineering and economic studies. In general, EIA is focused on a previously selected project, however, only the better EIAs consider the sector as a whole or the wider implications, such as policies.

This EIA report will be prepared considering the ToR, World Bank, and Bangladesh environmental policies and guidelines. The objective of the study is to help the GOB towards an efficient rehabilitation/construction of 13 coastal polders and drainage network following the detailed design, associated environmental and social safeguard policies which are a cornerstone of its support to sustainable poverty reduction. This project will be an attempt to accelerate agricultural production and yields and at the same time radically change living conditions in rural society by construction/ rehabilitation of the selected coastal polders. This EIA will provide both Bangladesh legislation and regulations and World Bank requirements as established by the Bank's ESS.

4.9.2 The overall approach of the study

As described, the EIA will be based on the requirements of DOE-Bangladesh regulations and the World Bank's ESS. Principal sources of information will be the field data for rapid environmental assessment (REA) followed by detailed terrestrial and aquatic data collection and scoping exercises. Supplementary information will be taken from direct consultations with BWDB staff, field observations and site assessments, review of documents and project plans, approved designs, and previous reports on similar projects implemented in other areas in Bangladesh. The Rapid Environmental Assessment (REA) checklist from field reconnaissance and DoE-EIA Guidelines will be used for environmental categorization purposes for EIA preparation.

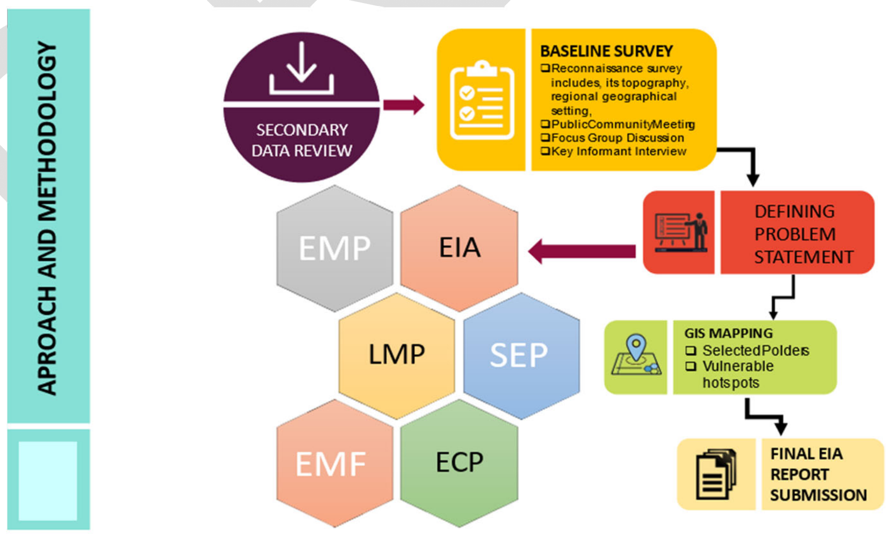

Figure 4.24: Flowchart of approach and methodology

Major Activity 01 - Environmental Assessment Report of selected polders

Approach

The environmental assessment will mainly assess the salt intrusion and sediment. Each polder will be assessed whether the sedimentation is an important problem or not. Areas where severe water logging is occurring will be avoided for the first batch of selected polders if there is no direct solution identified. However, prioritizing a specific polder can be an option for which a Tidal River Management (TRM) solution is available, and experts agree on the feasibility. In addition, other elements of environmental conditions such as the presence of protected areas, mangrove forests, important ecosystems, habitat of endangered species, and physical cultural resources will be assessed. The Environmental assessment report for prioritizing the next batch of polders will be finished before the end of the 5th month of the assignment.

Methodology

Secondary data for future growth will be used for the prioritization of polders. FGD-PRA will be conducted with the direct beneficiaries and different level stakeholders including BWDB officials of the polders to assess the environmental situation. The checklist will be developed to capture and record the information. The following table might be used in the FGD after pre-testing at the field level.

Table 4-11: Current situation of the polder (score)

Screening Questions	Current situation of the polder (Score)			Score obtained
	(100-67)	(66-34)	(up to 33)	
1. Topography (Elevation)				
2. Flooding, Tidal effect, Storm Surges				
3. Erosion and siltation				
4. Water pollution				
5. Salinity				
6. Flora and Fauna				
7. Aquatic resources (Fish & Fisheries)				
8. Adjacent to Protected area (Forest, wetland)				
9.Waterlogging problem				
10.Drainage congestion				
11.Surface and ground water (transmissibility) quality, quantity				
12.Loss of existing buildings, property, agricultural land, economic livelihood				
13.Endangered species				
14. Waterborne & insect borne diseases				
15.Storms & cyclones				
TOTAL SCORES:				

Activity 1: Assess Environmental issues associated with all proposed project activities

The Bangladesh National Environmental Policy, drafted and approved in May 1992, sets out the basic framework for environmental action together with a set of broad sectoral action guidelines. The objective of the policy includes maintaining ecological balance and ensuring sustainable development of the country through protection, conservation, and improvement of the environment, Identifying and regulating all activities that pollute and destroy the environment, Ensuring environment-friendly development in all sector, Ensuring sustainable and environmentally sound management of the natural resources and actively remain associated with all international environmental initiatives (MoEF, 1994)

The Environment Policy of 1992 requires specific actions to be undertaken for fifteen priority sectors, which includes industry. Concerning industry, the policy suggests:

- To adapt corrective measures to contain pollution;
- To conduct EIA for all new industries;
- To ban the establishment of polluting industries;
- To ensure sustainable use of raw materials to prevent wastage.

The DoE is directed to review and approve all EIA for all new industries. Depending upon location, size, and severity of pollution loads, projects/ activities have been classified in the ECR, 1997 into four categories: Green, Orange A, Orange B, and Red, respectively, to nil, minor, medium, and severe impacts on Important Environmental and Social Components (IECs).

As per Schedule-1 of the ECR 1997, the corresponding category related to polders construction, falls under RED category.

<u>Project Categorisation as per IFC Performance Standards:</u>

IFC categorization is used to reflect the size of impacts understood because of the client's social and environmental assessment and to specify IFC's institutional requirements.

- Category A Projects: Projects with potentially significant adverse social or environmental impacts that are diverse, irreversible, or unprecedented.
- Category B Projects: Projects with potential limited adverse social or environmental impacts that are few, generally site-specific, largely reversible, and readily addressed through mitigation measures.
- Category C Projects: Projects with minimal or no adverse social or environmental impacts, including certain financial intermediary projects with minimal or no adverse risks.

Activity 2: Literature review for all environmental and social Issues in the project area

At the initial stage of the EIA, preliminary information was obtained, and discussions were held to aid in the determination of what legal and other requirements apply to the project. This step was conducted utilizing a high-level description of the project and its associated facilities.

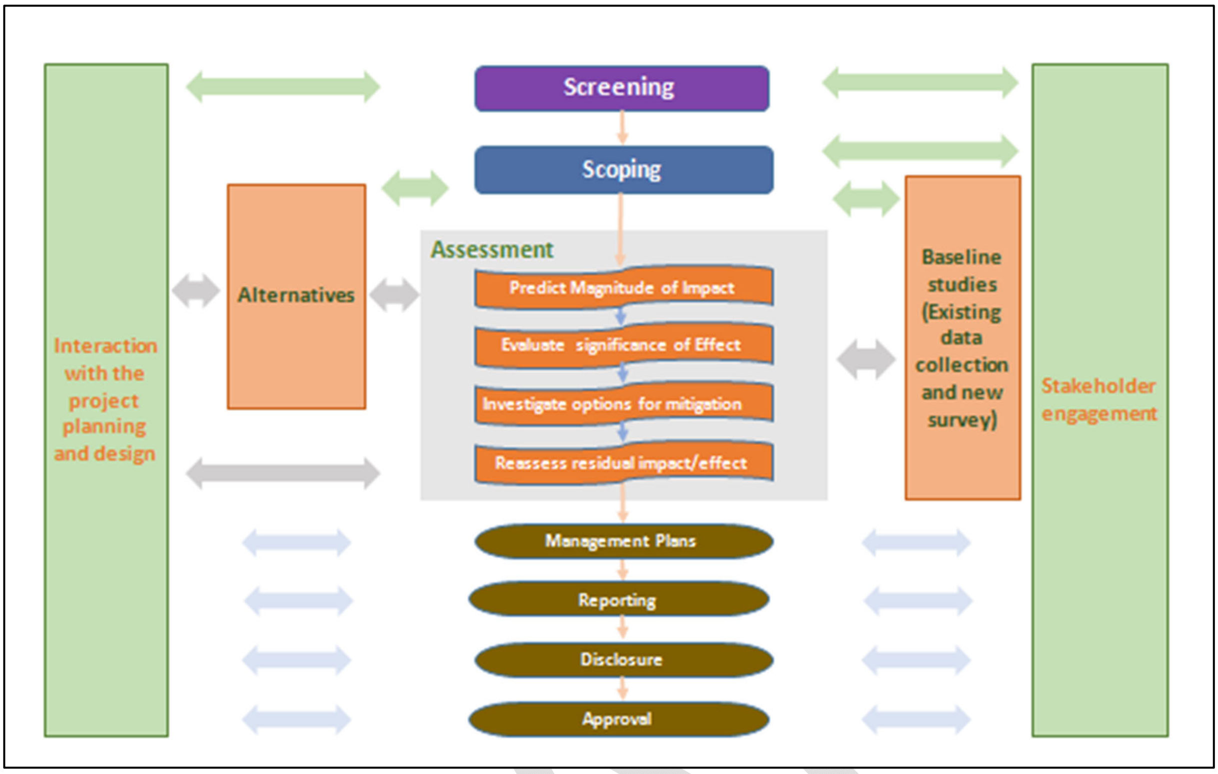

Figure 4.25: Impact Assessment Process / Framework

Major Activity 02 – Prepare EIA

Activity 3: Prepare Environment screening

This study will adopt a reconnaissance-based needs assessment approach. In this approach, reconnaissance studies would be commissioned for every aspect of the EIA framework including key EIA parameters viz. emission patterns, emission types, environmental safeguards, health and safety regulations, resettlement action plan and implementation, livelihood changes, and vulnerable population identification, land acquisition claims, compliance with local and international laws and rules, etc. After reconnaissance, the detailed design of the EIA study will be completed. Consultant will closely work with the related officials of MOEFCC/DOE and its project preparation team for this assignment.

To get insight into the impact as well as an understanding of the effectiveness and sustainability of the activities and issues, an attempt will be made to review the available secondary documents. It will include a review of the historical data and documents relating to context and area profile.

For this review, the following documents will be collected:

- Project documents: Project proposal, project log frame, project progress reports, baseline reports, situation analysis reports;
- Hydro-geological conditions: Geological survey reports, hydrological reports, rainfall data, surface runoff reports, previous geological, and hydrogeological field reports;

- Structural designs and/or reports: Relevant structural designs in the adjacent area, primary residence patterns, major infrastructure development in the project area;
- Environmental documents: IEE, EIA, EIA report, previous EMP, project documents, previous baseline survey reports, air quality reports, etc.;
- Supporting documents: RAP report, technical project report, necessary local governmental and regulatory approvals, public consultation records and social management plan, relevant extracts of the engineering, procurement and survey contract, relevant HSE records, EHS management plans, contractor agreements, etc.

Reconnaissance zero
At the beginning of the project, a brief reconnaissance study will be conducted at the project site to accumulate adequate information about the project area, its topography, regional geographical setting, local geology, and tectonic environment, natural hazards, vulnerability of the project site to these hazards and socio-economic implications of the project area. This study will be known as reconnaissance zero. Another key purpose of the reconnaissance study is the selection of EIA sites. The EIA sites/locations are the spots where various environmental quality parameters viz. ambient air quality, noise levels, vibration sensitivity, soil quality, surface, and groundwater quality, etc. are routinely measured. The potential EIA sites will be selected during reconnaissance zero and finalized in coordination with collected secondary information.

Field survey
The reconnaissance zero will be followed by a comprehensive field survey where IECs will be measured. Also, relevant actors and factors that impact the socio-economic lifestyle of the people within and adjacent to the project site will be monitored in these field surveys. Scheduling of these surveys plays a pivotal part in the overall design of the EIA framework, the most integral part being the corresponding intervals between two EIA dates of the same parameter. To solve the issue a cumulative weightage approach will be adopted where the weightage will be calculated based on the interaction of three factors:
- Scope: Degree of significance, sensitivity to smaller variations;
- Timeframe: Temporal sensitivity of data;
- Budget: Cost (direct and indirect) of one instance of measurement.

The primary objective of the environmental, ecological, and socio-economic baseline study is to provide a baseline against which potential impacts from the construction, operation, and decommissioning phases of the project can be assessed. The methodologies of baseline data collection for the environmental, ecological, and socio impact assessment and management of impact identification and assessment starts with scoping and continues through the remainder of the impact assessment process.

In short:
- Impact prediction: to determine what could potentially happen to resources/receptors because of the project and its associated activities;
- Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence, and the sensitivity, value, and/or importance of the affected resource/receptor;
- Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts;

- Residual impact evaluation: to evaluate the significance of impacts assuming effective implementation of mitigation and enhancement measures.

An extensive description of all impact survey components can be found in Appendix 8.

Activity 4: Design and carry out an EIA

Table 4-12: Design for EIA

Parameters	Locations	Method	Frequency	Responsible Agency	
				Implemented by	Supervised by
EIA During Field Survey Phase					
Air quality: PM_{10}, $PM_{2.5}$, SO_x, NO_x.	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Noise Level	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Noise level collection and analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Surface Water Quality: DO, COD, pH, TSS, oil and grease both for surface and groundwater and total coliform index.	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Drinking Water Quality: (WHO Drinking Water Guidelines and parameters)	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Environmental EIA During Project Operation Phase					
Air quality: SPM PM_{10}, PM2.5, SO_x, NO_x, and Lead, VOC.	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Noise Level	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Noise level collection and analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team

Parameters	Locations	Method	Frequency	Responsible Agency	
				Implemented by	Supervised by
Surface Water Quality: DO, COD, PH, TSS oil and grease both for surface and groundwater and total coliform index.	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Drinking Water Quality: (WHO Drinking Water Guidelines and parameters)	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Raw and Treated Sewage and Effluent: (BOD, COD, TSS, pH, Temperature, Faecal coliform, sulphate, phosphate)	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Indoor Air Quality EIA	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Work zone Noise	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	Sample collection and laboratory analysis	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Social Monitor During Both Phase					
Employment Opportunity	Project Implementation	To honour the local communities demand hence giving first preference to locals,	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Stakeholder Engagement	All Stakeholders	Build trust and amiability amongst the	Will be finalized upon discussion	KMC	BWDB Experts Team

Parameters	Locations	Method	Frequency	Responsible Agency	
				Implemented by	Supervised by
		stakeholders involved by conducting regular meetings with stakeholders	with officials of MoEFCC/DoE/WB		
Grievance Mechanism	Community and Worker Grievance	Grievance raised, action taken, number of grievance committee meetings	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Proposed Activities: Social Management Plan, LRP, RAP and CSR	Surroundings	Direct Implementation of Proposed Activities	As per Plan	KMC	BWDB Experts Team
Health & Safety EIA					
Health and Hygiene of Workers	Project Implementation	Observation and consultation	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Visual inspection of use of PPE	Project Implementation	Physical verification for integrity and safety to use. In the case of respirators and SCBA arrange third party fit test	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team
Regular Medical Check-up of Workers infectious Diseases	Project Implementation	Physical Examination, Audiometry, Spirometer, Total Lung Capacity, Eye Check-up, Vertigo Communicable/	Will be finalized upon discussion with officials of MoEFCC/DoE/WB	KMC	BWDB Experts Team

Activity 5: Verify the EIA study with the relevant ESSs of the World Bank

The EIA will assess the risks and impacts of the planned activities mentioned above against the relevant ESSs of the World Bank.

- ESS-01: Assessment and Management of Environmental and Social Risks and Impacts
- ESS-02: Labour and Working Conditions
- ESS-03: Resource Efficiency and Pollution Prevention and Management
- ESS-04: Community Health and Safety

- ESS-05: Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement
- ESS-06: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- ESS-07: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities
- ESS-08: Cultural Heritage
- ESS-09: Financial Intermediaries
- ESS-10**:** Stakeholder Engagement and Information Disclosure.

Table 4-13: Methodology for ESS

ESS	Methodology	Tools
ESS-01	As the basis for the assessment, relevant baseline data on physical, biological, ecological, social and cultural health and safety, etc. aspects will be collected, including relevant environmental modelling such as air quality, water quality, etc. Also find out the impacts on: • health and safety; • adverse impacts on disadvantageous or vulnerable people; • adverse impacts related to land acquisition or use; • Occupational Health and Safety (OHS); • potential adverse labour practices; • labour influx, gender gaps, Gender-Based Violence (GBV); • impact on any small ethnic communities.	▪ On-field testing; ▪ Laboratory; Testing; ▪ ODK survey; ▪ FGD & KII; ▪ Literature review.
ESS-02	Find out the key labour risks such as: • hazardous work; • child labour and forced labour; • migrant or seasonal workers; • discrimination against women; • vulnerable groups, etc.; • labour influx; • occupational health and safety; • possible accidents and emergencies; • risks of GBV among others.	▪ ODK survey; ▪ FGD & KII.
ESS-03	• Resource use and efficiency and pollution management; • Assessments of the use of energy, water, and raw materials for the operation of project supported facilities; • Generation of liquid and solid wastes at various stages and recommended approaches for treating/disposing of such waste in an environment-friendly manner; • Impacts on air quality, generation of hazardous and non-hazardous wastes, greenhouse gas emissions following internationally or nationally accepted methodology for estimating greenhouse gas emissions.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review
ESS-04	• Construction and operation of project-supported investments may expose communities to health and safety risks especially those communities that are immediately close to the project facilities; • The transportation of construction and production materials may create an adverse impact on the community; • Adequate engineering, health, and safety measures should be adopted to avoid any issue on community health; especially, wastes from the camps; communicable diseases, etc.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review.
ESS-05	• The EIA will check and update if any lands are to be acquired for the project-supported investment activities and whether	▪ Drone survey; ▪ ODK survey; ▪ FGD & KII;

	there will be any physical and economic displacement and any access restrictions resulting from implementing this project; • Information on the number and different types of project-affected people (PAPs), assess project effects on PAPs and propose measures to manage impacts following the mitigation hierarchy of avoidance, minimization, mitigation, and compensation. if the land acquisition is required, RAP wilt needs to be prepared by the Consultant.	▪ Literature review/
ESS-06	• Biodiversity and living natural resources effect of the project areas; • Also, studies on relevant ecosystem services will be made to address any impacts and risks.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review; ▪ Ecological survey.
ESS-07	• The Consultant will analyse and study if any small ethnic minorities will be affected under the project activities and recommend measures to address the same.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review; ▪ Field survey.
ESS-08	• An assessment will be done on all proposed project sites, once identified, to verify if sites are located near any heritage sites.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review.
ESS-09	• Environmental and social policy; • Clearly defined procedures for the identification, assessment, and management of the environmental and social risks and impacts of subprojects; • Organizational capacity and competency; • Monitoring and review of environmental and social risks of subprojects and the portfolio; • External communications mechanism.	▪ ODK survey; ▪ FGD & KII; ▪ Literature review; ▪ Field visit.

ESS-10	• Establish a systematic approach for stakeholder engagement that will help MOEF/DOE identify key stakeholders — project-affected parties and other interested parties — and build and maintain constructive relationships with them;
	• The SEP will assess the level of stakeholder interest and support for the project:
	  ○ Enable stakeholder views to be taken into account in project design and environmental and social performance;
	  ○ Promote and provide means for inclusive engagement throughout the project lifecycle;
	  ○ Ensure that appropriate project information is disclosed to stakeholders in a timely and appropriate manner and format;
	  ○ Provide stakeholder engagement, consultation, and communication, including Grievance Redress Mechanism (GRM), will be set up for the entire length of the project.
		▪ ODK Survey;
		▪ FGD & KII;
		▪ Literature review;
		▪ Field visits.

Major Activity 03- Develop Stakeholder Engagement Plan (SEP) FOR EMP

Activity 6: Identify various stakeholders

A stakeholder is defined as "an individual, group, or organization, who may be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project". "Stakeholder Analysis" is the process of sorting identified stakeholder groups according to their impact on the project and the impact the project will have on them. This information is then used to assess the way the interests of the stakeholders or projects impact on them should be addressed in the project development plan or its operation. This section of the report describes the stakeholder engagement process undertaken as part of the EIA.

Stakeholder identification is one of the most important processes throughout the project life cycle and documenting relevant information regarding their interests in the project, independencies, influence, and potential impact on the project. Stakeholders vary in terms of the degree of interest, influence, and control they have over the project. While those stakeholders who have a direct impact on or are directly impacted by the project are known as primary stakeholders, those who have an indirect impact or are indirectly impacted are known as secondary stakeholders. Identification of stakeholders will be carried out by KMC in discussion with MoEFCC/ DoE. Keeping in mind the nature of the project and its setting, the stakeholders have been identified and listed in the table presented below:

Table 4-14: Stakeholder identification

Sl. No.	Stakeholder Group/Category	Key Stakeholders			Description of the Stakeholder Profile
					Primary Stakeholders
1	**PAPs**	• Impacted land users; • Impacted landowners; • Impacted rent collector; • Vulnerable households.	•		• This stakeholder group comprises the PAHs and PAPs who owned land inside the project footprint; • The PAPs also comprise land users who are residing and carrying out cultivation inside the project footprint.
2	**Institutional stakeholders**	• Religious Authorities associated with Mosque; • Local Administration-Union Parishad and Mouza; • Regulatory Authorities.	•		• This stakeholder group includes the management authorities of the mosques located inside the project footprint; • This stakeholder group comprises regulatory authorities at

Sl. No.	Stakeholder Group/Category	Key Stakeholders			Description of the Stakeholder Profile
					the district, state, and national levels.
3	**Other primary stakeholders**	• DoE contractors.	•		• This stakeholder group i.e. BSSE is the SPV that has been incorporated into the project.#They are responsible for ensuring the effective implementation of the RAP and that the affected person is properly compensated and impacts are mitigated .
•		•		• **Secondary stakeholders**	
4	**Local community**	• Local community residing near the project footprint; • Agricultural labourers; • Vulnerable community.	•		• This stakeholder group comprises the community residing near the vicinity of the project area; • This group is expected to be indirectly impacted by Project activities but maybe indirectly impacted.
5	**Institutional# stakeholders**	• Land#and#Revenue# Department; • Survey#Department; • Relief#and# Rehabilitation# Department; • Irrigation# Department;	•		• This stakeholder group comprises of an expert on the different sectors for providing

Sl. No.	Stakeholder Group/Category	Key Stakeholders			Description of the Stakeholder Profile
		• Agriculture#Department; • Fisheries#Department; • Forest#Department.			inputs and information which are crucial for designing the resettlement site, and livelihood restoration measures; • These groups of stakeholders will serve as a support system for technical guidance and collaborative agency while implementing the RAP.
6	**Another secondary stakeholder**	• Local#NGOs; • Land#aggregators.			
7	**Project financing agencies/institutions**	• Financers and investors.	•		• This stakeholder group includes the World Bank and other investors who are evaluating a potential investment opportunity into the project.

Activity 7: Develop a SEP for EMP

The broad objective of the SEP and involvement process is to provide authorities, as well as interested and affected stakeholders with the opportunity to identify issues, concerns, and opportunities regarding the proposed project and to address key stakeholder concerns during the preparation of the EIA for this project.

Specific objectives for stakeholder consultations are as follows**:**

- To address relevant issues including those perceived as being important by other sectoral agencies, public bodies, local communities, affected groups, and others;
- To improve information flows between proponents and different stakeholders, improving understanding of a project;
- To identify important environmental and social characteristics or mitigation opportunities;
- To ensure that the magnitude and significance of impacts have been assessed properly;

- To Improve the acceptability and quality of mitigation and monitoring processes.

Figure 4.26: Photograph demonstrating FGD session with local stakeholder

Figure 4.27: Photograph demonstrating household data collection for SWM

Stakeholder mapping

Stakeholder Mapping is a process of examining the relative influence that different individuals and groups have over a project as well as the influence of the project over them.

The purpose of stakeholder mapping is to:

- Study the profile of the stakeholders identified and the nature of the stakes;
- Understand each group's specific issues, concerns as well as expectations from the project that each group retains;
- Gauge their influence on the project.

Based on this understanding, the stakeholders are categorized into high influence/priority, medium influence/priority, and low influence/priority. The stakeholders who are categorized as a high influence are those who have a high influence over the project or are likely to be heavily impacted by the project activities and are thus high up on the project proponent's priority list for engagement and consultation.

Similarly, the stakeholders categorized as a medium influence are those who have a moderate influence over the project, or even though they are to be impacted by the project, it is unlikely to be substantial and these stakeholders are thus neither high nor low in the project proponent's list for engagement. On the other hand, the stakeholders with low influences are those who have a minimal influence on the decision-making process or are to be minimally impacted by the project and are thus low in the project proponent's engagement list.

Activity 8: Develop an EMP

A site-specific environmental management plan will be prepared following the parameters laid down in the EMF and acceptable to the association. This will set forth a set of mitigation, monitoring, and institutional measures to be taken during the implementation and operation of the project activities to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels, and including the actions needed to implement these measures.

The significance of a stakeholder group is categorized considering the magnitude of impact (type, extent, duration, scale, frequency) or degree of influence (power, proximity) of a stakeholder group and urgency/likelihood of the impact/influence associated with the stakeholder group in the project context. The magnitude of stakeholder impact/influence is assessed taking the power/responsibility of the stakeholder group and is categorized as negligible, small, medium, and large. The urgency or likelihood of the impact on/influence by the stakeholder is assessed on a scale of low, medium, and high.

The following section provides brief profiles of the various stakeholders in the project as discussed in the previous subsection along with their degree of influence. The details are provided below.

Table 4-15: Stakeholder influence

Stakeholder category	Stakeholder group	The magnitude of impact/ influence	Stakeholder significance
Primary stakeholder			
Community	Project affected families and people	**Impact of project on stakeholder:** Large **Influence of stakeholder on project:** Medium	Urgent
	Vulnerable groups including women, elderly	**Impact of project on stakeholder:** Large **Influence of stakeholder on project:** Low	Urgent
Government bodies	Regulatory authorities	**impact of project on Stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
Other groups	DoE contractors and sub-contractors	**Impact of project on stakeholder:** Medium **Influence of stakeholder on project:** High	Urgent
Secondary stakeholder			
Community	Local community and union parishad	**Impact of project on stakeholder:** Large **Influence of stakeholder on project:** Medium	Urgent
Local government authorities	Relief and rehabilitation department	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
	Irrigation department	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
	Agriculture department	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate

Stakeholder category	Stakeholder group	The magnitude of impact/ influence	Stakeholder significance
	Fisheries department	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
	Forest#department	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
Institutional stakeholders	Project financing agencies	**Impact of project on stakeholder:** Large **Influence of stakeholder on project:** High	Urgent
Other groups	Local political groups	**Impact of project on stakeholder:** Medium **Influence of stakeholder on project:** High	Moderate
	Media	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate
	NGOs/CSOs operating in the area	**Impact of project on stakeholder:** Small **Influence of stakeholder on project:** High	Moderate

Major Activity 04- Develop LMP

Activity 9: Develop a LMP

Labour management procedures were developed to identify and manage risks associated with labour and working conditions under the Distribution Sector Recovery Program (DISREP). It identifies labour requirements in line with applicable laws, standards and sets out the procedures for addressing labour conditions and risks associated with the DISREP in line with the World Bank Environmental and Social Standard 2 (ESS2).

An overview of labour uses, and characterization of the project has been provided. The LMP has assessed the potential labour risks associated with the project based on the type of work and workers and documented appropriate mitigation measures.

Compliance obligations have also been documented which will serve as supplemental policies that will guide the implementation of this LMP including national laws, international laws, and in particular, the World Bank ESS2.

The LMP sets out policies and procedures governing the following:

- Non-discrimination and equal opportunity;
- Age of employment;
- Terms and conditions of employment;
- Working conditions;
- OHS;
- Forced labour;

- SH, SEA and GBV;
- GRM;
- Right of association and collective bargaining;
- Community health & safety;
- Engagement of community workers;
- Contractors' management;
- Primary suppliers;
- Discipline and termination of employment.

Roles and responsibilities for implementing the LMP have also been documented in line with the project structure for implementing the DISREP. This LMP recognizes the significance of having a structured process for managing complaints and has established a grievance redress mechanism for workers. It has also provided to guide the development of site-specific LMP's by contractors as part of the ESMP.

Activity 10: Verify developed LMP with the requirements of national law

The World Bank's stipulations related to labor are outlined in its ESS2. The implementing agency promotes sound worker-management relationships and provides safe and healthy working conditions. Key objectives of the ESS 2 are to:

- Promote safety and health at work;
- Promote fair treatment, non-discrimination, and equal opportunity for project workers.
- Secure protection of project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, following this ESS), and migrant workers, contracted workers, community workers, and primary supply workers, as appropriate;
- Prevent the use of all forms of forced labour and child labour;
- Support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law;
- Provide project workers with accessible means to raise workplace concerns.

ESS2 applies to project workers including full-time, part-time, temporary, seasonal, and migrant workers. Where government civil servants are working in connection with the project, whether full-time or part-time, they will remain subject to the terms and conditions of their existing public sector employment agreement or arrangement, unless there has been an effective legal transfer of their employment or engagement to the project. ESS2 will not apply to government civil servants.

Working conditions and management of worker relationships

The implementing agency will develop and implement internal labor-management procedures applicable to the project. These procedures will set out how project workers will be managed, following the requirements of national law and this ESS. The procedures will address how this ESS will apply to different categories of project workers including direct workers, and contract workers.

Project workers will be provided with information and documentation that is clear and understandable regarding their terms and conditions of employment. The information and documentation will set out their rights under national labor law and ESS requirements (which will include collective agreements), including their rights related to hours of work, wages, overtime, compensation, and benefits. This information will be provided at the beginning of the working relationship and when material changes occur.

KMC's social and environmental specialists will be responsible for the following:

- Implement this labor-management procedure;
- Ensure that civil works contractors comply with these labor-management procedures, and also prepare occupational health and safety plans before mobilizing to the field;
- Ensure, the contractors are in line with the provisions of this LMP and the project's ESMF, as detailed in the Project Operations Manual (POM);
- Monitor to verify that contractors are meeting labour and OHS obligations towards contracted and subcontracted workers as required by government law and respective contracts between KMC and the contractors;
- Monitor and implement training on LMP and OHS for project workers;
- Ensure that the grievance redress mechanism for project workers is established and implemented and that workers are informed of its purpose and how to use it;
- Have a system for regular monitoring and reporting on labor and occupational safety and health performance;
- Monitor implementation of the worker code of conduct.

Major Activity 05- Prepare ESCP

- The ESCP sets out a summary of the material measures and actions. Where the ESCP refers to specific plans or other documents, whether they have already been prepared or are to be developed, the ESCP requires compliance with all provisions of such plans or other documents relevant to the project.
- To prepare, disclose and adopt an EMF and assess the environmental and social risks and impacts of proposed project activities following ESSs and the EMF, including to ensure that individuals or groups who, because of their circumstances, may be disadvantaged or vulnerable, have access to the development benefits resulting from the project.
- Prepare, disclose, adopt, and implement ESMPs or other instruments required for the respective project activities based on the assessment process, following the ESSs, the ESMF, including Infection Prevention Control and Waste Management Plans (IPC & WMPs), and relevant good international industry practice including the WHO country & technical guidance - Coronavirus disease (COVID-19) and the WHO guidelines on safe management of wastes from health-care activities, in a manner consistent with the ESSs and acceptable to the World Bank.
- Incorporate the relevant aspects of this ESCP, including any ESMPs, ICP & WMPs and/or other instruments, ESS2 requirements, and any other required ESHS measures, into the ESHS specifications of the procurement documents and contracts with contractors and supervising firms. Thereafter ensure that the contractors and supervising firms comply with the ESHS specifications of their respective contracts according to the project implementation plan.

Activity 11: Prepare the Borrower's ESCP

- Prepare the Borrower's ESCP which will be submitted to the World Bank along with the regular monitoring reports on the environmental and social performance of the project, including but not limited to the implementation of the ESCP, status of preparation and implementation of documents required under the ESCP, stakeholder engagement activities, the performance of the grievance mechanism(s) and EMS implementation;
- Promptly notify the World Bank of any incident or accident related to the project which has, or is likely to have, a significant adverse effect on the environment, the affected communities, the public, or workers including but not limited to incidents and accidents encountered during implementation of the ESMS. Require sub-borrowers to provide sufficient detail regarding the incident or accident, findings of the root cause analysis, indicating immediate measures or corrective actions taken or that are planned to be taken to address it, compensation paid, and any information provided by any sub-borrower, as appropriate. Subsequently, as per the World Bank's request, prepare a report on the incident or accident and propose any measures to prevent its recurrence.

Activity 12: Connect with EMP & ESCP

Specified training should be provided to the strengthen awareness on the environmental, social, health, and safety issues associated with the construction works including HIV/AIDS, sexual exploitation and abuse, and gender-based violence.

The training will be conducted monthly and will be joined by:

- Site engineers of the contractor;
- PMU;
- Project Management Consultant.

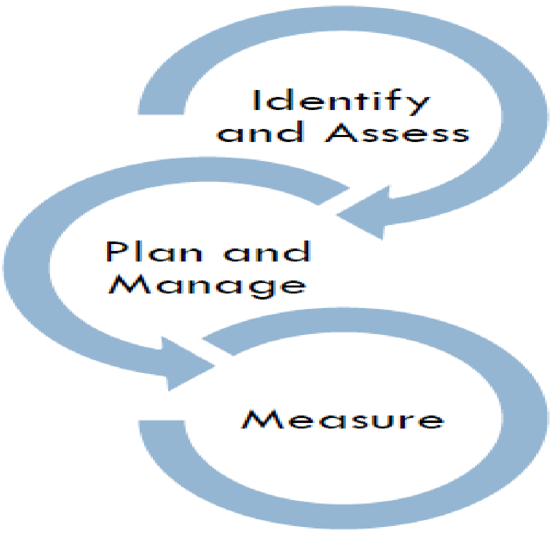

Figure 4.28: Steps for connecting with EMP and ESCP.

The contractor will develop and implement a code of conduct for all the construction workers with measures to prevent GBV and SEA. All construction workers should abide by the code of conduct through contractual obligation. The contractor's monthly training program will also cover topics related to the code of conduct such as SH particularly towards women and children; violence, including sexual and/or GBV, and respectful attitude, while interacting with the local community.

The contractor shall provide training to all his workers, before they start working on site, on basic ESHS risks associated with the proposed construction works and the workers' responsibility. The training program shall be repeated every month.

Major Activity 06- Assessment of Institutional Capacity

Institutional capacity building is considered here as one of the main types of capacity building efforts, along with human capacity building. Both are closely interrelated and complement each other. Institutional capacity building addresses capacity building beyond the provision of education and training of professionals. It aims to enhance the capacity of governments, businesses, non-governmental groups, and communities to plan and manage the coast efficiently and effectively. It also aims to improve institutional arrangements for coastal management. This implies addressing capacity building on a long-term, strategic level. Concepts such as leadership, awareness, and constituency building are part and parcel of institution building. There are several dimensions regarding institutional development: one at the government level and the other at the national/regional/local level.

Activity 13: Assessment of the existing Institutional capacity of MoEF/DoE

Capacity development needs in all thematic areas will be identified at the individual, institutional and systemic levels in Bangladesh. At the individual level, capacity building refers to the process of changing attitudes and behaviors, mostly imparting knowledge and developing skills through training. Capacity building at the institutional level focuses on overall organizational reform, performance, and functioning capabilities, as well as the ability of an organization to adapt to change. At the systemic level capacity building is concerned with the creation of an enabling environment, i.e., the overall policy, economic, regulatory, and accountability frameworks within which institutions and individuals operate.

Activity 14: Develop future institutional capacity development plan for MoEF/DoE

Bangladesh is recognized to be one of the most ecologically vulnerable countries in the world, highly vulnerable to climate change as a result of its unique geographic location, hydro-geological characteristics like the dominance of floodplains, low elevation from the sea, and lastly the socio-economical characters like high population density, high levels of poverty, and overwhelming dependence on nature. The physical environment of Bangladesh is diverse, and there is a mix of both traditional and modern methods of land use, all very closely adapted to the heterogeneous conditions. This complexity of environment and utilization patterns have important implications for the vulnerability and depletion of the natural resource base. The high population density, low economic growth, lack of institutional infrastructure, an intensive dependence on agriculture and agricultural products, geographical settings, and various other factors, all contribute to making the country weak in its economic development and quality of life.

Bangladesh's top-down decision-making system, however, has its diffuseness as the central government makes decisions while local government and administration implement policies. The overall decision-making process is suffering from a dearth of feedback processes from the lower to upper levels, resulting in inadequate reflection of the actual ground-level situation in policies and systems. On the other hand, the decision-making process provides no adequate channels for communication among decision-makers, the public, relevant actors (civil society members and non-state actors) and the media. As a result, non-state actors show less interest in undertaking initiatives in responding to policies, and the community for whom environmental protection programs are designed does not play a positive role in participation that limits the effectiveness of implementation, to a great extent.

Existing environmental policy guidelines don not offer operative apparatuses to deal with climatic change; even environment policy did not mention explicitly the term climate change and its adverse impacts. Formal or informal dialogues between governmental agencies particularly MoEF and DoE as well as polluters are not witnessed in the process of environmental policy implementation in Bangladesh. The institutional capacity of the concerned ministries for implementing the various action measures is not passable. Conversely, neither the fledgling MoEF nor DoE has developed the institutional capacity to extensively fight problems of environmental management and protection. Inadequacy in transparency and public consultation at decision-making process resulting in weakness of MoEF and DoE to care for environmental governance. In addition, several underlying causes are liable for poor environmental governance in Bangladesh, including a lack of institutional capabilities, untrained human resources, a lack of awareness, low community participation in resource management, and a paucity of research and lack of coordination among different stakeholders (governments, UN agencies, NGOs, private sector, and civil society).

Activity 15: Develop future institutional capacity development plan for other related agencies

Changes in institutional, administrative, and organizational arrangements would be necessary to enhance the effectiveness of political decisions. This would be preceded by an examination of the existing bodies in charge of climate change issues: national climate change committees, their degree of representativeness, and corresponding power and functions. Better coordination/integration of the different sectoral departments would be encouraged and institutionalized to render the services aiming at attaining governance for environmental protection. Efforts to be directed to find out a possible way forward to ensure accountability and efficiency of the local government managing natural resources and environment.

Relevant stakeholders should also play a major role to streamline the environmental governance by the way of information collection and dissemination through:

- Policy development consultation;
- Policy implementation;
- Assessment and monitoring;
- Advocacy for environmental justice.

We should bear in mind that, NGOs and other civil society groups are not only stakeholders in governance, but also a driving force behind greater international cooperation through the active mobilization of public support for international agreements. Due to their critical role in service delivery and implementation, civil society organizations have long been recognized as "partners" of the UN system, especially in environmental negotiations. Above all, the UN system, including international finance and development agencies, and all intergovernmental organizations and forums, should in consultation with non-governmental organizations, complement the efforts of the government of Bangladesh to accelerate the enforcement of legislation about environmental governance.

Major Activity 07- Review of appropriate country laws to address E&S impacts

Activity 16: Conduct a review of appropriate country laws and requirements to address E&S impacts

Table 4-16: Environment policy

Policy	Key Features	Applicability
The National Forest Policy, 1994	• Afforestation of 20% of the land; • Biodiversity of the existing degraded forests; • Strengthening of the agricultural sector; • Control of global warming, desertification; • Control of trade in wild birds and animals; • Prevention of illegal occupation of the forested land, tree felling and hunting of wild animals.	Applicable when considering global warming and the protection of forests
National Land-use Policy, 2001	• Deals with several lands use including agriculture (crop production, fishery, and livestock), housing, forestry, industrialization, railways and roads, tea and rubber; • Identifies land-use constraints in all these sectors.	Applicable as land-use changes from saltpans to industrial land
The National Water Policy, 1999	• Protection, restoration and enhancement of water resources; • Protection of water quality, including strengthening regulations concerning agrochemicals and industrial effluent; • Sanitation and potable water; • Fish and fisheries; • Participation of local communities in all water sector development.	Applicable for the preservation of surface water bodies and flood plains in the surrounding area of the Project
The Energy Policy, 1996	• Provides for utilization of energy for sustainable economic growth, supply to different zones of the country, development of the indigenous energy source and environmentally sound sustainable energy development programs; • Highlights the importance of EIA's for any new energy development project.	Applicable. The project is for the development of energy generation.
The Power Policy, 1995	Is an integral part of the Energy Policy and deals with a policy statement on demand forecast, long term planning and project implementation, investment terms, fuels and technologies, load management, institutional issues, private sector participation, technology transfer, and research program, environmental policy and legal issues	Applicable

Policy	Key Features	Applicability
Industrial Policy, 1999	Deals with industrial development, direct foreign investments, investment by the public and private sector, introduction of new appropriate technology, women's participation, infrastructure development and environmentally sound industrial development	Applicable as the project is a private sector, industrial development

Activity 17: Identify the implication of GOB laws

Environment-related policies in Bangladesh

- National Environmental Policy, 1992;
- National Environment Management Action Plan, 1995;
- National Conservation Strategy, 1992;
- Other Policies Relevant to the Environment;
- Environment and Social Related Legislations in Bangladesh;
- The Environment Conservation Act, 1995 (subsequent amendments in 2000 and 2002);
- Environment Conservation Rules (ECR), 1997 (subsequent amendment in 2017);
- Environment Court Act, 2000 and subsequent amendments in 2002;
- Bangladesh Water Act, 2013;
- National Land Use Policy, 2001;
- Land Reform Ordinance, 1984;
- Khas land (Agriculture) Management and Settlement Policy 1997;
- East Bengal State Acquisition and Tenancy Act, 1950;
- The Registration Act, 1908, amended in 2004;
- Transfer of Property Act, 1882;
- Land Holding Limitation Order, 1972, amended in 1982;
- Non-agricultural Khas lands Management and Settlement Policy, 1995;
- Non-Agricultural Tenancy Act of 1949;
- The Electricity Act, 1910.

Activity 18: Identify the implication of World Bank policies/acts/regulations/ESS for the project

Bangladesh is both an inspiration and a challenge for policymakers and practitioners of development with a better environment. While the country recorded strong performance in income growth and human development, Bangladesh faces daunting challenges with an increased level of vulnerability with about 39 million people still living below the national poverty line. The economic losses resulting from the environmental impacts considered in this report are equivalent to more than 4 percent of Bangladesh's Gross Domestic Product (GDP). Among these impacts, three sources of environmental degradation stand out as currently receiving insufficient attention given their relative significance: (1) indoor and urban air pollution, (2) the degradation of water quality in Dhaka, and (3) the decline of capture fisheries. The economic losses associated with these three concerns alone may amount to more than 2.7 percent of GDP.

Major Activity 08- Prepare EMF

Approach

The EMF will be prepared for CEIP-2. The EMF will aim to provide guidance on safeguard screening, assessment, institutional arrangements, and processes to be followed for components of the CEIP-2 (sub-project polders packages), where the design will take place after the client approval. The sub-project selection packages will be done for the executing agency, considering engineering and environmental project selection criteria. The executing agency will agree with the client on screening and categorization, environmental assessment, preparation and implementation, monitoring, safeguard plans for the sub-project packages to facilitate compliance with the requirements specified in IFC-WB and GOB rules and laws. An EMF will be prepared to identify mitigation measures for some potential negative environmental impacts, and monitoring plans for both construction and post-project maintenance phases. It is expected that the EARF will support the integration of these measures and practices in the project design. Since environmental assessment reports and EMPs to be prepared for subsequent sub-project packages are borrower's documents, these shall be officially endorsed by the executing agency and submitted to the World Bank for review, approval, and disclosure.

Methodology

The EMF (i) will describe the project and its components; (ii) explain the general anticipated environmental impacts and mitigation measures for the individual sub-project packages, which will be financed under the project; (iii) specify the requirements that will be followed with screening and categorization, assessment, and planning, including arrangements for meaningful consultation with affected people and other stakeholders and information disclosure requirements; (iv), assess the capability of the project proponents to implement national laws and World Bank ESS (policies and guidelines) requirements and identify needs for capacity building; (v) specify implementation procedures, institutional arrangements, and capacity development requirements; and (vi) specify monitoring and reporting requirements.

The EMF will also guide environmental assessment and reporting requirements to comply with both World Bank and government policies.

The activities with regards to EMF include but are not limited to the following:

Review environmental policies, regulations, and lessons learned

All the pertinent laws, regulations, and standards governing environmental quality, occupational health and safety, protection of sensitive areas and endangered species, siting, land use control, construction, etc., at international, national, regional, and local levels, are expected to apply to the proposed project activities will be reviewed. Various laws, standards, treaties, rules, and regulations about coastal areas of the country will be taken into consideration. Also, relevant studies, analysis, and experience in coastal embankment improvement in Bangladesh and other countries with similar environments and working conditions will be identified and the gaps to integrate environmental considerations in the project implementation will be determined. Finally, applicable ESS of the World Bank (ESS 1, ESS 2, ESS 3, ESS 4, ESS5, ESS 6, and ESS 10) will be reviewed. The Consultant will confirm their applicability, and the applicability of any others not mentioned here and describe their relevance to the project. A table will be prepared with all the necessary clearance/permission from the DoE and assisted BWDB in getting clearance/permission.

Define geographic scope and project components for EMF

The geographic area will be defined in which project activities will be carried out and field visits will be conducted as well as assembled secondary information to establish a preliminary baseline assessment of environmental issues and aspects about the project. All components of the project which may necessitate EIA, environmental screening, or other types of environmental assessment and management as per the national/regional/local regulatory framework as well as World Bank ESF will be identified and described accordingly.

Develop EMF

Environmental screening and assessment methodology (with project team) will be developed for the full range of potential project activities investments, which may broadly be considered. The EMF from CEIP-I will be used as a starting point so that EMF from CEIP-1 will be updated accordingly since the newly developed ESF applies to CEIP-2. The EMF will become a guiding material to prepare polder-specific EIAs. The developed EMF will provide guidelines (including procedures and institutional responsibilities) for preparation of sub-project specific environmental and social screening, assessment, management, and monitoring plans, including generic environmental codes of practice applicable to the range of investment activities expected under the project.

Consultation and disclosure plan

A consultation and disclosure plan will be developed for (a) the EMF, and (b) future subproject specific assessments and plans (including inter alia: how many, where, what level, by when, documentation requirements, etc.). The consultation and disclosure plan will identify the institutional mechanisms, responsibilities, and budget, including for inter-agency coordination, needed to implement the EMF and ensure all environmental considerations, as well as prevention, mitigation, and management aspects, are properly operationalized.

COVID-19 regulations and plan

A description about the survey plan for field survey considering COVID-19 can be found in Appendix 9.

Reporting and submission of documents

EMF report	By 6th Month

- Environmental screening and assessment methodology (with project team) will be developed for the full range of potential project activities investments, which may broadly be considered.
- The EMF from CEIP-I will be used as a starting point so that EMF from CEIP-1 will be updated accordingly since the newly developed ESF applies to CEIP-2.
- The EMF will become a guiding material to prepare polder-specific EIAs.

Polder wise draft EIA report (13 EIAs)	By 9th Month

Each draft EIA report will set out EMP containing the comprehensive mitigation measures with institutional responsibility, schedule, and associated cost. This will also include an environmental monitoring system to enable regular monitoring of the environmental performance of the project at the pre-construction, construction, and operational stage.

Contents of the EIA report

- Consultation plan;
- Collect baseline information;
- Alternatives during project development;
- Determine potential impacts including cumulative impacts;
- Evaluate climate change impacts;
- Consultation with modelling group;
- Define mitigation measures;
- Health and safety for construction workers;
- Public consultation.

Final EIA reports incorporating World Bank and BWDB comments	By 11th Month

Each draft EIA report will set out EMP containing the comprehensive mitigation measures with institutional responsibility, schedule, and associated cost. This will also include an environmental monitoring system to enable regular monitoring of the environmental performance of the project at the pre-construction, construction, and operational stage.

4.9.3 Fishery

Implementation of CEIP targets to protect the resident of that area from natural disasters as well as to protect, conserve fish and fisheries producing more fish and fisheries. The coastal region is characterized by numerous morphologically active tidal rivers and creeks, which provides a drainage net-work for a system of embanked hydrological units/polders. These peripheral rivers of the coastal polders have been experiencing siltation. To evacuate this silt every year as dig out the drain as well as need to construct the embankment. For constructing drainage and making embankment naturally a constraints are getting from entering water from river to basin area. With this fish migration inhibited and induce spawning of fish is not done. As a result, continuous incremental production of fish is not seen. Rather it is decreasing. To sustain and increase fish production need to take some measures. Need to maintain Community awareness and Community based Polder Aquaculture and Shrimp farming. In some Polder it can be done by Compartmentalization individually. Detail Feasibility study is necessary for doing this.

Consultant will conduct field visits targeted rural areas and will collect information and data directly from residence, shrimp fishers and farmers, and their association leader if any and other stakeholders. Information can collect through Participatory Rural appraisal (PRA) method, through Focus Group discussion and through in-depth interview and discussion. Data can be collected from the respective Departmental representative. For that Senior Upa-zila Fisheries Officer, officers from Research Institutes, Bangladesh Water Development Board (BWDB), and other NGO worker involved in fisheries activities can supplement this. Data, information can be collected on Total number of different Waterbodies, culture patterns and Practices, present Production, cost and benefits, impacts ,solution, fishing crafts and gears used, species composition and seasonal variability, routes of migration, breeding, constraints and possible solutions, species of conservation significance, intake of fish nutrition, income from fisheries ,value chain , marketing chain cooling facilities, safety of foods, to develop it, post harvesting facilities, keep safe handling ;Through intensive field visits and discussion with shrimp farmers, fish culturist and fishermen can be done. And from this it is possible to bring out the problems and prospects of fisheries in the polders and documentation of rarer experiences on innovative practices; Through conducting Focus Group Discussion can be collected fisheries information from Union and Farmers Level. Household survey can be conducted for collecting Farmer's response on identification and adaptation of new culture practices; in addition to these, from websites, related knowledge can be obtained.

Collected field data based on FGD and Household Survey can be Processed and analyzed for the drafting of the reports. The findings of the present study can be reviewed and analyzed. Based on the present situation on fisheries in the inside and outside polders fish biodiversity, seasonality, production of both fish, shrimp/Prawn of different existing waterbodies, potential scope culture practice interventions, enhance production, constraint, solution, impacts, prospects and future improvement, value chain, marketing chain, cooling facilities, safety of foods, to develop it, post harvesting facilities, keep safe handling and post harvesting situation with economic benefit can be obtained.

4.10 Economics

The Consultant will prepare an economic analysis - so called Cost-Benefit Analysis (CBA) - of the proposed interventions relevant for the selected 20 polders (13 selected + 7 from CEIP-1). The analysis will present insights in the financial and economic feasibility of the proposed interventions reflected by indicators regarding cost-effectiveness, benefit-cost ratios and economic rates of return. Important inputs for the economic analysis are the hydrological results (inundation maps for without interventions and with interventions for the years 2021-2050) and some key outputs of the technical feasibility analysis (preliminary designs of proposed interventions including estimations of investment and maintenance costs by the engineers).

In below figure the key stages of the economic analysis are shown. Some key issues will be highlighted below.

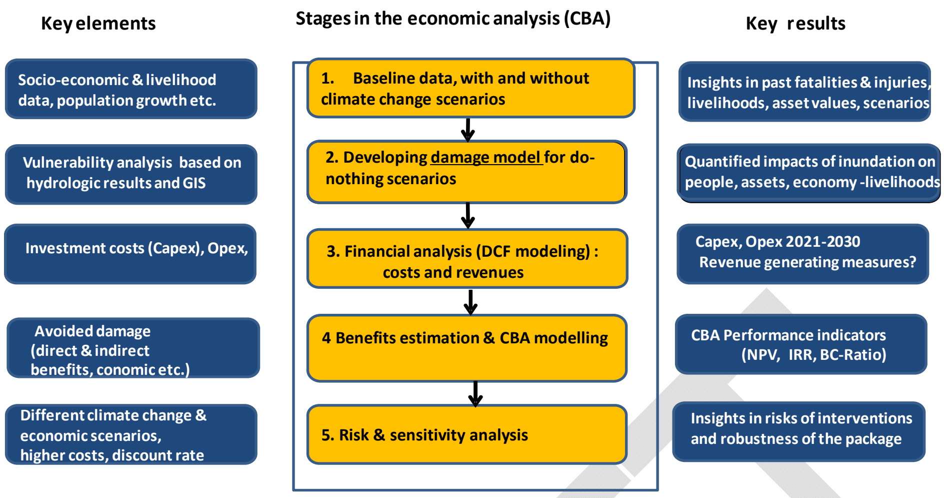

Figure 4.29: Key stages implementing the cost benefit analysis

Stage 1: Collecting baseline data and developing scenarios

The first stage will consist of collecting baseline data and developing scenarios. Baseline data regarding socio-economic indicators, previous flood events (storm surge and internal polder water logging), assets and economic sectors and livelihoods will be collected for the selected polders. Information from field surveys regarding the selected polders and existing assets from the previous stages of this assignment will be used. Also data from statistics office and google earth and street maps will be used.

Because the CBA is based upon future developments two development alternatives will be developed for the polders; so called baseline (do-nothing) alternative (without interventions). For the baseline (do nothing) alternative the existing protection (embankment height) will be inserted in the hydrodynamic model and if/ when this is not possible due to lack of data, it will be assumed that all polders are protected from storm surge events of 10 years return period (without climate change). Alternatives with interventions will therefore protect for more extreme events than T10. For the future scenarios the Consultant will aim to develop two scenarios: i) a scenario without climate change and ii) scenario with climate change. The without climate change scenario will be combined with a low economic growth scenario for Bangladesh and the polders. This will represent the modest estimation of future potential damage of storm surges or cyclones. The scenario with climate change will present a more pessimistic estimation of the future damage (the upper side of the bandwidth of damage). In this way we can present a realistic bandwidth for the impacts of flooding of the polders as a baseline for the period 2021-2050-2075.

Stage 2: Developing a damage model

CBA is always an incremental analysis (comparing with and without interventions scenarios). Therefore, we will develop a ***damage model*** for the two baseline (do-nothing) scenarios (without interventions). In the damage model the damage will be modelled based on the following hazards: storm surge level, significant wave height during cyclones, cyclonic wind speed, surface elevation for monsoon period, significant wave height for monsoon.

Regarding the avoidance of damage to assets it is proposed to assess this for the following different types of assets:

- Housing units (with if possible a classification of housing among (pucca, semi-pucca, kutcha, jhupri);
- Roads;
- Agricultural land areas;
- Aquacultural areas;
- Economic zones or tourism;
- Education facilities;
- Power and telecom;
- Health facilities.

The damage model estimates flood damages from storm surge events for multiple return periods. The return periods and their corresponding probability of flooding is listed in *Table 4-17*. Damage curves will be applied to estimate the damage for the do-nothing scenarios for different storm surge events (T10, T25, T50, T100). We will use international Global flood depth-damage functions of JRC for this analysis and aim to collect damage curves from other studies in Bangladesh. The impacts of the proposed interventions on inundation will be assessed by the engineers and hydrologists compared to the baseline (do-nothing scenarios) for these events. These estimations from the engineers/hydrologists will serve as inputs for the damage model (with interventions) and CBA. Ultimately, the Average Annual Expected Damage (AED) will be assessed for the period 2021-2050 (-2075) (with and without interventions) for 2 scenarios (with and without climate change combined with low and high socio-economic growth).

Table 4-17: Return periods and probability of flooding

Return period	Probability of flooding
10	0.1
25	0.04
50	0.02
100	0.01

Stage 3: Financial analysis of interventions

The investment costs (Capex) and operational and maintenance costs (Opex) will be estimated by the engineers. For the financial model a Discounted Cash Flow (DCF) model will be developed including the timing of the investments and operational and maintenance costs. Annual investment and maintenance costs and annual financial revenues will be presented in this model. If any interventions could generate financial revenues (for example land sales or toll income from a road on an embankment) for the initiator of the interventions, these will be included in the DCF model.

Stage 4: Estimation of societal benefits and costs of interventions

Regarding the societal *benefits of the coastal erosion, flood risk mitigation measures and drainage improvement* a CBA model will be developed. Some key societal benefits are to be expected from the proposed interventions (non-exhaustive) direct and indirect benefits:

a) Direct casualties and direct damage reduction;

Estimations of reduced casualties (fatalities and injuries), avoidance of asset damage (for about 7 different asset categories) will be presented. Special attention will be given to the agricultural and aquacultural assets, because in many polders primary benefits of the proposed interventions may be avoided agricultural and shrimp production damage and loss due to (i) a reduction in crop damages/losses; ii) improved drainage and flood management; (iii) changes in cropping patterns. The prevention of agricultural asset losses can translate into prevention of livelihoods of the people generating their income from agriculture & aquaculture.

In order to quantify the direct asset damage reduction benefits of interventions the outcomes of the hydrological analysis and damage model will be used. Regarding the economic and livelihood benefits relevant data on economic sectors (especially crops and shrimp areas of land) will be collected and previous study results (i.e. CEIP-1) will be used and updated.

b) Costs and benefits on social aspects, environment, health etc.

The social & environment impacts of the interventions will be assessed by KMC. In case KMC provides quantified impacts, CBA aims to monetize these impacts if monetization variables are available. The possibilities to quantify and monetize the social & environmental costs and benefits will to a large extent depend on the available data at polder level. A number of these benefits will be quantified and monetized, but some (like avoided fatalities or health and environmental benefits) might be more difficult to quantify of monetize. Consultant has ample experience assessing these benefits and can make use of the information collected from the CEIP-1 feasibility study, other CBA studies undertaken in Bangladesh and a recent study regarding conceptual designs for coastal erosion preventing interventions for 3 polders for the World Bank. Apart from this new data will be collected regarding livelihoods, existing and affected assets, agriculture and aquaculture, etc. which will be consistent with the needs for the socio-economic impact assessment. All in all this will ensure the proper quality of the cost-benefit analysis study in line with the World Bank requirements of appraisal.

Stage 5: Risk and sensitivity analysis

In the final stage a risk and sensitivity analysis will be undertaken. The sensitivity of CBA results (Internal Rate of Return (IRR), benefit cost-ratios) for different assumptions regarding discount rates or economic growth will be presented. Also the effects of risks such as higher investment costs will be shown. Moreover, the impacts of a different economic scenario with a larger shift from agricultural rise production to less inundation sensitive types of aquaculture (i.e. shrimp production) will be shown (as requested in ToR as shrimp production might be less vulnerable for flooding compared to agriculture).

The economic analysis has close relationships with other components of the feasibility study, such as the hydrological analysis and assessments of impacts of proposed interventions on inundation of the selected polders, technical feasibility and cost estimation and socio-economic and environmental impact assessment. The Consultant is fully aware of these relationships and will manage the study accordingly. The quality of the inputs of the hydrological experts (inundation maps, impacts of interventions on inundation levels) and local experts (volumes and prices of assets, agricultural and aquaculture production, sales or volumes of crops and fish species, volumes and prices of different categories of assets (housing, roads etc.), cost estimations, is in this respect of utmost importance.

5. Polder pre-screening report of 23 polders

This Chapter, constitutes the Deliverable "Polder Screening Report" as indicated un the ToR (Appendix 1). In this report, the process of pre-selection of 23 polders out of the 122 remaining polders is elaborated. Use is made of data and information available to the Consultant and provided by BWDB. It should be noted, that due to limited availability of the data required to perform polder screening, the Polder Screening Report concludes in selection of 23 polders based on a number of factors, however, a more detailed rationalization will be elaborated in the next report "Prioritization List of 13 Polders" (as per ToR in Appendix 1).

5.1 Introduction

The Bangladesh's Government progress to reduce the vulnerabilities of the coastal zone communities, includes construction of 139 polders, and has been outstanding during the last 60 years. However nowadays, the effectiveness of the polders have been compromised by either direct or indirect causes. Direct causes are amongst others, severe cyclones, shifting coastal and river bank lines and indirect causes are siltation and water-logging.

The prevailing vulnerability of the coastal zone to direct and indirect coastal threats, highlights the urgency to rehabilitate the damaged infrastructure as well as improve their resistance to climate change threats. Even though polder rehabilitation projects from severe cyclones have been introduced recently, such as ECRRP, the need to action is vital.

When the Polder concept was introduced, Polders have been designed to protect only against tidal flooding. Recently, and by taking projections of climate change into consideration, the Polder design has been upgraded by including additional protection measures against storm surges and cyclone flooding. The upgraded design was introduced and is currently being implemented under the Coastal Embankment Improvement Program (CEIP-1).

In 2013, the Coastal Embankment Improvement Project (CEIP-1) has initiated where 17 priority Polders have been selected for feasibility and implementation of rehabilitation and improvements. The Polders are clustered in six districts: Khulna, Bagerhat, Pirojpur, Barguna, Patuakhali and Satkhira mainly in the South West region. The commonalities between the selected Polders lay on their underlying threats by storm surges, drainage congestion, sedimentation and erosion. Currently only 10 polders of Packages 1 being polders32, 35/1, 33, 35/3 and Package-2 being polders 39/2C, 40/2, 41/1, 43/2C, 47/2 and 48 are being implemented and the 7 remaining polders of the envisaged 3 Packages, being Polders 14/1, 15, 16, 17/1, 17/2, 23 and 34/3.

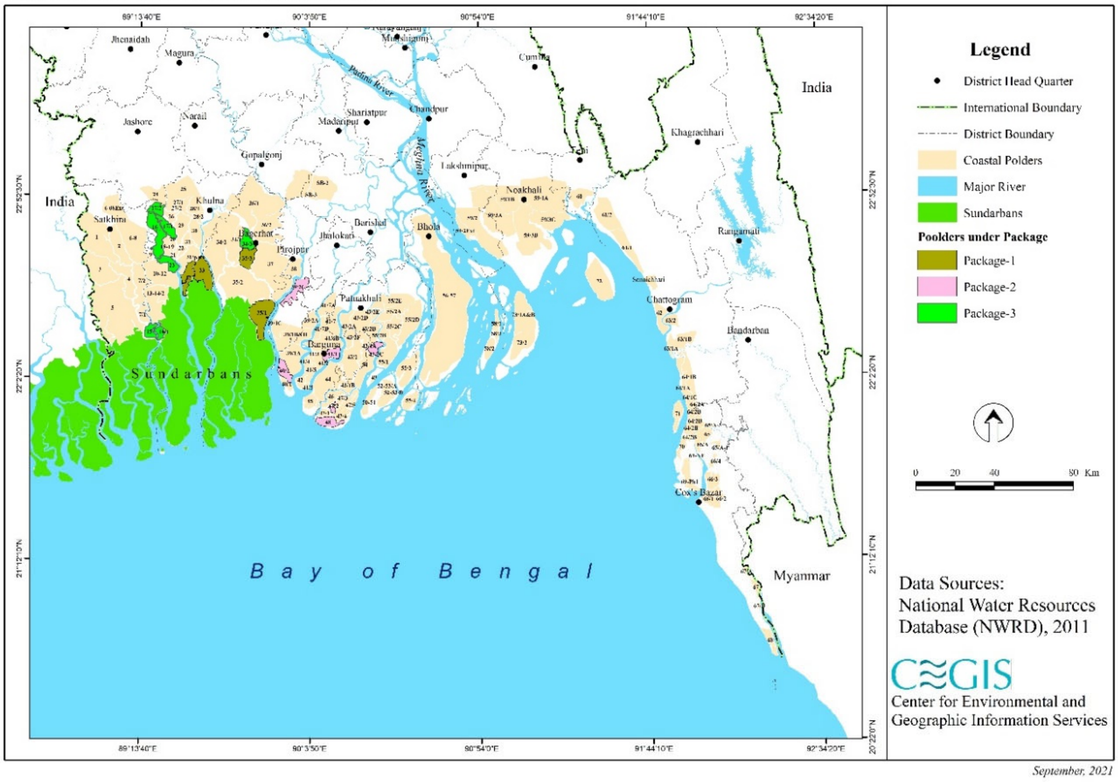

Figure 5.1: CEIP-1 Polders and other polders

Following CEIP-1, within Phase-2 of CEIP is intended to access the remaining 122 polders and select a next batch of 13 polders for implementing infrastructure improvement works. The selection of the polders will be done in stages and the approach and methodology is delineated in Section 4.3.

This Chapter focuses on the first stage of pre-selection of 23 polders out of the 122 remaining polders.

5.2 Pre-screening Framework

Pre-screening of the 122 polders in the coastal zone is carried out via means of a straight-forward framework as presented in Figure 5.2. This structured approach has allowed the Consultant to perform a quick-assessment and conclude to a first subset of polders which are considered more vulnerable and appear suitable to be taken forward in CEIP-2. The initial subset is intended to be less than 122 and more than 23 polders. Once this initial subset is formed, the polders included will be assessed via partial application of a Multi Criteria Analysis tool which is further described in the following sections.

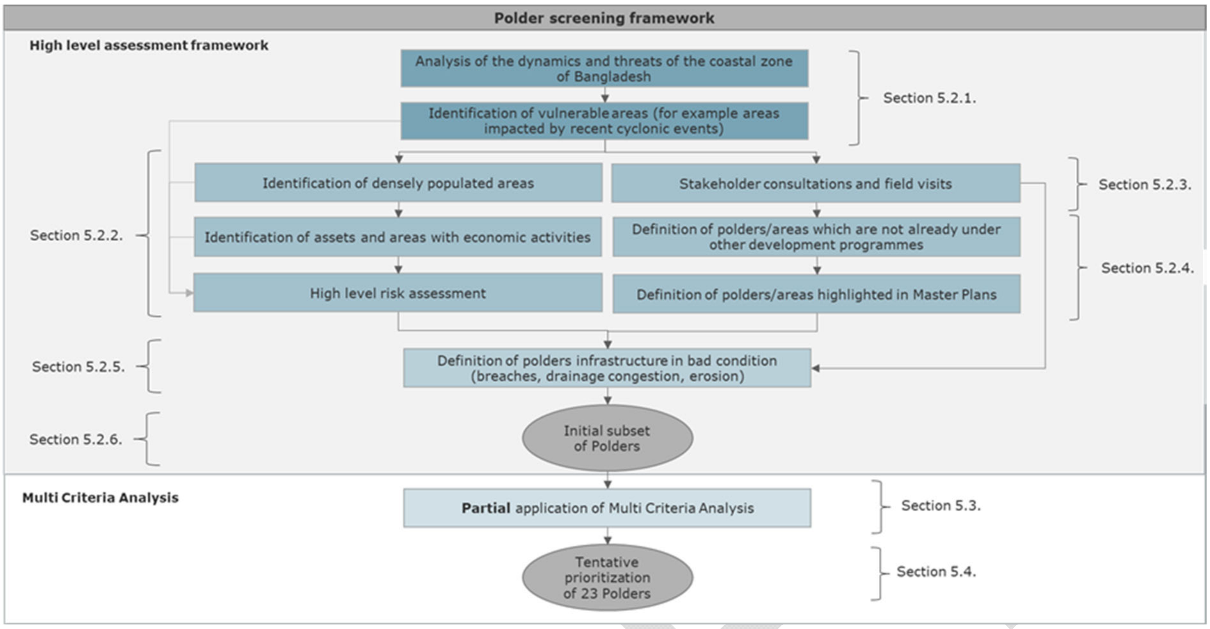

Figure 5.2: Polder pre-screening framework

As is mentioned in introductory section, due to lack of required data and limited time, this approach has not been followed precisely as:

- Important data in relation to the condition of the polder water related infrastructure have only been retrieved to a limited extent, until this moment;
- Important project documents (such as Long Term Monitoring Study) have not been received by the Consultant until this movement;
- Accuracy of data used as input for the high level risk assessment is not high;
- Key-stakeholder consultations are still ongoing.

Based on the collected information, the Consultant has made a tentative pre-selection of 23 polders based on the high-level assessment framework, while the MCA's use has been rather limited due to lack of data.

5.2.1 High level overview of coastal zone and vulnerabilities

Gaining a good understanding of the coastal zone dynamics (physical, social, environmental and economic), constitutes the first crucial step. Screening of the polders cannot take place before a good comprehension is established.

A brief presentation of the analysis results is presented below, and each of the components are more thoroughly elaborated in Appendix 10.

The coastal zone of Bangladesh can be divided into four zones[19] (Figure 5.3). Each of these zones has different physical characteristics related to tidal amplitude, sediments, morphological dynamics and vegetation.

Ganges Tidal Plains West (GTPW): This region is protected against hydrodynamic energy from the Bay of Bengal by the Sundarbans (mangrove) forest, that cover the first 60 to 80 km inland from the coastline. Mangrove belts form an effective, nature-based, coastal protection and provide the hinterland to the north with a significant of protection from cyclonic waves and surges, although cyclones still have an impact. Upstream of the Sundarbans, a vast system of low-lying polders surrounded by a complex river network exists till about 125 kilometers from the coastline. This area has long drainage routes of low gradients and limited freshwater flow from the parent river (the Ganges), mostly through the Gorai River. The tide is penetrating the entire area, bringing both salt water and fine sediments into the system and causing tidal fluctuations. The tidal variation at the coast is around 3 meters whereas the tide near Khulna is still 1.5 meter. There is some cyclic erosion and sedimentation occurring along the tidal rivers, whereas the open coast is predominantly eroding. Cyclones can generate extreme water levels and wind speeds in this area. Apart from the open coastline, waves are generally limited to locally generated wind waves. The interior part of the coastal zone is also subject to monsoon flood levels. Large-scale and long-term changes in the bifurcation of water and sediment over the rivers in the delta induced by both man-made and natural causes affect the fresh water and sediment input to the coast. A serious problem is restricted drainage, especially for the depressions ("beels"), which cause waterlogging and affect agricultural production. In several beels tidal river management (TRM) has already been implemented.

Ganges Tidal Plains East (GTPE): This area is characterized by a younger stage of estuary development, the land being intersected by a number of rivers receiving water from the Lower Meghna river, and from the Padma river via the Arial Khan river. This area has a flat topography with most areas just above mean sea level. The tidal range along the coast is somewhat higher at the coast (3.5 meter) but dampens further inland. The tidal rivers show cyclic behavior of erosion and sedimentation often located in the river bends due to lateral migration but the magnitude is generally limited to say a few meters per year. There is no substantial (mangrove) forest area, only a limited number of Sundarbans mangrove forest pockets located at the coastline with similar biotic characteristics as described above. The polders extend about 60 km inland from the coastline. Those facing the sea are subject to coastal erosion and lateral migration of the rivers is eroding polder embankments. River floods are not a major problem in this area, most of which is primarily subject to tidal effects. This zone is vulnerable to cyclonic storm surges and possible damages to infrastructure, agriculture and aquaculture.

[19] Hugh Brammer (2014). Bangladesh's dynamic coastal regions and sea-level rise

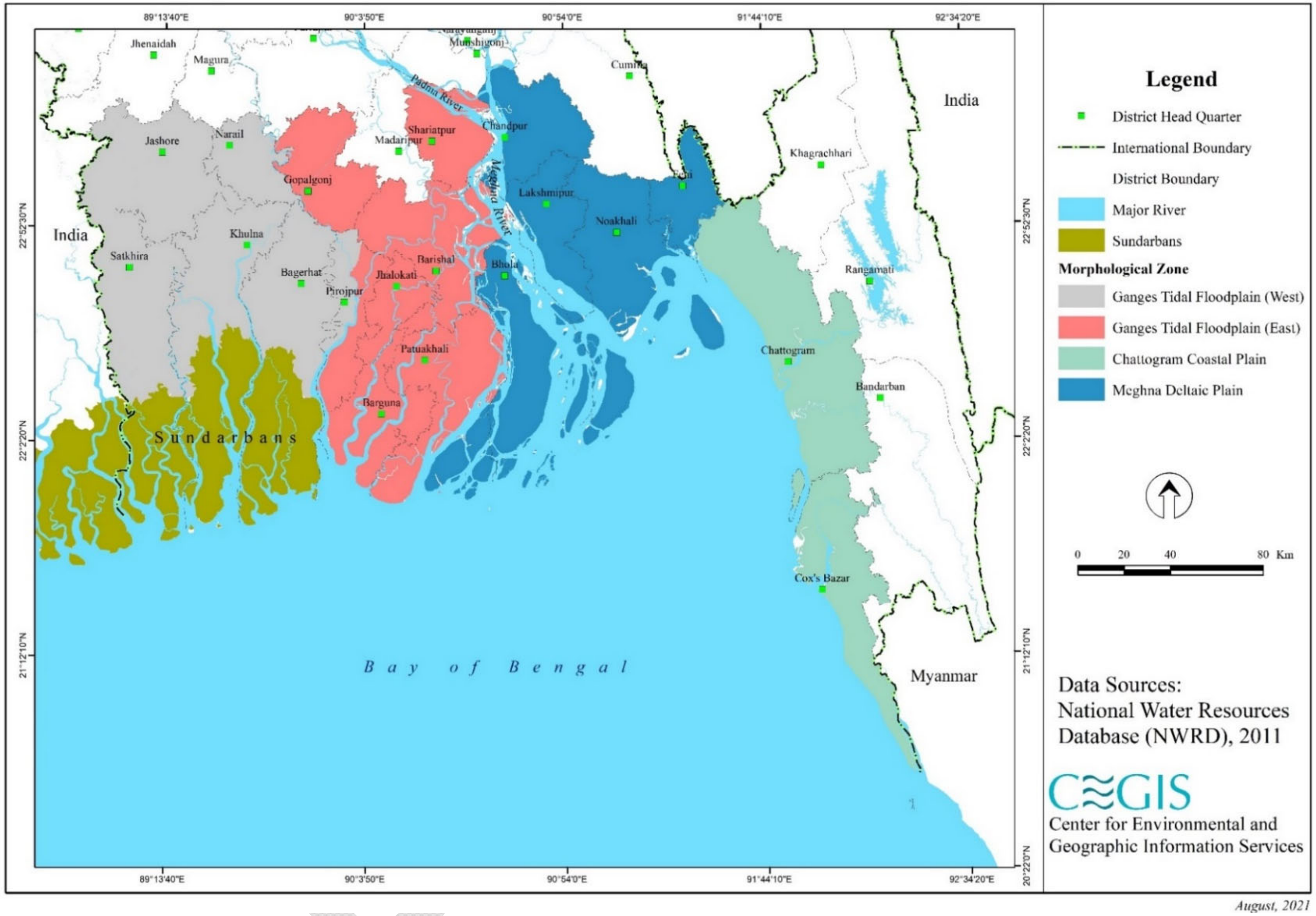

Figure 5.3: Coastal zone of Bangladesh

Meghna Deltaic Plain (MDP): is a very dynamic and flat estuarine coastal system due to the main outflow of the GBM system into the Bay of Bengal. This area has several very large polder systems such as Bhola island. The tidal range is high ranging its peak along the coast of Bangladesh of about 6 meters near Sandwip island. Large quantities of sediment are transported continuously towards the shallow coastal region of Bengal. The Meghna Plain is outbuilding as new land and it is being formed at a rate faster than the erosion of older land in this area. The planform of this area is rapidly changing with 100 meters or more per year in certain areas. Besides winds, cyclones can generate high water levels in this area. Some interior parts of the coastal zone near the Meghna Estuary also face elevated water levels during river floods. The newly accreted areas are initially too low and vulnerable for human settlement and agricultural use. Population pressure and urgent need for land is, nevertheless, causing people to settle on these recent deposits. Most of the islands are vulnerable to cyclone storm surges and erosion. The north-east and east sides of Bhola island, north and west sides of Hatia, west side of Manpura, and west side of Sandwip islands have been experiencing severe erosion. Some areas are also increasingly subject to prolonged waterlogging due to encroachment and land reclamation by closing the tidal channels. River floods are severe in some parts of the mainland near the Meghna estuary, especially in the districts of Chandpur, Lakshmipur, Noakhali and Feni.

Chittagong Coastal Plain (CCP): is a relatively narrow and stable flat coastal area but with a steep topography gradient into the hinterland. Between Chittagong and Cox's Bazar, a narrow strip of small polders exists with a few polders more south of this point. The tide ranges from 6 meters in the far north to about 3 meters near Teknaf. The coastal strip is directly exposed to winds and storm surge from cyclones. A problem that is not seen in the other three areas is flash floods from the hills immediately to the east. The steep gradients, and the tendency of hills to generate intense rainfall, produce rapid increases in discharge, which the rivers and other drainage channels across the flat coastal plain cannot convey safely. Sediment is delivered to the coast by small rivers originating from the hilly hinterland. Most of the coastline consists of sandy beaches, parts of which suffer from coastal erosion (e.g. along the Marine Drive south of Cox's Bazar). Waves generate a northward directed longshore current, that redistribute sediments along the coast. Due to variations in the wave forcing over the years and variations in sediment supply, erosion and deposition at the coastline is also variable over time and location. Some parts of the coast have rocky outcrops, that cannot erode.

5.2.2 High level risk assessment of storm surge inundation

A disaster risk signifies the possibility of adverse effects in the future and is composed from the hazard event itself, the exposure and the vulnerability of each coastal area. *Exposure* refers to the inventory of elements in an area in which hazard events may likely occur, while *vulnerability* suggests propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events[20,21], or else the degree of incapability of a coastal system to cope with the consequences of climate change, climate extremes, and

[20] UNDRO, 1980: Natural Disasters and Vulnerability Analysis. Report of Experts GroupMeeting of 9-12 July 1979, UNDRO, Geneva, Switzerland
[21] Cardona, O.D., 1986: Estudios de vulnerabilidad y evaluación del riesgo sísmico: Pla nificación física y urbana en áreas propensas. Boletín Técnico de la Asociación Colombiana de Ingeniería Sísmica, 33(2), 32-65

accelerated sea level rise[22]. Lastly, risk is defined as the probability of harmful consequences, or expected losses resulting from interactions between natural or human-induced hazards and vulnerable conditions[23].

An assessment of hazard related risks implies combination of exposure and vulnerability with the potential for harm, loss, or damage during an event occurring at certain locations[24].

Tropical cyclones, being the most prominent hazards in the coastal zone, generate excessive water levels and wind speeds, leading to extreme tangible risks on people, livelihoods and infrastructure. Those associated risks are largely stipulated by the physical vulnerability and are related to the probabilistic nature on the cyclones (return period and the cyclone track). As it is recognized that every cyclonic event generates different storm surge levels along the coast, the probability of occurrence of water levels varies along the coastal zone. Combining exposure with socioeconomic vulnerability, generates an area specific impact of cyclonic storm surge inundation levels.

Along those lines, a risk assessment of storm surge inundation of the coastal polders, paves the road towards obtaining an overview of associated impacts of such extreme events, which when combined with the probability of occurrence, result to bringing risk hotspots to the surface, which could subsequently be prioritized. Within CEIP-2, a GIS-based preliminary high-level risk assessment is considered high-level has been developed. This tool needs to be updated further in the study due to the following reasons: some of the currently used data does not provide the required accuracy (such as digital elevation model, inundation model), level of detail and date of data. In addition, for the sake of the purpose and the timeframe within which this risk assessment was required to be built, few assumptions have been made in relation to aspects such as existing level of protection, types of housing etc.

A brief description of the assessment of exposure and physical and socio-economic vulnerability, as used in this tool is presented in Appendix 10 (A10.8).

The high level risk assessment is used to perform a vulnerability assessment and thereafter transforming those damages into risk. By definition, risk considers the consequences and weighs in the aspect of the probability of occurrence of a hazardous events such as storm surge inundation. Large events that normally cause substantial damage may not contribute a great deal to the average annual costs due to their low probability. Increasing return periods also means an increase in the damage costs, however also a lower probability of occurring, yielding the relation seen in this figure between the flood risk and the return period[25]. Through estimation of Annual Expected Damage (AED), the mean loss (the “expected value”) that occurs in any given year is signified, which represents a long-term average. Based on the Estimated

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[22] Intergovernmental Panel on Climate Change (IPCC). 2001b. Climate change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the IPCC. Cambridge, UK: Cambridge University Press
[23] UN-ISDR (2009). Terminology on Disaster risk Reduction. URL: https://www.unisdr.org/we/inform/terminology
[24] Kron, W. Flood Risk = Hazard • Values • Vulnerability. Water Int. 2005, 30, 58–68
[25] Anders Skovgård Olsen et al. (2014) Comparing Methods of Calculating Expected Annual Damage in Urban Pluvial Flood Risk Assessments

Annual Damage, the following risk maps have been generated (Figure 5.4 Figure 5.5) for the baseline and climate change scenario.

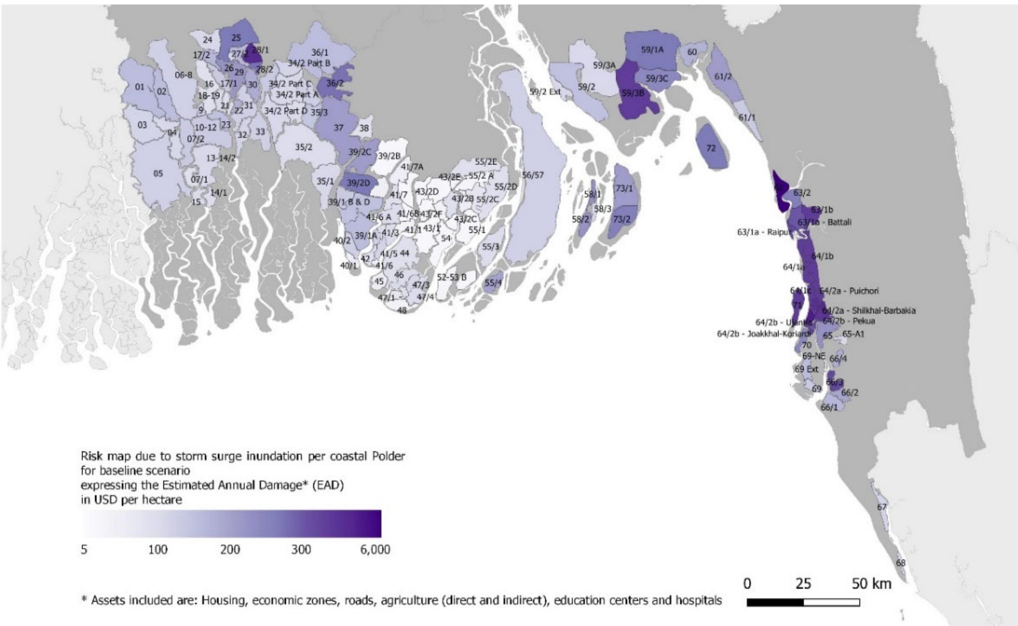


Figure 5.4: Risk map due to storm surge inundation in baseline scenario

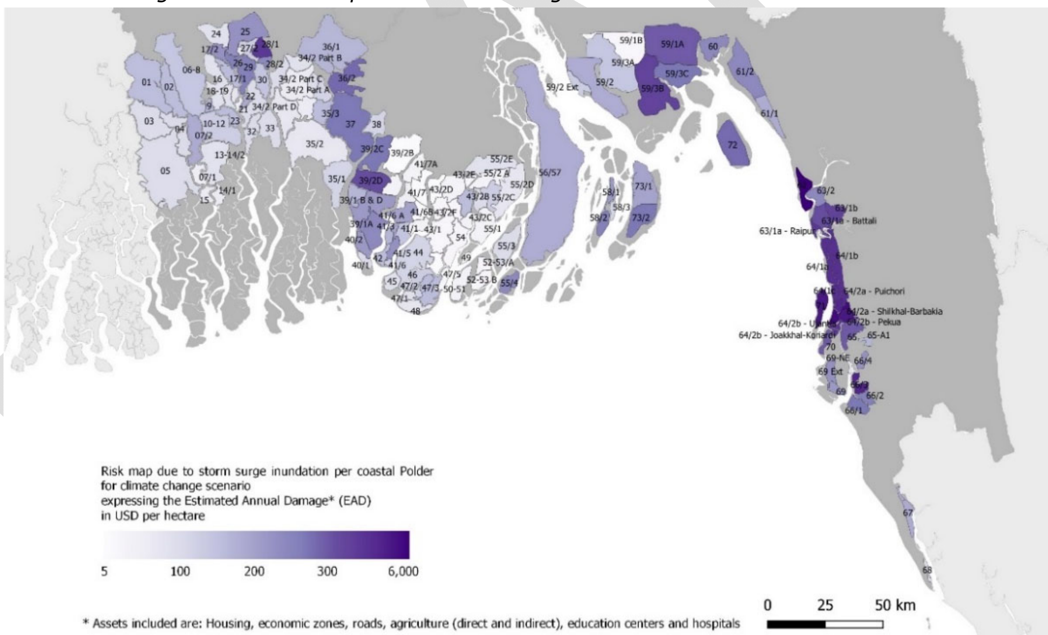


Figure 5.5: Risk map due to storm surge inundation polder in climate change scenario

5.2.3 Stakeholder consultations and field visits as inputs

Stakeholder consultations

Stakeholder consultations was a crucial parameter for the polder screening, since it brought valuable information into the surface, both related to high-priority polders in connection to potential developments in the coastal zone as well as the condition of the polder water infrastructure.

The following list of Field officials of Bangladesh Water Development Board (BWDB) contacted for collection of coastal Polders data/information.

Sl. No.	Name and Designation	Office Address
01	Akhil Kumar Biswas, Chief Engineer	South-Eastern Zone, BWDB, Chattagram.
02	Md. Rafiq Ullah, Additional Chief Engineer	South Western Zone, BWDB, Khulna.
03	Md. Nurul Islam Sarker, Additional Chief Engineer	Southern Zone, BWDB, Barisal.
04	Md. Abul Hossain, Superintending Engineer	Khulna O & M Circle, BWDB, Khulna.
05	Mozibur Rahman, Superintending Engineer	Patuakhali Water Development Circle, BWDB, Patuakhali.
06	Md. Ashraful Alam, Executive Engineer	Khulna O & M Division-1, BWDB, Khulna.
07	Md. Abul Khayer, Executive Engineer	Satkhira O & M Division-1, BWDB, Satkhira.
08	Md. Rashidur Rahman, Executive Engineer	Satkhira O & M Division-2, BWDB, Satkhira.
09	Bishajit Baydda, Executive Engineer	Bagerhat O & M Division, BWDB, Bagerhat.
10	Md. Halim Salehe, Executive Engineer	Patuakhali O & M Division, BWDB, Patuakhali.
11	Md. Kaisar Alam Executive Engineer	Barguna O & M Division, BWDB, Barguna.
12	Hasan Mahamud, Executive Engineer	Bhola O & M Division-2, Charfashon, Bhola
13	Md. Nasir Uddin, Executive Engineer	Noakhali O & M Division, BWDB, Noakhali.
14	Faruk Ahmed, Executive Engineer	Laxmipur O & M Division, BWDB, Laxmipur.
15	Nahid-Uz- Zaman Khan, Executive Engineer	Chittagong O & M Division-2, BWDB, Chattagram.
16	Prabir Kumar Goshswami, Executive Engineer	Cox's-Bazar O & M Division, BWDB, Cox's-Bazer.

Field visits

Field visits have been performed to a significant number of polders among the ones pointed out during the stakeholder consultations. The purpose of the field visits was to perform a quick-visual inspection of the condition of the water infrastructure. The most vulnerable/ damaged spots have been visited and pictures have been taken which are presented in Appendix 7.

5.2.4 Exploration of coastal zone developments

5.2.4.1 BDP2100

The current Investment Plan is the first such selection of projects to put the BDP2100 into action. It sets out the physical and institutional investments the Government will make to put the Delta Plan into effect. The current Investment Plan consists of a total of 80 projects: 65 are physical projects, and 15 are institutional and knowledge development projects. These 80 projects were then grouped into the seven 'hotspots' defined in the Delta Plan, among which the Coastal Zone and the River and Estuarine Hotspots are the most relevant to CEIP-2.

Some interventions within the investment plan simply build and expand on what is already being done (Cluster 0+ projects). Others require a change from the current approach (Cluster 1 projects). At the extreme, some may require changing the behaviour of the water system (Cluster 2 projects).

Coastal zone hotspot:

The 23 projects included in the BDP2100 related to the coastal are predominantly focused on the theme of 'preventing too much water' and include flood protection infrastructure, land reclamation projects, and development of chars and polders.

The knowledge-oriented projects include the development of GIS and remote sensing technologies for Integrated Coastal Zone land use planning; preparatory studies of ways to reclaim land beyond the coast; a study on the morphological dynamics of the Meghna Estuary; a study on integrated management of drainage congestion for the Greater Nohkhali (southeast region); studies aiming to develop a suitable institutional arrangement for proper management of polders, and environmental and social impacts of TRM; Rationalization of Polders in vulnerable areas; studies of the possibilities for multipurpose sea-dykes and barriers; and development of a Climate Smart Integrated Coastal Resource Database.

Twelve projects simply build and expand on what is already being done, are slated for immediate commencement. Two of the Coastal Zone projects require a change from the current approach projects, meaning that they involve a step change in approach. The first of these is the Urichar-Noakhali cross dam project. This is programmed to start in 2022, after the relevant knowledge products have been completed. The second project involves land reclamation by constructing a cross dam between Hatiya and Nijhum Dwip.

Two investment plans are put on the spotlight which are highly relevant with CEIP-2:

- Rationalization of Polders in Baleswar – Tentulia Basin (CZ1.44);
- Rationalization of Polders in Gorai-Passur Basin (CZ1.40).

These investment plans are aiming to reduce the loss of assets, crops and livestock; reduce vulnerability loss; reduce salt water intrusion; increase agricultural production; improve drainage congestion situation; improve institutional setting.

Rivers and Estuaries hotspot:

The Rivers and Estuaries Investment Plan includes seven projects focused on improving management of rivers. Two are knowledge projects, and five are infrastructure projects.

The most significant of these is the Integrated Jamuna- Padma Rivers Stabilization and Land Reclamation Project. The aim of the project is to stabilize the banks of the Jamuna-Padma to control river-bank erosion, increase land reclamation, reduce flood risk by construction of embankments, restore navigation and maintain safe navigation channels, increase land-based productivity through intensified agriculture, and designate environmental protection zones along the river.

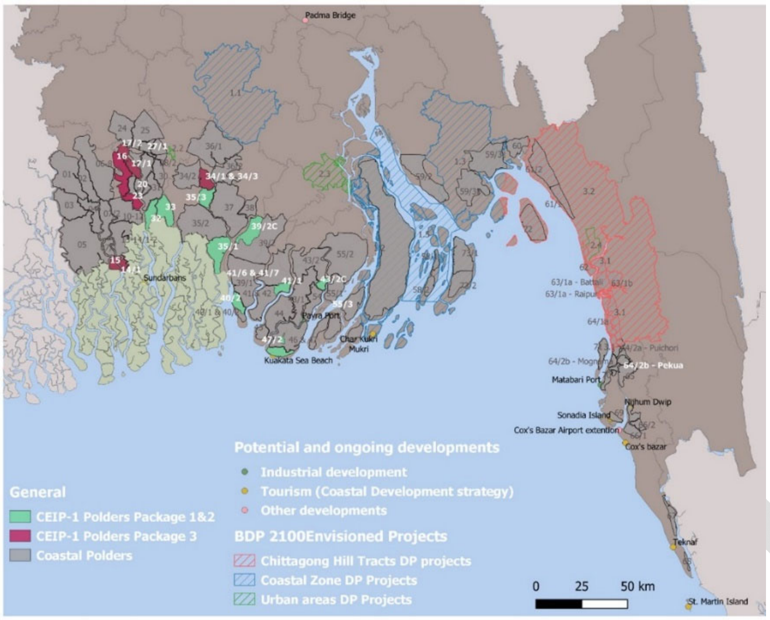
The other three infrastructure projects aim to ensure that there is enough water when and where it is needed, whether for navigation, irrigation, or municipal supply. The Sustainable Restoration of Connectivity of Major Navigation Routes will use dredging and other techniques to restore and maintain navigability of 24 river routes by dredging; open up around 2500km of waterways for smooth and year-round plying of waterways; increase the water flow of the respective rivers.

Based on, amongst others, the Bangladesh Coastal Policy of 2005 and more recently the BDP2100, potential and ongoing developments are shown in Figure 5.6.

5.2.4.2 Coastal zone Policy

The Coastal Zone Policy[26] (CZPo) and the Coastal Development Strategy[27] consider that out of the 19 districts belonging in the coastal zone, a total of 48 upazilas/thanas are considered as ‘exposed’ directly to vulnerabilities from natural disasters. The exclusive economic zone (EEZ) is regarded as the seaward coastal zone. The Government has made the coastal zone policy statements in relation to development objectives. These policies provide general guidance so that the coastal people can pursue their livelihoods under secured conditions in a sustainable manner without impairing the integrity of the natural environment. Its is mentioned that Cox’s Bazar, Nijhum Dwip, St. Martin Island and Kuakata sea beaches and Sundarbans will be further developed to attract tourists and those areas and islands will be developed as “Special Zone for Tourism”.

[26] Coastal Zone Policy, Ministry of Water Resources, Government of the People’s Republic of Bangladesh, 2005.
[27] Coastal Development Strategy, http://old.warpo.gov.bd/strategy/coastalDevPolicy.pdf, 2006.



Legend:

Coastal Zone BDP 2100
1.1 West Gopalganj Integrated Water management project
1.2 Development of Water Management Infrastructure in Bhola Island
1.3 Char Development and Settlement Project- V
1.4 Rehabilitation of Water Management Infrastructure in Bhola Island
1.5 Morphological dynamics in Meghna Estuary for sustainable Char development

Urban area BDP 2100
2.1 Khulna Water Supply Project Phase II
2.2 Improvement of drainage network, flood control and solid waste management
2.3 Improvement of drainage congestion, canal dredging flood control
2.4 Improvement of Drainage and Congestion and flood control

Chattogram Hill Tracks BDP 2100
3.1 Rationalization of Polders
3.2 Enhancement of livelihood through good agricultural practises
3.3 Flow control and water storage

Figure 5.6: Potential developments in coastal zone of Bangladesh

5.2.4.3 Ongoing/ past projects/ programmes

CEIP-1, ECRRP and Blue Gold

Several polders have been recently rehabilitated by ECCRP and of course, CEIP-1. In addition, the Blue Gold Programme Program has rehabilitated several polders and in addition has improved the drainage practises and infrastructure. In general, a number of these polders are considered to be in a good condition since those projects have only been recently completed. However, there are many exceptions of polder which have deteriorated and severely damaged due to impacts from recent cyclonic events and monsoon discharges.

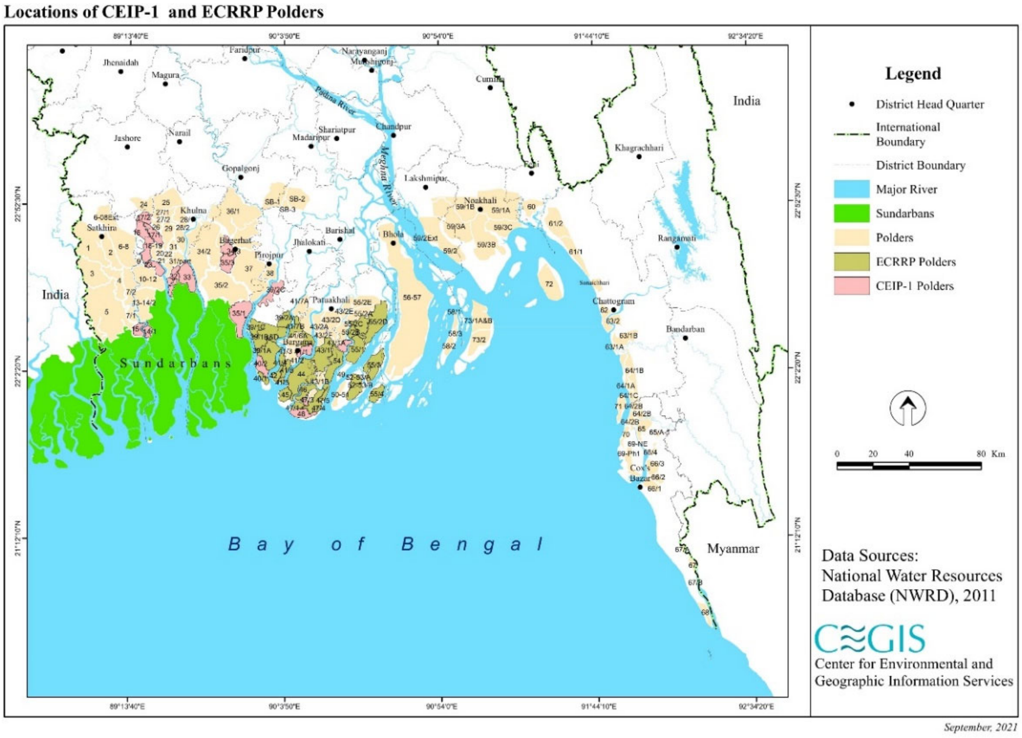


Figure 5.7: CEIP-1 and ECRRP polders

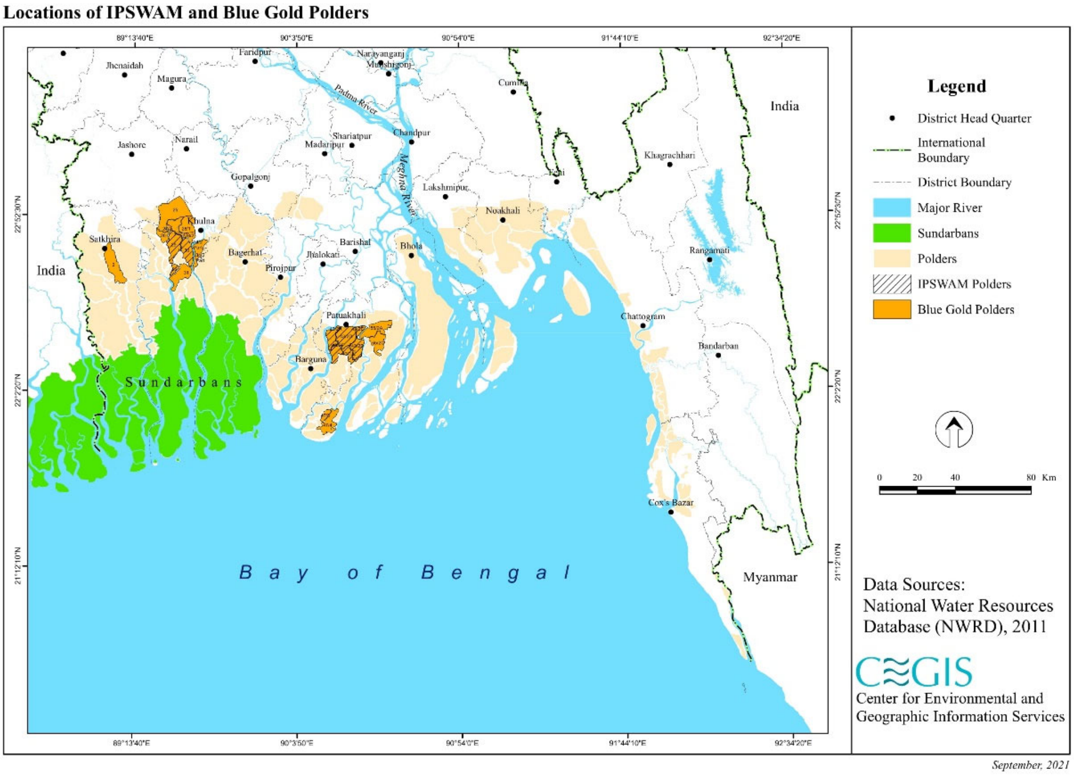


Figure 5.8: IPSWAM and Blue Gold Programme rehabilitated polders

Payra Port development

The objectives of the Payra Port development are the development of the region through the development of the port and adding much needed port capacity in Bangladesh. One of the current drivers of the port development are the powerplants located 20 km inshore (30 million tons of coal are expected). Even though the Master Plan has not yet been finalized, an alternative location of the port would be in the confluence of Galachipa River and Rabnabad Channel. Sedimentation volumes are expected to be very large based on previous studies conducted and that would require continuous dredging of the access channel.

With port developments on the way, in combination with raising and strengthening the embankment, it may be crucial that CEIP-2 will consider wideing the embankments to accommodate the future traffic load in connection with the associated development of a targeted middle-income country. Within the development scenaros, the export/import potential will increase the investment in the existing shrimp/fish ghers inside and outside the embankments which might complicate the planned width and alignment of the embankments, and this issue should be well addressed in he planning.

Mongla Port and powerplant

Mongla Port the second largest seaport, 48 km south of Khulna town and is situated on the confluence of the rivers Pasur and Mongla at mouza Selabunia of Rampal upazila of Bagerhat district. Tthe port often remained closed because it lost proper depth required for the ocean-going ships and every time it was reopened after dredging. Currently studies are ongoing to improve the access channels from sea to Mongla Port.

5.2.5 Assessment of infrastructure condition

The coastal zone has various infrastructure systems enabling livelihoods of the coastal communities but these are also key for the Bangladesh economy as a whole. These infrastructure systems are relevant in that these are necessary for protection against flooding (polder embankment system), for transportation of people, goods and materials (roads and waterways/ports) and for agriculture/aquaculture and other economic activities in the polder system (water management systems). Within this assessment, water management infrastructure are put in the spotlight.

The polders have two main water infrastructural elements: coastal embankments surrounding the polder and a drainage system inside the polder. In total, there is about 5,000 kilometers of embankments in the coastal zone protecting an area of 1.2 million ha (25% of the coastal zone). These embankments are earthen embankments with a grass cover. The elevation of these embankments varies but is typically 2 to 4 meters above ground level and often also have a road on top. Where necessary, slope protection is present at the sloping facing the waterside to protect against cyclone waves. Also, bank protection is put in place below the waterline where the riverbank or coastline is eroding to ensure stability of the embankment. Due to lack of rock in Bangladesh, slope and bank protection is typically made from concrete blocks to withstand the impacts of waves and currents.

These polders are criss-crossed by a gravity-based drainage network exists of small canals (khals) to regulate the water levels and drain excess rainfall from the polder. These are typically a few meters wide and shallow. Water level control structures ('regulators') are present in these canals. These are relatively small structures which can be raised or lowered to have different canal levels and regulate the flow. Drainage structures are much larger structures inside the embankments and connect the internal drainage system with the adjacent river system. These are structures which can be manually opened during low water to let water drain into the adjacent river or let water in during high water to flush the canal systems. The estimated length of canals inside the 139 polders is around 8,000 km and there are more than 2,000 drainage structure and more than 1,000 regulators[28] in the entire coastal zone.

The good condition of the water infrastructure is vital for the protection of the coastal communities from coastal hazards and their livelihoods, and for that reason the current condition has been assessed via stakeholder consultations and field visits.

5.2.6 Conclusions

Identification of vulnerable areas

As a result of the high level overview of the coastal zone and its vulnerabilities, and in combination with the findings of the BDP2100 (the districts that face serious natural hazard risks have been assessed), the following could be concluded, in terms of district-wise presence of natural hazards (Table 5-1). The ranking is based on a simple methodology whereby districts facing the most number of hazard risks are ranked as most hazard-prone[29]. More specifically, districts that face 4 or more types of hazards are rated as the most hazard-prone districts and are given a rating of 1. Districts that face 3 types of hazards are rated as next most hazard-prone and given a rating of 2. Some districts that face 2 types of hazard but the intensity and potential economic damage is large are also rated as 2. The methodology does not seek precision but is intended as indicative to enable an assessment of the relationship with welfare indicators, especially poverty and income.

Table 5-1: District Level Natural Hazard Ranking (source: BDP2100)

District	Hazard ranking	Sea Level Rise[1]	Flood	Cyclone [2]	Salinity	Drought	River Erosion[3]	Water logging [4]
Bagerhat	1	x	x	x	x			x
Barguna	1	x	x	x	x		x	
Barisal	2		x	x			x	
Bhola	1	x	x	x	x		x	
Chandpur	1		x				x	
Chittagong	1	x	x	x				
Cox's Bazar	1	x	x	x	x			

[28] These numbers are estimated based on the CEIP-1 documentation for 17 polders and scaled to the entire polder system.
[29] BDP2100

Feni	1	x		x	x		x	
Jessore	2				x	x		x
Jhalokati	2		x		x			
Khulna	1		x	x	x			x
Lakshmipur	1	x	x	x	x		x	x
Noakhali	1	x		x	x		x	x
Patuakhali	1	x	x	x	x		x	
Pirojpur	1		x	x	x		x	
Satkhira	1	x	x		x	x		x
Shariatpur	2		x				x	

1. Impact from climate change increase of storm surge*:* Calculated by differences in modelled storm surges between baseline and climate change scenario based on CEIP-1 models. It appears that the coastal polders located in the East Ganges Plein are impacted the most from enhanced storm surge from climate change,.

2. Vulnerability to past cyclones: West and East Ganges plain have been most severely impacted from the three last cyclones (Sird, Aila and Amphan). Particularly cyclone Sidr affected severely Bagerhat, Barguna, Patuakhali districts. Cylone Aila had strong impacts in Satkhira, Khulna and Patuakhali Districts. And last but not least, cyclone Amphan's effects where maximized in Satkhira, Khulna, Barguna and Patuakhali Districts. In addition, Khulna and Satkhira presented the largest damages in embankments and infrastructure during Amphan.

3. Erosion*:* An understanding of the dynamics of the morphology in the coastal zone, in combination with visualization of the erosion map from Aquamonitor tool (Deltares) and from discussions with Long Term Monitoring Study Consultants, the rivers located in the West and East Ganges Plain suffer from significant erosion. Rivers such as Pussur, Biskhali and Baleswar experience high erosion rates. In addition, CEIP-1 polders which are located along the Baleswar river have revealed fluctuating erosion rates which peak when current velocities are maximized. In addition, the sediment–water dynamics within the Meghna estuary are very complex due to its irregular shape, wide seasonal variations, and the role of the tide.

4. Water logging: Recent remote sensing images show that water logging is occurring mainly in southwestern region (Bagerhat, Khulna and Satkhira) of coastal zone.

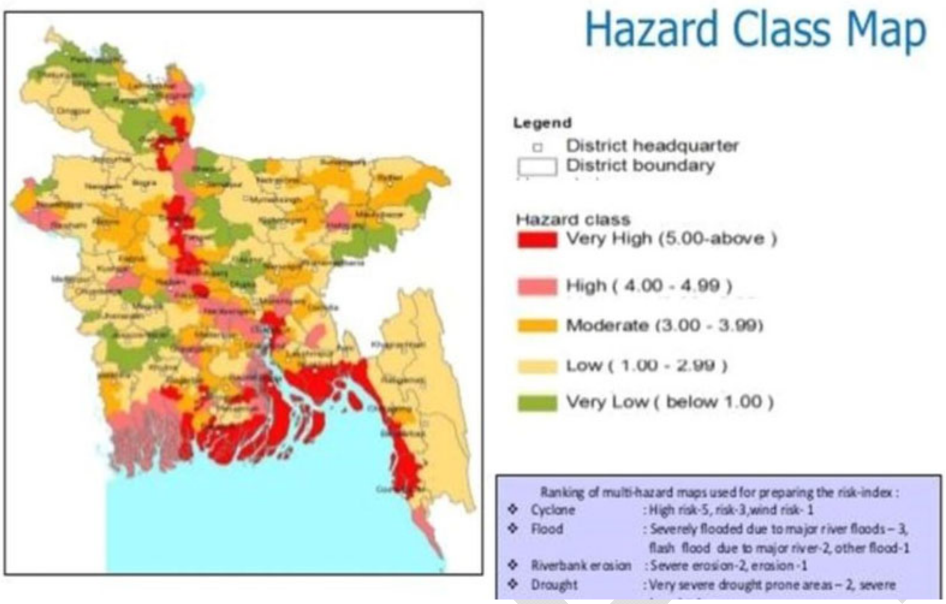


Figure 5.9: Hazard map Bangladesh.
Source (Rahman, 2014, May 15)

High level risk assessment: Polders in the West and East Ganges Plain are under risk of storm surge, due to combination of low land elevation, frequent occurrence of cyclonic events and large population and economic activities.

Stakeholder consultations: During key-stakeholder consultations (BWDB), the importance to rehabilitate polders which have been impacted by Amphan was indicated since they are currently in a bad condition and are located in the south-western part of the coastal zone. In addition, some other polders have been highlighted as top priority, in relation to the condition of the infrastructure, as well as since they are part of wider development plans.

Field visits and condition of embankments: The field visits performed in the polders which have been identified as very vulnerable, throughout the high level analysis and during the stakeholder consultations, verified their bad condition.

Development plans:

The development plans in the coastal zone have put in the spotlight the polders in Baleswar – Tentulia Basin as well as Gorai-Passur Basin which, as indicated in the BDP2100, there are plans to rationalize those polders.

In addition, potential development of Payra port leads to focus on polders that are located along the future access channel. In addition, several polders that have been rehabilitated under ECRRP (completed in 2018) and are already in bad condition indicates the urgency for rehabilitation due to two the following main reasons:

- Since water related infrastructure is newly constructed, eventual damages indicate significant exposure to hazards;

- Those polders may be less capital extensive since large extent has already been rehabilitated;
- Acting soon is important since the condition of the infrastructure adjacent to the damaged parts could deteriorate soon, due to absence of a polder system behaviour.

The same refers to the Blue Gold polders but in a lesser extent, since Blue Gold is mostly water management oriented. However, this component is also significant within CEIP-2.

Pre-screening results

The pre-screening polder framework has brought into the surface the vulnerability of the East and West Ganges Plain and specifically the Baleswar – Tentulia Basin as well as Gorai-Passur Basin.

Consultant understands that the whole coastal zone is exposed to a wide range of threats and is highly vulnerable but after all, the prioritization will only define which polders will be improved sooner and which ones will be dealt with later. In that respect, and in terms of efficiency in planning and construction works, polder clustering will be an important parameter, as has been also proved from CEIP-1 implementation. Since the primary focus is on areas which have been impacted by the most recent cyclones (thus the West and East Ganges Plain), Consultant recommends to cluster the selected polders in packages which are located in those two wider areas. Consequently, polders located in Meghna Estuary Plain and Chittagong Plain will not be taken forward in the selection procedure.

Appendix 11 presents the list of polders and respective high-level scoring of each of above categories.

5.3 Multi Criteria Analysis

5.3.1 Introduction

Flood protection projects deal with multiple aspects which relate either to the proper investment location or the selection of the optimal protective structure/ mechanism. Those aspects should be evaluated considering a variety of factors related to their technical efficiency, the environment, the society. In addition they should be economically evaluated in terms of their efficiency, i.e. the sum of the costs and benefits of a project over its lifetime.

Within CEIP-2, the evaluation of the most urgent investment locations (in other words the selection of polders) is performed using a MCA tool.

As delineated in the approach description of Section 4.3, MCA tool will be used during two stages of the study in different level of detail:

1. During selection of 23 polders out of the first reduced batch (as explained in the previous section);

2. During selection of 13 polders out of the 23 prioritized polders (as is explained in the following section).

In this stage, the Consultant has already prepared the MCA template, as explained in the following sections. However, in this Report, due to limited availability of the data, the use of the MCA was rather limited and the selection of 23 polders has been performed mostly based on the pre-screening framework (as explained in Section 5.2). A more detailed rationalization (using the MCA) will be elaborated in the next report "Prioritization List of 13 Polders" (as explained in the ToR in Appendix 1).

5.3.2 Guiding principles

Definition of the guiding principles of this project is crucial for setting up an MCA which takes into account all the aspects which are relevant and important for successful project execution. In other words, the guiding principles will outline the rationale of the MCA and the content of the scoring criteria. Definition of the guiding principles will be extracted from important lessons learned from past/ ongoing projects, visions of plans and policies, personal judgement of the Consultant and last but not least, the views of the BWDB and other key stakeholders.

Both feasibility study and implementation phase of CEIP-1 are widely relevant to this present study, and its lessons learned will assist in shaping the guiding principles for CEIP-2. Important aspects are amongst others, feasibility, technical design, numerical modelling, environmental and social assessment, land acquisition, resettlement, bidding and construction. The lessons learned for each of those aspects are elaborated in detail in Section 2.3.2, Appendix 3.

The Blue Gold Programme is also very relevant for CEIP-2, as it focuses on establishing and empowering rural community co-operatives to sustainably manage their sea defense, drainage and irrigation infrastructure in order to achieve, amongst others, an increased sustainability of the development of the polders and effective use of water resources. Internal water management is applicable for CEIP-2, since it goes in hand with the rehabilitation and construction of new regulators. The lessons learned from Blue Gold are elaborated in Section 2.3.2. and some are used as guiding principles for CEIP-2.

The Bangladesh Delta Plan 2100 (BDP2100), a strategic plan with a long-term horizon of 100 years as well as a short-track implementation programme, paints the horizon and defines the wider direction of CEIP-2. The BDP2100 has thus been very closely looked at in order to derive socio-economic development scenarios, projections and visions.

Lessons learned from other projects (Appendix 3) as well as the wide experience of the Consultant in the coastal zone of Bangladesh and stakeholders' views have contributed in the delineation of guiding principles as presented below.

<u>Land acquisition</u>
The significance and relevance of land acquisition to the project is two-fold.

Firstly, resettlement of people during construction and land acquisition is affecting the people of the coastal community, both positively and negatively by, amongst others:

- Straining on the social fabric with addition of employment business opportunities in providing goods and services to the project and to the labour force;
- Leaving their place would potentially make them socially and culturally dislocated and yearning for opportunities to be resettled in their original cluster community;
- Disruption of settlements and agricultural activity by the land taken temporarily to service the contractors' activities and additional land that is acquired permanently for embankment retirement and re-sectioning;
- Necessary eviction of embankment settlers, at least for the period when the embankment is being re-sectioned.

Secondly, land acquisition is a critical factor for the progress of the works. To obtain physical possession of the site first affected land owners need to be compensated. Within CEIP-1, the approval of payment of compensation to the affected landowners has taken a very long time, resulting in delays of the works in the field.

Erosion and land acquisition

If a polder is located along a dynamic river and erosion rate is high, then there is the risk that when time for implementation comes, significant changes have appeared in this stretch and thus land acquisition may be required for the retirement of the embankment. Therefore, when a high erosion rate is present requirement for land acquired will be larger, accounting for a larger set back distance. During CEIP-1, in several locations, the original alignment through the existing embankment had to be changed and there was decided to construct a retired embankment and subsequently a revised LAP had to be proposed which is an extremely lengthy process. It took a long time to obtain the physical possession of lands for continuation of the ongoing works.

Construction logistics

The availability and accessibility of construction materials is highly important for the timely progress and quality of the construction works. Polders located in remote areas are more likely to present difficulties in accessing construction materials. In CEIP-1, the construction/re-sectioning of the embankments had to be carried out by the contractor taking earth by their own initiatives. Since there were no free borrow pit areas adjacent to the alignment, the contractor had to make the earth available with the help of local people. Sometimes they had to deal with people who took money without fulfilling their commitment.

In terms of construction logistics, clustering of polders which are located in the same wider area is very significant for the effective execution of works. In that way, both supervision staff and equipment can operate within a wider area, avoiding traveling long distances. In addition, the connection among those polders, as well as the connection of each polder to urban areas is very significant.

Plans and policies such as the BDP2100

Key stakeholder views, policies and strategies play a crucial role when prioritizing the polders. For example, the BDP2100 is a strategic plan with a long-term horizon of 100 years as well as a short-track implementation programme to solve urgent problems which contributes to the overall development of Bangladesh. Thus, consideration should be given to the various investment plans and development scenarios.

Risk appreciation

A risk assessment leads to a good understanding of the resilience of the coastal communities and assets to coastal threats and other hazards.

Risk is defined as the product of the hazard, the exposure and vulnerability:

- *Hazard* is inherently connected to the coastal zone. The most prominent one in Bangladesh coastal zone is cyclone activity, but riverbank and coastal erosion, salinity intrusion and land subsidence are also important hazards in this area. Trends such as sea level rise, but also the possible change in cyclone activity may exacerbate these impacts. These hazardous events are not deterministic events such as the tide but are probable events in the future and can vary in terms of intensity, landfall location. Therefore, these type of events are generally expressed in terms of probabilities.
- *Exposure* refers to the entire inventory of elements in the coastal zone that can be impacted by coastal hazards. This includes the population and their homes and belongings, public infrastructure such as roads, drinking water, sanitation, drainage and flood protection infrastructure, healthcare and school facilities, but also environmental assets such as mangrove systems and sediment buffers in the coastal zone. This inventory is not static, but dynamic in time due to changes due to physical processes, population growth, migration to cities, changes in economic activities (e.g. change from agriculture to aquaculture).
- *Vulnerability* is the degree in which exposed elements such as human beings, their livelihoods, and man-made and natural assets suffer adverse effects when impacted by hazards. Hazards can cause casualties, direct damage to assets and disruption of services in the coastal zone. High vulnerability is generally the outcome of skewed development processes, such as those associated with environmental management which leaves room for improvement, demographic changes, rapid urbanization in hazardous areas, governance, and the scarcity of livelihood options for the poor.

It is noted that 'vulnerability' depends on both the hazard and the exposure. Hence, vulnerability and risk are often used interchangeably. There is, however, an important difference in that vulnerability expresses to what extent an exposed element is affected by a specific hazard situation whereas risk weighs in the aspect of the probabilities of all hazardous events.

The appreciation of the risk that threatens the community and assets in each polder is very important, due to the following reasons.

Firstly, hazardous events have a probabilistic nature and cyclones are the best example of this. Different parts of the coast are hit at different times by relatively weak and small tropical storms with minor and temporal impacts, but now and then a major cyclone hits the coast with devastating and long-lasting impacts. In other words, large events that normally cause substantial damage may not contribute a great deal to the average annual costs due to their low probability. Increasing return periods also means an increase in the damage costs, however also a lower probability of occurring, yielding the relation seen in this figure between the flood risk and the return period[30]. Through estimation of AED, the mean loss (the "expected value") that occurs in any given year is signified, which represents a long-term average.

Secondly, the contribution of hazard, exposure and vulnerability helps to better understand which would be the most suitable interventions. Interventions can reduce the hazard, the exposure or the vulnerability or a combination of these. For example, embankments reduce the probability of coastal floods, whereas drainage structures can also reduce the vulnerability to the communities (since proper regulators may reduce salinity intrusion and avoid waterlogging hence agriculture is less impacted). Both interventions reduce the risk but in a different way.

<u>Climate change</u>

Climate change is culpable for rising temperatures, changing precipitation patterns, and intensifying extreme events, such as storms and droughts. Nowadays, flood protection interventions cannot be designed without considering climate change and specifically sea level rise, leading to increase of surge level. It is expected that existing embankments may be subject to more frequent overtopping in 50 years' time

As indicated in the BDP2100, accelerated sea level rise is expected to be 1 m or more by 2100. This is likely to cause significant changes in river salinity in the southwest coastal zone of Bangladesh during the dry season (October to May) by 2050. Inundation of between 17-21% of total area of the coastal zone is expected. In addition, future storm surge heights will double due to higher wind speeds. All current polders will be flooded with prolonged water logging; damages to infrastructure, agriculture and aquaculture. Last but not least, storm surge height is expected to increase with sea level rise and will affect at least 50% of coastal zone and increased salinity and destruction of polder embankments.

The current height of the embankments is not in line with the height attainable by storm surges, further increased by climate change. However, not every area of the coastal zone interacts the same with sea level rise. The Sundarbans in the west effectively trap sediment and can keep up with sea level rise better than the Ganges tidal plain west, which is not protected by mangroves. The Meghna Estuary delivers a lot of sediment to the coast, which makes this part of the coastline less vulnerable to sea level rise. Because of low rates of sea-level rise or even the record of sea-level fall, lower vulnerability has been indicated in the eastern part of the Bangladesh coast. Vertical upward movement of land in this zone is causing a fall in sea level.

[30] Anders Skovgård Olsen et al. (2014) Comparing Methods of Calculating Expected Annual Damage in Urban Pluvial Flood Risk Assessments

Participatory water management

Participatory water management, is very important not only for the proper operation of the drainage structures but also for effective O&M of embankments and said drainage structures. One of the key elements in the approach of the Blue Gold Program is working with / enhancing the Water Management Groups (WMG) within a polder. Below are presented some of the key lessons learned in relation to participatory water management from the Blue Gold Programme:

- Water Management Groups and Associations flourish when working closely with Local Government Institutions and line agencies. This partnership must be extended to the whole country;
- New legislation establishes local and regional water resource committees. Such bodies must enhance the synergy between national, regional and local interest;
- Water Management Groups and Associations develop small-scale infrastructure but also are stakeholders in main infrastructure. The planning of small and large-scale infrastructure must be optimized to complement each other;
- Participatory Water Management (combining infrastructure, stakeholder partnerships and agricultural commercialization) should be part and parcel of future water sector investments;
- O&M Agreement required setting down respective roles and responsibilities of BWDB and WMA.

Room for innovations and nature-based solutions

CEIP-1 has already proven to be a success story, even with its implementation still ongoing. Within CEIP-1, mostly traditional coastal protection works are being used consisting of 'hard' structures which reduce or stop natural dynamics and, in this way, may also reduce or stop the erosion processes as well. In many cases, such hard structures are the only viable option, however, they can also have negative side effects to the natural system, like e.g. downdrift erosion. Although in CEIP-1 as well as in other coastal protection projects in Bangladesh, new technologies have been introduced from time to time (which have proven highly beneficial and cost effective), the basic design and monitoring approaches applied can still be seen as traditional when compared to global practices.

An important prerequisite for embankment works is the required safety level which determines the embankment height. A zonally varying safety level (defined by the land-use, inhabitation and other factors) may potentially result in cost reduction and consequently more flexible and sustainable solutions. Within the context of planning of coastal interventions to fight climate change in Bangladesh, a policy should be developed which, among other things, describes how to protect the Coastal Zone against storm surges and associated erosion and flooding. Following the latter, new design guidelines for design of coastal protection works should follow a more adaptive approach which takes functional requirements, land use zoning and safety levels into account. The Netherlands can be taken as an example where this adaptive approach is applied.

Several of those interventions, following a more adaptive approach, fit under the umbrella of the 'Building with Nature' concept. Through this innovative concept, natural strengths and dynamics are identified and incorporated into the coastal protection works to combat erosion and/or flooding risks rather than enforcing designs controlling nature and at the same time developing additional functions promoting socio-economic development, such as ecological, recreation and some examples that have been successfully implemented around the world are: Dike realignments to create sufficient "Room for the River" and reduce flooding sand nourishments are examples of innovative designs to fight erosion and create suitable habitat conditions for restoration of wetlands and coral reefs..

Preliminary Cost benefit Analysis for scoring and selection

In this phase of more detailed selection a preliminary estimation of potential benefits of protection interventions will be undertaken. Direct benefits in terms of asset damage reduction will be tentatively estimated based upon flood maps (or indications of % of flood affected land per polder) and an inventory / field survey and/or GIS maps of assets of the polders (buildings, roads, agricultural crop land, aquaculture surface). Based upon indications of asset values (per m2 building, m road, m2 of agricultural crop land) etc.) indications of potential benefits of protective interventions will be made. For this some typical flood events (for example with a return period T25 and T50) will be assumed and translated into an AED reduction. The present value of these expected annual potential direct damage reduction benefits will be compared with the present value of indicative investment costs and preliminary benefit-cost (B-C) ratios will be deduced and translated to numerical scores per polder. (A b-c ratio of 1 implies discounted benefits equal discounted costs, the higher the b-c ratio the higher the benefits over costs, the higher the score as input in the MCA). Polders can also be classified with a value of assets per ha and then scored in case no information on typical events (T25, T50) is available. Based on that value per ha, the coastal zone will then be divided in risk categories.

5.3.3 Proposed criteria and scoring

Using as a basis the guiding principles as defined in the previous section, five cluster categories have been defined, which represent the thematics of these guiding principles: Social and institutional, Technical, Constructability, Environmental, Economic. Each of these clusters comprise from a list of criteria which better reflects on the guiding principles. The cluster categories and respective criteria are presented in the following tables, along which a description of what they are representing.

Table 5-2: Social and institutional MCA criteria and description of considerations

Cluster category	Criteria	Description and considerations for each criterion
Social and institutional	**People affected (Social risk from storm surge inundation)**	The estimated annual number of people affected by storm surge events (calculated based on a high level risk assessment considering storm surge return periods of 10, 25, 50 and 100 years)
	Community vulnerability	The recent cyclones amongst others Sidr, Aila, Amphan and Yaas have impacted several polders on a different extent and magnitude. The vulnerability of each polder to those cyclones will be addressed using report findings, stakeholder consultations and site visits.

Cluster category	Criteria	Description and considerations for each criterion
	Land acquisition and displacement	Land acquisition and displacement is a lengthy and difficult procedure which impacts the coastal community. The criterion will take into account the following aspects and different weight will be applied for the following aspect: • Number of people from whom land will potentially be acquired; • Number of people that will potentially be displaced during construction but they will be able to return once construction is finalized. In addition: • Land acquisition is a significant social issue, which in parallel impacts significantly the constructability of the works causing major delays; • If polder is located along a dynamic river and erosion rate is high, then there is the risk that when time for implementation comes, significant changes will be made in this stretch and thus land acquisition may be required for retirement of embankment[4]. Thus, when high erosion rate is present, then requirement for land acquired will be larger, accounting for a larger set back distance.
	Community water management	Proper operation and maintenance of the investments is related to the community water management responsibility: • Active WMOs; • Conflicts between WMOs; • Interest of more people joining the WMOs; • WMOs duties also expanded in monitoring erosion of embankments.
	Stakeholder policies and strategies	Key stakeholder views, policies and strategies play a crucial role when prioritizing the polders. For example, the Bangladesh Delta Plan 2100 is strategic plan with a long-term horizon of 100 years as well as a short-track implementation programme to solve urgent problems which contributes to the overall development of Bangladesh. Thus, consideration should be given to the various investment plans and development scenarios.

Table 5-3: Technical MCA criteria and description of considerations

Cluster category	Criteria	Description and considerations for each criterion
Technical	**Condition of embankments**	The criterion will take into account the following aspects, and different internal weights will be applied for the following: • Length of embankment that is breached in proximity of area of high importance (densely populated, mosque and other important factors); • Length of embankments that are breached; • Length of embankments that are in a bad condition but not yet breached; • Condition of the slope protections; • Condition of the crest level.
	Erosion of banks	The criterion will take into account the following aspects and different internal weight will be applied for the following aspects:

Cluster category	Criteria	Description and considerations for each criterion
		• Length of banks experiencing strong erosion (more than 10m/ year); • Length of banks experiencing medium erosion (between 5m/ year and 10m/year); • Length of bank experiencing mild erosion (lower than 5m/year); • Length of existing bank protection works (if any) that are in a bad condition; • Length of channels that are siltated (on a larger scale).
	Drainage congestion	The criterion will take into account the following aspects and different weight will be applied for the following aspects: • Hectares of drainage congested areas in polder. This aspect will be divided in three categories, in relation to the severity of the congestion and impact on social community; • Number of drainage and flushing sluices that are in a bad condition in terms of gates, hoists, concrete and sufficient invert levels; • Condition of the canals; • Siltation (smaller scale).
	Design under climate change	Nowadays, flood protection interventions cannot be designed without considering climate change and specifically sea level rise, leading to increase of surge level. It is expected that existing embankments may be subject to more frequent overtopping in 50 years' time.

Table 5-4: Constructability, Environmental and Economic MCA criteria and description of considerations

Cluster category	Criteria	Description and considerations for each criterion
Constructability	**Logistics and travel times**	The presence and condition of road/ railway connection of the polders is highly important during construction will be considered in addition to travel times.
	Availability of construction materials	Construction works in polders located in remote areas may increase the difficulty of accessibility to construction materials[2].
	Polder clustering into Packages	In terms of logistics, package clustering of polders which are located in the same wider area is considered very efficient for supervision and implementation of the works.
Environmental	**Ecologically sensitive areas**	Preservation of ecologically sensitive areas is important as a whole. This criterion can be looked in two opposite directions: • If an ecologically sensitive area is impacted by the non-proper functioning of the polder, this criterion will contribute positively in prioritization of a polder; • If an ecologically sensitive are will be impacted from construction works, this criterion will contribute negatively in prioritization of a polder.

Cluster category	Criteria	Description and considerations for each criterion
	Aquatic fauna	Aquatic fauna per polder will be considered. Rehabilitation works will contribute in more favourable conditions for the growth of aquatic species.
	Soil quality	To assess the soil quality the crop production and the salinity intrusion are combined. A high crop production indicates a good soil quality whereas salinity intrusion indicated a bad soil quality. A polder with a high crop production and low salinity intrusion will therefore positively contribute in prioritization of the polder.
	Opportunities for Nature Based Solutions	This criterion indicates the opportunities for NBS to improve the embankments by mangroves.
Economic	**Economic risk due to storm surge inundation (EAD) – to be considered**	The economic risk (estimated annual damage) of each polder's assets being inundated from storm surge is estimated (calculated based on a high level risk assessment considering storm surge return periods of 10, 25, 50 and 100 years). The assets considered are: houses, industries, roads, agriculture. The results from the high-level risk assessment is presented as USD/hectare of polder. Based on that value, the coastal zone will be divided in risk categories.
	Rehabilitation cost	The rehabilitation cost will be roughly estimated based on the condition of the existing structures of polder, the expected required crest of the embankments, the need for bank protection works and land acquisition.
	Estimated benefit cost ratio	A high total economic risk (USD/polder) and a low rehabilitation cost results in a very profitable option. On the other hand, a medium total economic risk and a high rehabilitation cost results in a less profitable option.

The scoring ranges are illustrated in Table 5-5 to illustrate what gives a higher and what lower score for each criterion and are presented in following tables, tentatively.

Table 5-5: Scoring ranges social and institutional criteria

Cluster category	Criteria	Scores	
		Values for MCA	**Description**
Social and institutional	**People affected**	1	People affected / ha < 0.1
		2	0.1 < people affected / ha < 0.2
		3	0.2 < people affected / ha < 0.5
		4	0.5 < people affected / ha < 1
		5	People affected / ha > 1
	Community vulnerability to recent cyclones	1	Low vulnerability to recent cyclones (Aila, Sidr, Amphan)
		3	Medium vulnerability to recent cyclones (Aila, Sidr, Amphan)
		5	High vulnerability to recent cyclones (Aila, Sidr, Amphan)
	Land acquisition	1	High land acquisition > 40

Cluster category	Criteria	Scores	
		Values for MCA	Description
		2 3 4 5	30 < land acquisition [ha] < 40 20 < land acquisition [ha] < 30 10 < land acquisition [ha] < 20 Low land acquisition < 10
	Community water management	1 3 5	Non-active WMOs comprised by limited people, encountering instutional conflicts Semi-active WMOs Active WMOs, many people participating and no institutional conflicts
	Stakeholder policies and strategies	1 3 5	Wider polder area and/or polder itself is not included in development plans/policies nor the polder is considered crucial to rehabilitate based on stakeholder consultations Wider polder area and/or polder itself is included in development plans/policies and the polder is considered that should rehabilitate based on stakeholder consultations Wider polder area and/or polder itself is included in development plans/policies and the polder is considered crucial to rehabilitate based on stakeholder consultations

Table 5-6: Scoring ranges technical criteria

Cluster category	Criteria	Scores	
		Values for MCA	Description
Technical	**Condition of embankment**	1 2 3 4 5	Embankment breached = 0 and Embankments to be potentially breached in near future = 0 0 < Embankment breached < 5% and 0 < Embankments to be potentially breached in near future< 10% 5% < Embankment breached < 10% and 10% < Embankments to be potentially breached in near future < 20% 20% < Embankment breached < 40% and Embankments to be potentially breached in near future > 20% Embankments breached > 40%
	Erosion of banks	1 2 3 4 5	erosion < 5 m / year 5 m /year < erosion <10 m / year 10 m /year < erosion <15 m / year 15 m /year < erosion <20 m / year Banks with strong erosion > 20 m / year

Cluster category	Criteria	Scores	
		Values for MCA	Description
	Drainage congestion	1	Low number of bad drainage and flushing sluices < 5
		2	5 < bad bad drainage and flushing sluices < 10
		3	10 < bad drainage and flushing sluices < 15
		4	15 < bad drainage and flushing sluices < 20
		5	High number of bad drainage and flushing sluices > 20
	Design under climate change	1	Based on climate change simulations of cyclone and sea level rise, experiencing a surge differnence comparatively to baseline scenario <0.01m
		2	Based on climate change simulations of cyclone and sea level rise, experiencing a surge differnence comparatively to baseline scenario > 0.01m and <0.5m
		3	Based on climate change simulations of cyclone and sea level rise, experiencing a surge differnence comparatively to baseline scenario >0.5m and <1m
		4	Based on climate change simulations of cyclone and sea level rise, experiencing a surge differnence comparatively to baseline scenario >1 m and < 2m
		5	Based on climate change simulations of cyclone and sea level rise, experiencing a surge differnence comparatively to baseline scenario > 2m

Table 5-7: Scoring ranges constructability and environmental criteria

Cluster category	Criteria	Scores	
		Values for MCA	Description
Constructability	**Logistics and travel times**	1	Travel time > 120 minutes
		2	Travel time < 90 minutes < 120 minutes
		3	Travel time < 60 minutes < 90 minutes
		4	Travel time < 30 minutes < 60 minutes
		5	Travel time < 30 minutes
	Availability of construction materials	1	Not available
		2	Available in limited quantity in far distance from polder
		3	Available in limited quantity in proximity of polder
		4	Available in large quantity in far distance from polder
		5	Available large quantities in proximity of polder
	Polder clustering into Packages	1	Polder located >300km from majority of potentially selected polders

Cluster category	Criteria	Scores	
		Values for MCA	Description
		2	Polder located > 200 and <300 km from majority of potentially selected polders
		3	Polder located > 100 and <200 km from majority of potentially selected polders
		4	Polder located >50km and <100km from majority of potentially selected polders
		5	Polder located <50 km from majority of potentially selected polders
Environmental	**Ecologically sensitive areas**	1	Not impacted
		2	TBD
		3	TBD
		4	TBD
		5	Highly impacted
	Aquatic fauna	1	High ha cultivable land for aquaculture > 40000
		2	3000 < cultivable land for aquaculture < 4000
		3	2000 < cultivable land for aquaculture < 3000
		4	1000 < cultivable land for aquaculture < 2000
		5	Low ha cultivable land for aquaculture < 1000
	Soil quality	1	Agricultural lands are being utilized> 90%
		2	70%<agricultural lands are being utilized <90%
		3	50%<agricultural lands are being utilized <70%
		4	30%<agricultural lands are being utilized <50%
		5	agricultural lands are being utilized <30%
	Opportunities for NBS	1	Not suitable environmental conditions for development of NBS
		2	TBD
		3	TBD
		4	TBD
		5	Suitable environmental conditions for development of NBS

Table 5-8: Scoring ranges constructability, environmental and economic criteria

Cluster category	Criteria	Scores	
		Values for MCA	Description
Economic	Economic risk	1	AED [USD / ha] < 25
		2	25 < AED [USD / ha] < 50
		3	50 < AED [USD / ha] < 100
		4	100 < AED [USD / ha] < 200
		5	> 200
	Rehabilitation cost	1	> 200
		2	150 < Cost [Crore BDT] < 200

Cluster category	Criteria	Scores	
		Values for MCA	Description
		3	100 < Cost [Crore BDT] < 150
		4	50 < Cost [Crore BDT] < 100
		5	Cost [Crore BDT] < 50
	Estimated benefit cost ratio	1	CB <0.5
		2	0.5<BD<1
		3	1<BD<1.5
		4	1.5<BD<2
		5	2<BD

5.3.1 Weighting

Very often qualitative data cannot be expressed in the form of absolute values. For this reason, many decision-making methods aim to determine the relative importance of each parameter involved in the problem[31].

In the pairwise comparison method, also known as the Analytical Hierarchy Process (AHP) [32], a decision-maker must indicate for each pair of criteria at a time which criterion is the most important one. Subsequently one must indicate in qualitative terms to what extent a criterion is more important than another. The pairwise comparison method converts these comparisons of all pairs of criterions to quantitative weights for all criteria.

For the purpose of this study, a simplified AHP approach is used, where the following options are available for a comparison between two criteria: Less important, equally important, more important. In other words, the extent of importance has been removed for simplicity reasons and for different audiences to participate in the weighting formulation, such as Governmental Agencies, Engineers, Climate Change Specialists, people living in the polders etc.

The first stage of the pair-wise comparison estimates the relative importance of three criteria clusters (social and institutional, technical, constructability, environmental and economic) through a pair-wise comparison made between them and provides their respective weights Ws, Wt and Wc, We and Wec.

In the second stage, pair-wise comparison is made individually between the identified criteria 'i' for each cluster criteria Wis (i = 1 to 5), social Wit (i = 6 to 9) and Wic (i = 10 to 13), Wie (i = 14 to 17), Wiec (i = 18 to 20) and the weights of them in their cluster category are found.

31 Triantaphyllou, E., & Mann, S. H. (1995). Using the analytic hierarchy process for decision making in engineering applications: some challenges. International journal of industrial engineering: applications and practice, 2(1), 35-44.
32 Saaty, T. L. (2008). Decision making with the analytic hierarchy process. International journal of services sciences, 1(1), 83-98.

The comparative importance will be obtained through personal interviews with stakeholders, normalized weights and the average of normalized weights. The normalized values are obtained by dividing by its corresponding column sum. The set-up of the spreadsheets which are provided to key-stakeholders, enabling them to provide their views of comparative importance is presented in Figure 5.10 and Figure 5.11.

In the third stage, the weights for each dimension to estimate each criterion weights is found by multiplying the Wis, Wit, Wic, Wie and Wiec with their respective Ws, Wt and Wc, We and Wec.
i.e. Wi = Ws * Wis (i = 1 to 5)
Wi = Wt * Wit (i = 6 to 9)
Wi = Wc * Wic (i = 10 to 13)
Wi = We * Wie (i = 14 to 17)
W = Wec * Wiec (i = 18 to 20)

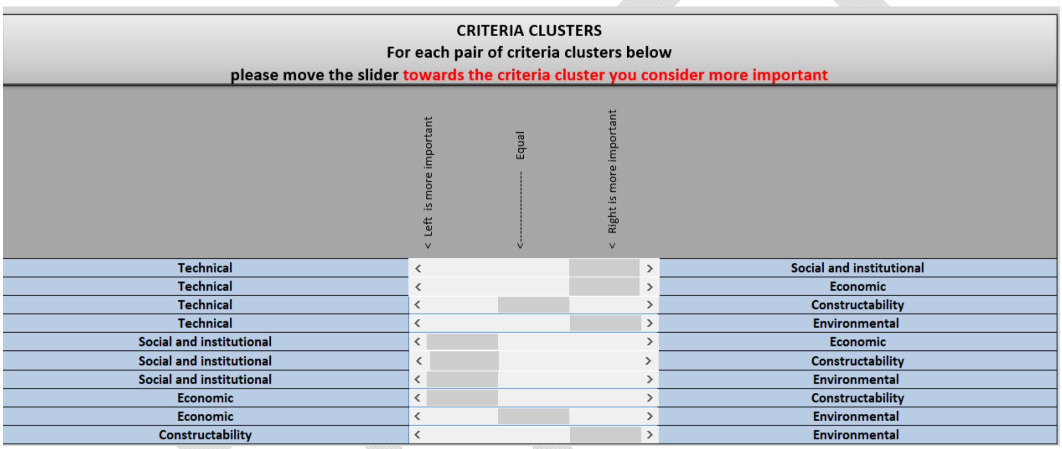


Figure 5.10: Comparison of criteria clusters (example answer from stakeholder)

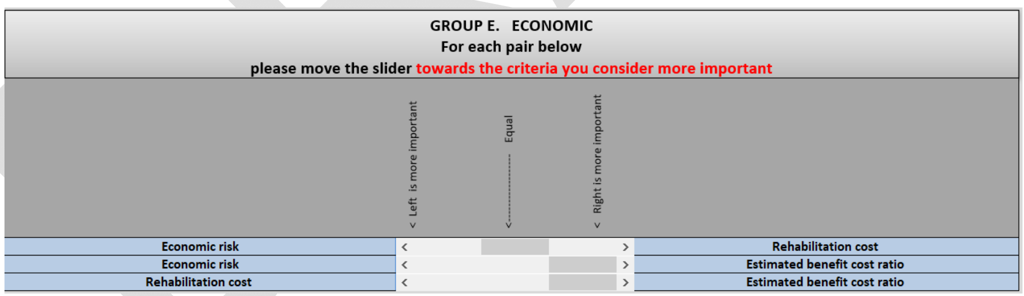


Figure 5.11: Comparison of economic criteria (example from answer of stakeholder)

Appendix 11 presents the list of polders and respective high-level scoring of each of above categories.

5.4 Preliminary list of screening of 23 polders

Based on an analysis of the dynamics of the coastal zone of Bangladesh, an identification of vulnerable areas and high level risk assessment have been conducted. Furthermore, Consultant has identified high priority development zones via desk studies and consultations. The latter also allowed making an assessment of the conditions of the polder water related infrastructure. Based on the afore mentioned, a narrowing down resulted in a first subset of polders, following the rationale explained in Section 5.2.6. To this sub-set of polders a partial application of the MCA tool developed will be conducted. The application of the MCA depends on the sufficiency and quality of the data that will be retrieved, as has been explained in Section 5.3. Based on the information available to the Consultant during Inception period, Table 5-9 provides a Preliminary list of screening of 23 polders. The 23 polders are shown in the map in Figure 5.12.

Table 5-9: Preliminary list of 23 polders to consider including in investment plan

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

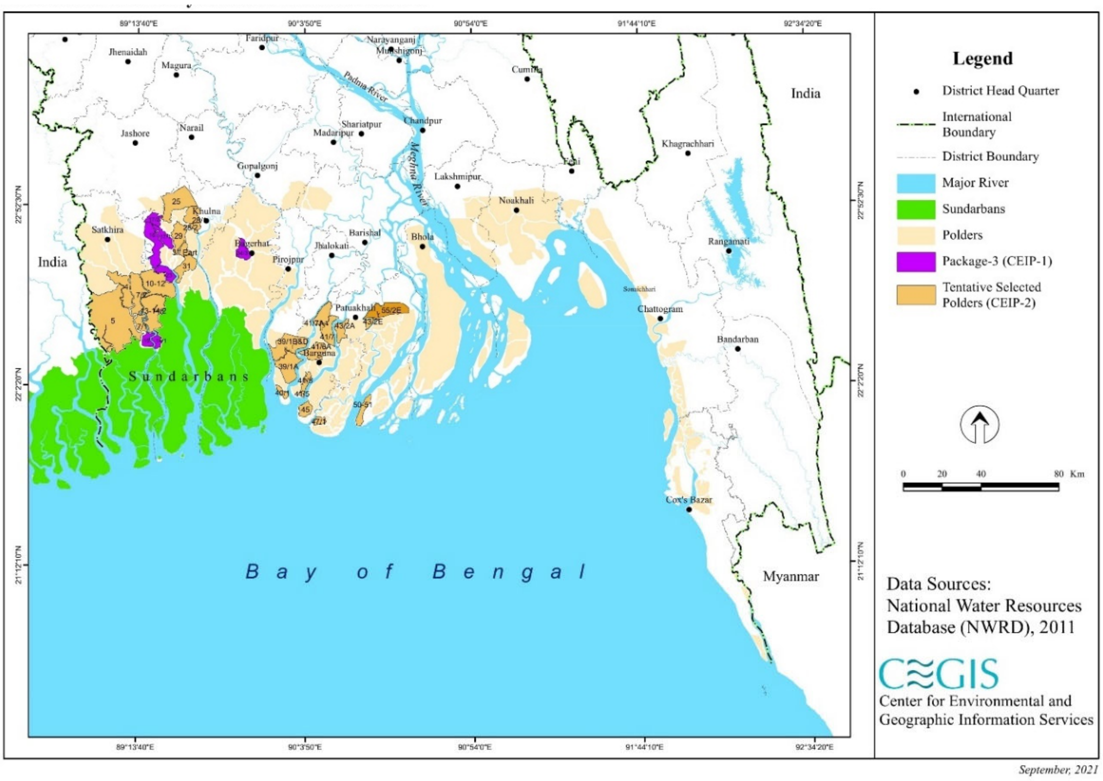


Figure 5.12: Proposal for 23 polders to consider

By applying the MCA, this list will be further narrowed to 13 polders after discussions with the BWDB and MOWR. After submission of this draft Inception Report, the said 23 polders will be discussed with the BWDB and after confirmation be included into the Final Inception Report.

It is noted that MOWR has a list of some 57 polders for which already a DPP is prepared and yet to be shared with Consultant. It is furthermore noted that these 57 polders may possibly only be only improved or rehabilitated partially and not to the extend as the polders under CEIP-1; in the latter, polders are completed improved after finalisation.

6. Project organization and execution

6.1 Outline of the project organization

The organization and arrangement of the Consultants' Team is considered critical for the smooth running of the project and the timely achievement of all the project goals. With this objective a highly experienced and capable multidisciplinary team of Consultants has been formed based upon the following criteria:

- Identifying the fields requiring specialist inputs and a staff list by discipline;
- Assigning task activities to the appropriate expert position or sub-team of specialists;
- Selecting individual candidates who have technical and practical experience to match the assigned duties and have the personality and commitment to suit the role;
- Reviewing the timing of required activities in conjunction with the detailed work-plan to ensure that staff are on the project at the right time and for the right duration, and
- Addressing the management and organizational structure of the Team.

The proposed professional experts will be organised into a multi-disciplinary organisation under the direction of the Senior Advisors. The Team structure has been carefully chosen with the quality of the final outputs in mind, together with the training and transfer of technology in targeted areas of the Project. The project team organisation chart is shown in *Figure 6.1* and presents an overview of the various teams and the proposed interactions with client, donor, government organizations and sub-contractors.

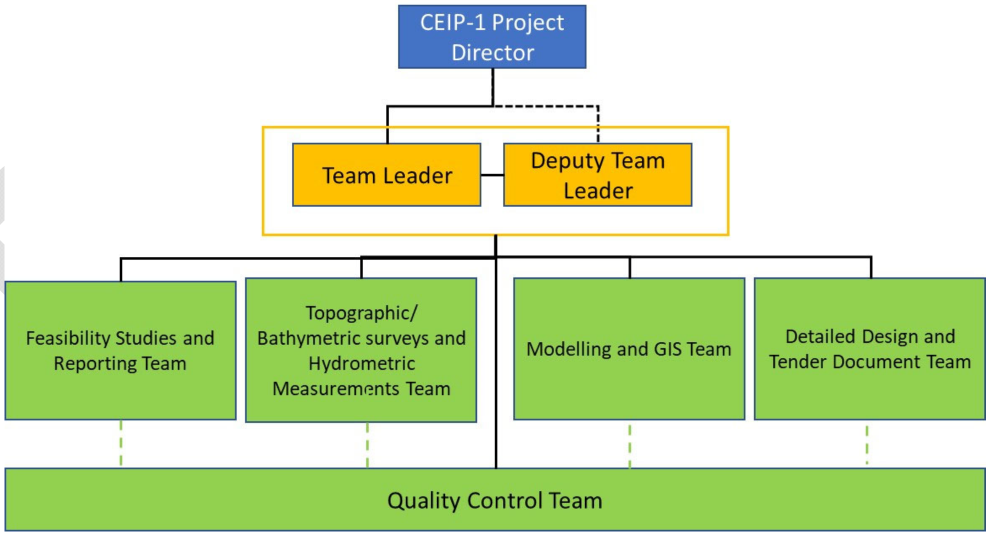


Figure 6.1: Project team organisation chart

The Key Staff (International and National) are going to guide and direct the project professionals. The Consultant's team will work under the Project Director, PMU-CEIP BWDB. He will guide, direct and advise the team so as to ensure the successful achievement of the project objectives.

6.2 Work plan

To complete a task in time, a realistic work plan is necessary with the task assignment to accomplish the different activities included in the work plan in a specified time frame.

The proposed work plan as shown in Figure 6.2 has been prepared accommodating all the activities delineated in the ToR (and realities in relation to time limit for execution of all the activities. In the work plan time has been assigned for each item of activity separately.

The work plan will be updated time to time based on actual progress of activities and discussion with PD, CEIP-1. The solid bars of the work plan denote activities of continuous duration where as those with broken bars shows intermittent activities. The work plan also shows events like deliverables like inception report, progress report, project completion report etc.

Figure 6.2: Workplan (1/2)

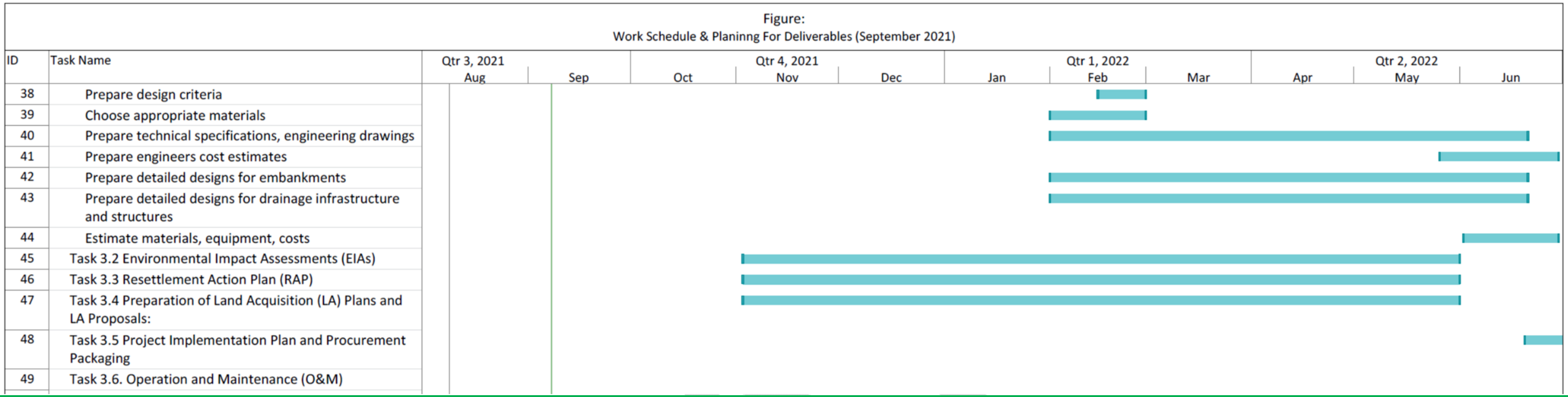


Figure 6.3: Workplan (2/2)

6.3 Staffing schedule

The correct and efficient scheduling of the inputs such as project staff is important. Effort of each Team member is required careful timing to complement with the other members and co-ordinate with the different activities of the project work-plan. Table 6-1 shows the list with Team members.

Table 6-1: List of Team members

Names	Names	Position
International Consultant (Key Experts)		
IK-1	Jean Henry Laboyrie	Team Leader
IK-2	Marius Sokolowitz	Coastal and Estuarine Expert
IK-3	Peter van der Kreeke	Hydraulic Structural Engineer
IK-4	Joost van der Schrier	Geotechnical Engineer
IK-5	Arend Jan vd Kerk	Coastal Zone Management Specialist
INK-1	Bokepalli Kanaka Durga Raja	Social Scientist / Sociologist / Resettlement
INK-2	Sara Bennett	Environmental Specialist
INK-3b	Ries Kluskens	MIS Specialist
INK-3c	Ralf Behrens	Economist
INK-5	Knut Oberhagemann	Project Coordinator (in country)
INK-6	Jesper Mathiesen	Survey Cordinator (in country)
INK-7	Angela Thomson	River Modeller
INK-8	Alex Hooijer	Project Director Consultant
National Consultant (Key Experts)		
NK-1	Md. Habibur Rahman	Deputy Team Leader
NK-2	Dr. Shahjahan Ali	Cyclone and Storm Surge Modelling Specialist
NK-3	Dr. Maminul Haque Sarker	Coastal and Estuarine Morphologist
NK-4	Jalauddin Md. Abdul Hye	Coastal Drainage and Flood Mngmt Specialist
NK-5	Babul Chandra Shil	Senior Hydraulic Engineer - 1
NK-6	Md. Asaduzzaman	Senior Hydraulic Engineer - 2
NK-7	Md. Aminul Islam	River Engineer
NK-8	Begum Swada	Social Development and gender Specialist
NK-9	Kh. Khairul Matin	Resettlement and Indigenous Peoples Specialist
NK-10	Dr. Syed Muhammad Latif	Environmental Specialist
National Consultant (Non-key Experts)		
NNK-1	Dr. Dewan Abdul Quader	Climate Change Specialist
NNK-2	Md. Abdus Sattar	Design Engineer - 1
NNK-3	Md. Mozammel Hossain	Design Engineer - 2
NNK-4	Md. Sohel Rana	Design Engineer - 3

Names	Names	Position
NNK-5	Ananta Kumar Das	Design Engineer - 4
NNK-6	Md. Shamsul Islam	Geo-technical Engineer
NNK-8	Md. Mostafizur Rahman	GIS/Remote Sensing Specialist
NNK-9	Sarder Sirazul Hoque	Procurement / Contract Management Specialist
NNK-10	Md. Ebrahim Akanda	Agrultural / Irrigation Specialist
NNK-11	NA Gazi	Economist
NNK-12	Md. Rafiqul Mahbub	Survey Engineer / Quantity Surveyor - 1
NNK-13	Md. Osman Ghani	Survey Engineer / Quantity Surveyor - 2
NNK-14	AFM Imdad Rasul	Survey Engineer / Quantity Surveyor - 3
NNK-15	Md. Ziaul Alam	Survey Engineer / Quantity Surveyor - 4
NNK-16	AKM Enamul Huq	Land Acquisition Specialist - 1
NNK-17	Md Saidur Rahman	Land Acquisition Specialist - 2
NNK-18	Dr. Dilruba	Communication / Community Relations Specialist
NNK-19	Mohammad Rashidul Islam	Mechanical Engineer
NNK-20	Shah Md. Ruhul Kabir	AutoCAD Specialist - 1
NNK-21	ATM Sajjadul Islam Bakshi	AutoCAD Specialist - 2
NNK-22	Shahad Mahbub Chowdhury	Ecologist
NNK-23	Shaikh Mizanur Rahman	Forestry Specialist
NNK-25	Md. Oliur Rahman	Fischery Specialist

6.4 Reporting

The Consultant will prepare a number of reports as per requirement of the ToR. The reports and deliverables to be submitted are shown in Table 6-2. The months count from Commencement of the Services as per Consultancy Contract and being 9th August 2021.

Table 6-2: Reporting and submission of Contractual deliverables

Deliverables		Submission of Deliverable (Months from Commencement of Assignment)
1	Inception Report (it shall include but not limited to Executive Summary, technical approach, exploration of available data and assessments, review of Final Report of Technical Feasibility Study and Detailed Design for Coastal Embankment Improvement Programmer (CEIP) (40 Copies). The Inception Report will also include Preliminary List of screening of 23 Polders out of 122 Polders (Task 1.1)	1st Month
2	Prioritization List of 13 Polders with detailed Report updating MCA of 2013 (Task-1.2) and the Strategic Plan report on selection of an optimal investment option including 20 Polders (including CEIP-1 Polders) (Task 1.3). Feasibility Bathymetric, Hydrometric and Topographical Surveys Reports for max. 13 Polders (Task 2.1. b)	2nd Month

	Deliverables	Submission of Deliverable (Months from Commencement of Assignment)
3	Feasibility Geotechnical Surveys Reports for max. 13 Polders (Task 2.1. b)	4th Month
4	Modelling Reports (Storm Surge Modelling and Polder, Morphological Analysis and Polder Drainage Modelling) for max. 13 Polders (Task 2.1. c, d and e)	6th Month
5	Feasibility Design Report for Flood Embankments, Drainage Canals, Protection Works and Drainage Infrastructure and Structures for max. 13 Polders	7th Month
6	Economic & Financial Analysis Report for max. 20 Polders (Task 2.2 and 2.6)	7th Month
7	Social and Environmental Reports (SIA, SMRPF, EMF) for max. 13 Polders (Task 2.3 and 2.4)	7th Month
8	Monitoring and Evaluation Report for max. 20 Polders (Task 2.5)	7th Month
9	Feasibility Report from the selection set of max. 20 polders (Task 2.1 to Task 2.6) (30 Copies)	7th Month
10	Reviewing and updating of Detailed Designs of 7 Polders of CEIP-1 Package-3 (Task 3)	9th Month
11	Draft Polder Reports for 7 Polders (Package 3 under CEIP-1) including review and upgradation of analysis/modeling, detailed design, EIA/EMP, RAP/LAP/SIA including executive summary (as per the Bank safeguard policies) (30 copies) and Bidding documents (Task 3.1. to Task 3.4) (4 draft + 20 final)	9th Month
12	Detailed Bathymetric, Hydrometric and Topographical Surveys Reports for max. 13 Polders (Task 3.1)	9th Month
13	Detailed of Geotechnical Surveys Reports for max. 13 Polders (Task 3.1)	9th Month
14	Update Modelling Reports for max. 13 Polders (Task 3.1)	9th Month
15	Detailed Design Reports for Flood Embankments, Drainage Canals, Protection Works and Drainage Infrastructure and Structures for max. 13 Polders (Task 3.1)	12th Month
16	Environmental Impact Assessments (EIAs) and Environmental Management Plan (EMP) Reports for max. 13 Polders (Task 3.2)	12th Month
17	Resettlement Action Plan (RAP), Land Acquisition Plan (LAP) and Social Impact Assessment (SIA) Reports for max. 13 Polders (Task 3.3 and 3.4)	12th Month
18	Operation and Maintenance (O&M) Report for max. 13 Polders (Task 3.6)	12th Month
19	Bidding Documents for max. 13 Polders (Task 3)	12th Month
20	Draft polder reports (40 copies) for max. 13 polders, analysis/modeling, detailed design, EIA/EMP (10 copies), RAP (10 sets each), LAP (10 sets in tracing cloths + digitalized 5 sets) /SIA including executive summary (as per the Bank safeguard policies) and Bidding documents (Task 3.1 to task 3.4) (4 draft + 20 final)	12th Month
21	Development Project Pro Forma (DPP), giving final project description, cost estimates, economic analysis, institutional arrangements, etc. (Task 3.5) - (120 copies, as per requirement at different stages)	12th Month
22	Full final documentation of deliverables. (40 copies)	12th Month

6.5 Coordination is key – need for a communication protocol

In this section Consultant provides their thoughts about the main risks and challenges which can occur. Continuous and fluent communication and coordination between the different components is Obviously, this is firmly on the radar of the World Bank and BWDB, but it cannot stop there. Consultant will assign the task of proactively communicating with the leadership of the other components to Consultant's Team Leader, to ensure that Consultant knows what is going on within the other components and proactively share what our Team is doing as part of this assignment. Consultant do recommend that in close coordination with the World Bank and BWDB an (in)formal communication protocol will need to be established to facilitate the required coordination and to ensure the work of the different parties on realising the objectives of the Project is properly aligned key to the successful implementation of the Project.

6.6 Project management risk control

In this section Consultant provides their thoughts about the main risks and challenges which can occur during the Inception Phase and give suggestions on how to deal with these as listed in Table 6-3.

Table 6-3: Main risk and challenges and mitigating actions

Risk/Challenge	**Mitigating action**
High occurrence of disasters and cyclones possibly disrupting the works or destroying temporary or partially built works. This might cause unexpected delays. Climate in general having effect on construction idle days.	For the detailed design we take into consideration the probability of climate effects on construction, we will include risk management strategies to be adopted by the Contractor. In addition in our detailed design we will incorporate robust solutions cross checked on "buildability" and climate influences. Not only for the final construction, but also for the different construction stages. Selection of an experienced contractor will help in reducing this risk.
Social and political unrest in Bangladesh such as Hartals. Travel restriction on International staff as imposed through SOS International.	By having a strong and experienced combined team from the Netherlands, Canada, Germany and Bangladesh Consultant can anticipate and be flexible on the management of the project and its output during periods when either international staff would have travel restrictions, or Bangladesh staff would be hampered by for instance Hartals.
The COVID-19 pandemic can cause interruptions due to health of Staff and restrictions set forward by the Government of Bangladesh.	Consultants are already working in Bangladesh since the pandemic started in March 2020 and have been able to cope with this via strict COVID-19 protocols in the Offices and the field and by utilising virtual meeting tools to continue communicating wit hall parties concerned.
Decision making and approvals from GOB may take more time than anticipated and cause delays in submitting the contractual deliverables.	Through recent works with the BWDB Consultant is fully aware of their strengths and weaknesses through which Consultant can ensure that submission of the deliverables will contribute to the success of the project, for the BWDB, the World Bank and above all the people of Bangladesh. In addition, we will put in place a good risk management system en register. A Risk Register will be set up and maintained throughout the project as a database of all the project risks, the assessment of their likelihood and severity, the planned risk responses for risk reduction and mitigation.
Risk of outdated and insufficient data, technical surveys take longer than expected due to adverse weather conditions.	Consultant has recently implemented and are currently working on several other projects in Bangladesh, Experiences from these projects are of great relevance to the proposed Consultancy Services and the data and surveys that are required to undertake the services.

6.7 Data storage and sharing

As mentioned, Consultant has set up a BOX data and document sharing system in the cloud to which all Team members have access.

At the end of the Project, Consultant will store and share all the data, documents and reports as stipulated in the ToR and summarized as follows:

- Store all collected primary/secondary/raw datasets including meta-data on the Geospatial Data Sharing Portfolio (GeoDASH) and also the Database or Sharepoint system of BWDB.
- Completed and validated including meta-data, stored in GeoDASH and also the Database or Sharepoint system of BWDB.
- Analytical results, graphs, tables shared in GeoDASH and also the Database or Sharepoint system of BWDB.
- Technical memorandum describing the validation and completion procedures that have been used by the Consultant for all type of data; for reproducibility purposes to be stored in GeoDASH and also the Database or Sharepoint system of BWDB.

Geospatial data will include details of projection and will be provided in a standard OGC format or well-known format. The minimum requirements to be followed for all geospatial (GIS) data are:

- Metadata: Detailed documentation needs to be provided for each data set. This metadata must include description, source, contact, date, accuracy, restrictions. A description of attributes needs to be provided for vector and tabular datasets. There are available ISO standards commonly used by World Bank financed projects to guide the development of metadata.
- Vector data: Geospatial vector data must be provided in a well-known GIS format. This includes but is not limited to: ESRI shapefile, KML, GML, WKT. Additional formats may be used with approval. Where possible, styling information should be provided in SLD format. All files must include projection parameters.
- Raster data: Geospatial raster data must be provided in a well-known format. This includes but is not limited to: geoTiff, JPEG, JPEG2000, ArcInfo ASCII, Binary grid, MrSid. Additional formats may be used after discussion with the Project Director. Where possible, styling information will be provided in SLD format. All files will include projection parameters.
- Tabular data: Tabular data will be provided in a readily accessible or well-known format. This includes but will not limited to CSV or Microsoft Excel spreadsheet. Additional formats may be used after discussion with the Project Director.

All spatial data will meet OGC standards http://www.opengeospatial.org/standards. The vector data will be delivered as shape files with associated OpenGIS® Styled Layer Descriptor (SLD) and the Raster data will be delivered in the GeoTiff format. All data will be geo referenced and projected in WGS 84 UTM zones. Metadata documentation shall be produced in an approved format compatible with the Federal Geographic Data Committee. FGDC-STD-001-1998. Content standard for digital geospatial metadata (revised June 1998). Federal Geographic Data

Committee. Washington, D.C. Media/method of transfer: All data sets will be transferred onto database of GeoDASH and also the Database or Sharepoint system of BWDB.

Consultant will agree upon with the Project Director on how data, documents and reports will be shared during the course of the Project. A suggestion made here by Consultant is to provide the Project Director access to the said BOX system in the cloud.

Appendices

Appendix 1 Terms of Reference

1. Background information

Coastal Zone of Bangladesh

Bangladesh is situated at the confluence of three great trans-Himalayan rivers — the Ganges, the Brahmaputra or Jamuna, and the Meghna (GBM). While over 90 percent of the GBM catchment lies outside of Bangladesh, approximately 200 rivers and tributaries of the GBM drains through the country via a constantly changing network of estuaries, tidal inlets, and tidal creeks, before emptying out into the Bay of Bengal[33]. Thus, the coastal zone of Bangladesh, the lowest landmass of the country, is continually influenced by these Himalayan drainage ecosystems that join to form one of the largest, youngest, and most active deltas in the world.

The coastal zone[34] of Bangladesh spans over 710 km of coastline and is prone to multiple threats. Sixty-two percent of the coastal land has an elevation of up to 3 meters and eighty-three percent up to 5 meters above mean sea level[35]. The flow of the rivers entering the GBM delta is the third largest in the world and river floods occur regularly, often leading to flooding of one thirds of the country. In 1998, the flooded area covered as much as two thirds of the country. With a sediment supply of 1 billion tons per year, this is the delta with the largest sediment supply in the world. This leads to accretion of the land area in the coastal zone (5-10 km^2/year, mainly in the Meghna Estuary), and to highly unstable river branches and estuaries. The large amounts of sediments also lead to natural subsidence of the soil. This subsidence is increased at several places by anthropogenic factors like drainage and ground water extraction. On top of that there are tectonic movements in the deep subsoil, caused by horizontal plate movements.

The coastal zone constitutes 32 percent of the land area and hosts nearly 28 percent of the population[36] (i.e., nearly 42 million[37]). The coastal population is projected to grow to 61 million by 2050[38]. Coastal districts are characterized by a high pace of population growth[39]. This trend continues to push millions of people to live in the low-lying coastal areas which are highly vulnerable to natural hazards. The vulnerability of the coastal population is on the rise due to climate change. Climate variability and change will accentuate the intrinsic risks facing coastal Bangladesh. These risks span: (i) cyclones and storm surges (ii) river bank erosion and

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[33] Yu W. et al., 2010. Climate Change Risks and Food Security in Bangladesh. World Bank.

[34] The delineation of the Coastal Zone, approved by the Ministry of Water Resources in 2003, comprises 19 districts, 147 upazillas and the exclusive economic zone.

[35] Bangladesh Water Development Board. Coastal Embankment Improvement Project, Draft Final Report, Sept 2012.

[36] Islam, M.R., 2004. Where land meets the sea: a profile of the coastal zone of Bangladesh. Dhaka, the University Press Limited. 317 pp.

[37] Based on a total population of 148.7 million in 2010; as per World Bank Open Data.

[38] Ahmad, M. 2005. Living in the coast: urbanization. Dhaka, Program Development Office for Integrated Coastal Zone Management Plan Project, Water Resources Planning Organization.

[39] In 1990s, population growth is estimated to be 2.25% according to Mcgranahan G., D. Balk, and Bridget, A., 2000. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanization April 2007 vol. 19 no. 1 17-37, doi: 10.1177/0956247807076960.

vulnerability of islands and chars, (iii) sea level rise, (iv) salinity intrusion, and (v) coastal erosion. Much is still to be understood of this dynamic delta.

Polder Development and Challenges in Bangladesh

The Government of Bangladesh's commitment to develop a safe and inhabitable coastal zone can be dated back to the 1960s. Compelled by the call for intensive rice cultivation during the green revolution, the government constructed a series of embankments and polders[40] in order to provide tidal flood protection for coastal population; thereby enabling intensification of crop production and agricultural growth. Coastal embankment projects put in place regulators and other structures to control water intake and drainage of polder areas with the primary principle of improving agriculture productivity.

Primarily, the coastal embankment system brought benefits to the people living along low lying areas. The system was designed originally to protect against the highest tides, without much attention to storm surges. Recent cyclones brought substantial damage to the embankments and further threatened the integrity of the coastal polders. In addition to breaching of the embankment due to cyclones, siltation of peripheral rivers surrounding the embankment caused the coastal polders to suffer from water logging, which lead to large scale environmental, social and economic degradation. Poor maintenance and inadequate management of the polders have also contributed to internal drainage congestion and heavy external siltation. As a result, in some areas soil fertility and good agriculture production are declining because of water logging and salinity increase inside polders. River erosion has also caused damage to the embankment in many places of the Polder located by the side of the mighty river.

For the long term, it can even be questioned whether the polder concept, as it is practiced now, will last. Water logging in the peripheral rivers is only one side of a morphological phenomenon. The sediment previously entered the area before it was a polder, thus contributing to maintaining the soil level while, currently, the polders are isolated areas deprived of natural sediment supply. Together with the (artificially reinforced), drainage this will lead to subsidence of the soil, which is similar to the polders in the Netherlands that lie below sea level, due to subsidence. The sinking polders in the Netherlands require ever increasing pumping activities. In the much more dynamic GBM delta, this problem will be even worse. Although the subsidence problem might not yet be so manifest after the few decades that they exist, the water logging is a sign that polders, as they are now, are alien entities in the delta.

Salinity is another problem in the polders. Changing relations between river discharges and tides, aggravated by climate change and sea level rise, can make agricultural activities in the area more and more difficult. In some polders, agriculture is gradually replaced by aquaculture. It is not really clear if this has to do with salinity conditions in the rivers around a polder or with the profitability of the activities, regardless of physical conditions.

The years 2007 and 2009 were indicative of the vulnerability of coastal population and the development challenges of these polders. Severe flooding from July to September 2007 along the Ganges and Brahmaputra rivers affected the lives and livelihoods of over 13 million people and caused extensive damage to agricultural production and physical infrastructure. This

[40] The Dutch term "polder" is used to designate areas that are enclosed on all sides by dykes or embankments, separating them hydrologically from the main river system and offering protection against tidal floods, salinity intrusion and sedimentation. Polders are equipped by in- and outlets to control the water inside the embanked area.

catastrophic flood event was shadowed by cyclone Sidr, which made landfall across the southern coast on November 15, 2007, further causing over 3,400 deaths. The cyclone destroyed over a million tons of rice and incurred over US$1.6 billion in damages and losses. The concurrent increase in international prices of oil and food placed further strains on both Government budgets and household livelihoods. In May 2009, cyclone Aila caused 3-6 meters storm surge in western Bangladesh and the Sundarbans, 179 fatalities, flooding that affected 400,000 people, widespread diseases impacting over 10,000 people and over US$0.5billion in damages. Recent cyclones (e.g. Cyclone Fani) have again showed the vulnerability of the coastal population in the polders in the southwestern part of Bangladesh.

Notwithstanding the security and enhanced resilience brought by polders, the vulnerability of the coastal population is further on the rise due to climate change. Climate variability will accentuate the intrinsic risks facing coastal Bangladesh. These risks span: (i) cyclones and storm surges (ii) river bank erosion and vulnerability of islands and chars, (iii) sea level rise, (iv) saline intrusion, and (v) coastal erosion. A lack of investment to retrofit and upgrade the polders scheme will weaken their capacity to mitigate against natural hazards and protect livelihoods and assets. Studies have shown that investing in adaptation measures today will provide huge savings in the future by minimizing the damages associated with extreme weather events.

Coastal Embankment Improvement Project Phase 1 (CEIP-1)

The most recent program to reduce the vulnerability of the coastal polder system is the Coastal Embankment Improvement Project – Phase 1 (CEIP-1). This project has been initiated after Cyclone Sidr (2007) and Aila (2009). The objectives of this project are to: a) Increase the area protected in selected polders from tidal flooding and frequent storm surges, which are expected to worsen due to climate change, b) Improve agricultural production by reducing saline water intrusion in selected polders; and c) Improve the Government of Bangladesh's capacity to respond promptly and effectively to an eligible crisis or emergency. The long-term objective of CEIP is to increase the resilience of the entire coastal population to tidal flooding and natural disasters by upgrading the whole embankment system. With an existing 6,000 km of embankments with 139 polders, the magnitude of such a project is enormous. Hence, a multi-phased approach will be adopted over a period of 15 to 20 years.

CEIP-I is the first phase of this long-term program. To achieve the development objectives of the project in a complex and changing environment and to pilot innovative concepts in design and implementation, it was decided that a single investment loan would be most appropriate. Based on the success of the project, a series of projects that capture the lessons learned from CEIP-I can potentially be designed for other exposed areas along the coastal region of Bangladesh. As part of the strategic polder assessment, a multi criteria analysis was developed for 139 Polders to guide the prioritization process of selection of polders. Based on this assessment, a first priority group of 17 polders (see figure 1) were selected for CEIP Phase I.

The implementation of CEIP-1 has been split into three packages. Work Package 1 consists of Polders 32, 33, 35/1 and 35/3. The detailed design has been finished in 2016. The construction contract for this work package started in January 2016 and is estimated to be finished mid 2020. Six polders (39/2C, 40/2, 41/1, 43/2C, 47/2 & 48) are included in Work Package 2. Detailed design has been finished in 2016 and contract period is from July 2017 till January

2021. Work Package 3 of CEIP-1 includes 7 polders (14/1, 15, 16, 17/1, 17/2, 23, 34/3). Preparatory activities (designs, bidding documents, EIAs, preparation of LAP/RAP, etc.) have been undertaken and will be finished by June 30, 2019. There is no contract in place for construction of Work Package 3 since the extra costs for Work Packages 1 and 2 within CEIP-1 do not allow to implement the works for the polders of Work Package 3. Hence, these 7 polders from Work Package 3 shall be part of the current study in that the designs shall be reviewed/updated for the next phase of CEIP. These 7 polders have been prioritized earlier and do not need to be taken into account in the prioritization of this study (so in total 139 – 17 = 122 polders for prioritization in this study).

Apart from these Work Packages, CEIP-I also contains a long-term study component to obtain more insight into the large- and meso-scale morphological dynamics in the area including the impact of implementing the current CEIP-1 works and possible measures to avoid water logging. The overarching objective is to define new and more sustainable polder concepts or other concepts safeguarding the coast areas. However, this long-term study is to be initiated in 2018 and it will take time before (intermediate) results can be expected. Despite this, it is important to take this study into consideration for next phases of CEIP as good as possible.

Relevant recent/ongoing programs/efforts for the coastal zone

Parallel to CEIP, several other efforts and developments are worth mentioning in the context of increase the resilience of the coastal zone. Between 2003 and 2011, the **IPSWAM (Integrated Planning for Sustainable Water Management)** project was carried out. This project identified in some of the coastal polders the concept of ecologically sound polder management. This has been based on GoB policy documents like the National Water Policy and the National Water Management Plan, It finally resulted in the IPSWAM guidelines in 2011. Based on the outcomes of IPSWAM, the **Blue Gold** project focuses on sustainable water management by mobilizing the local communities into Water Management Groups. In some selected polders, the emphasis was on people's participation for which training programs were designed and implemented.

Another planning exercise relevant for the coastal zone is the development of **Bangladesh Delta Plan 2100**[41]. The formulation of the plan is led by the General Economics Division of the Ministry of Planning with funding of the Government of the Netherlands. The plan formulation started in 2014 and a draft plan is available at this moment. The ambition of this plan is a holistic approach in which the physical aspects (targeted within CEIP) and the institutional and social aspects (targeted in IPSWAM/Blue Gold) are brought together. The Bangladesh Delta Plan 2100 not only covers the coastal zone but the country as a whole. Within this plan, several national policy documents play an important role, like the 7th 5-year plan (2016-2020) and the Bangladesh Climate Change Strategy and Action Plan.

Within the Bangladesh Delta Plan 2100, several ideas were developed for the coastal zone, mainly from two different perspectives: Banyan and Shapla. Banyan masters the water as much as possible to enable maximum use of the natural resources. It strengthens the (water) infrastructure, curtails the dynamic behavior of rivers and controls floods as much as possible.

[41] See for more information: http://www.bangladeshdeltaplan2100.org/

Shapla adapts to the environment by changing land use, building with nature and promoting flood proof houses. The strategies are opposite to each other to show how different choices can look like. In reality, neither of the strategies will probably be realized in full. Nevertheless, the promising measures in the Coastal Zone as mentioned in the Delta Plan could be a source of inspiration when coming to choices for CEIP-II.

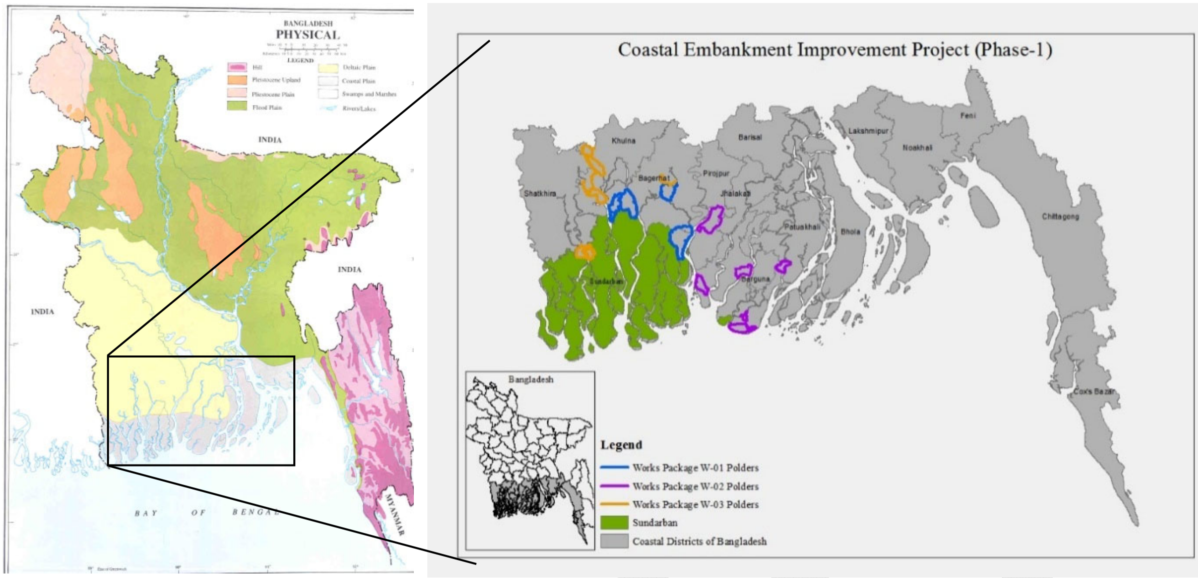
Next phase and Focus of Coastal Embankment Improvement Project

Following CEIP-1, the next phase is to update the CEIP for the remaining 122 polders and select a next batch of polders for implementing measures in the nearby future (CEIP-II). To further enhance the quality and success of CEIP, it is deemed necessary to incorporate the results of ongoing activities, such as lessons learned when implementing the current work packages under CEIP-1 and the Long-term study. Some of the practical experiences, such as the difficulties to mobilize implementation capacity, land acquisition and resettlement procedures, distances between work sites within one construction contract and to produce protection material (e.g. concrete blocks), can be considered. Also, the various recent planning studies provide more strategic insights / principles to be considered for the CEIP-II.

Ideally, it would have been beneficial at the time of writing of the Terms of Reference to have a full evaluation of the implementation of work packages and the results of the long-term study from CEIP-1. This, however, will take another two to three years to complete CEIP-1. The vulnerability of the coastal zone, but also the time to prepare the implementation of improvements for a new batch of polders warrants a next phase at this moment.

2. Objective of Consulting Service

The main objective of the consulting services is to support Government of Bangladesh's Water Development Board (BWDB) in preparation of comprehensive coastal embankment improvement program and implementation of the following phases of CEIP. The consultancy services will be carried out with a detailed feasibility study according to the international standards, which will form the basis for project appraisal by the World Bank and the Government of Bangladesh and will also cover the detailed design and bidding documents of a batch of works to be implemented under the CEIP-II project.



Figure_Apx 1: Coastal zone of Bangladesh and polders in CEIP-I project

3. Scope of Services, Tasks (Components) and Expected Deliverables

A pragmatic approach will be applied in that the lessons learned thus far from CEIP-1 and other programs will be collected during the initial task of this study. Based on this inventory, an overview of the remaining 122 polders will be prepared with special attention to:

- Vulnerability river banks and relationship with embankment stability
- Complexity issues regarding water logging, Tidal River Management
- Adaptive water management and innovative design techniques;
- Probabilistic design approach
- Opportunities to combine embankments with road infrastructure and/or waterway transport
- Improvements to drainage/irrigation within the polders
- Land acquisition and resettlement requirements
- Alternatives for the polder approach of safeguarding the coastal areas
- Land reclamation and dredging
- Construction logistics
- Bidding procedures and associated criteria
- Building with Nature concepts
- etc.

It is envisioned that these aspects will be used during the prioritization for the next batch of polders for CEIP-II (next to 'standard' aspects such as cost-benefit, etc.) and to focus on 'quick wins' and 'no regret' options. If this can be implemented successfully, it may avoid stagnation in the progress of the polder upgrading in the Coastal Zone during the next phase of CEIP. In the meanwhile, more knowledge and experience can be gathered which can be incorporated in the next phases of CEIP.

The Consulting Service is for comprehensive coastal embankment improvement program study for the remaining 122 polders, the following main tasks are envisaged:

- Task 1: Prioritization to select the next batch of polders for CEIP 2;
- Task 2: Preparation of Feasibility Studies for the 20 polders (including updating 7 Polders of Package-1 of CEIP-1) selected in Task 1;
- Task 3: Preparation of Detailed Designs and Bidding Documents of the 13 polders and reviewing detailed Designs and Bidding Document of 7 Polders of Package-1 .

These are distinct activities with separate deliverables but in practice there will be overlap in data and knowledge to perform these tasks. Prioritization mainly depends on needs and benefits but to assess these in a proper way, some preliminary design work can be necessary. It is important, however, to hold on to the sequence of these activities, to reach an effective result in an efficient way and to avoid making 122 detailed designs before prioritization and Consultants should come up with an approach of tunneling this prioritization in the most effective manner taking into account all criteria and requirements of all stakeholders. This includes, but it is not limited to, the Environmental and Social Framework (ESF) of the World Bank which will be applicable for the feasibility study and detail design activities. The tasks will be elaborated upon below in the detailed scope of work.

Detailed Scope of Work

The activities and scope of work for the assignment will include, but not limited to the following:

Task 1: Prioritization to select the next batch of polders for CEIP-2

Three tasks will need to be implemented for the prioritization of the polders to come to the selection of 13 polders for which Feasibility Studies will have to be prepared in Task 2:

1.1 Prioritization of 122 polders and selection of 23 polders for detailed prioritization
1.2 In depth prioritization of 23 polders and selection of 13 polders for Feasibility Study
1.3 Selection of an optimal investment option.

The prioritization activities listed above including the selection for an optimal investment option and shall be reported in the deliverable of Task 1: Prioritization report.

Task 1.1: Prioritization of 122 polders and selection of 23 polders for detailed prioritization

Use will be made of data and information available within the BWDB; no additional surveys, consultations and/or investigations will be conducted.

It is envisioned that these aspects will be used during the prioritization for the next batch of polders for CEIP-2 (next to 'standard' aspects such as cost-benefit, etc.) and to focus on 'quick wins' and 'no regret' options.

It is envisioned that a subset of 23 polders from the original 122 polders can be quickly selected without going in more detail based on a variety of reasons.

Task 1.2: Detailed prioritization of 23 polders and selection of 13 polders for Feasibility Study

Prioritization mainly depends on needs and benefits but to assess these in a proper way, some preliminary design sketches for typical structures can be necessary, when cost cannot be assessed differently. It is important, however, to hold on to the sequence of these activities, to reach an effective result in an efficient way and to avoid making 122 detailed designs before prioritization and Consultants should come up with an approach of tunneling this prioritization in the most effective manner taking into account all criteria and requirements of all stakeholders. This includes, but it is not limited to, the Environmental and Social Framework (ESF) of the World Bank which will be applicable for the feasibility study and detail design activities. The tasks will be elaborated upon below in the detailed scope of work.

To come to a priority for the next phase of CEIP, the following criteria will play an important role:

- Physical condition and interventions of polder infrastructure
- Population and social conditions (including future developments)
- Economic activities in the polder (including future developments)
- Environmental conditions
- Implementation opportunities/challenges (e.g. land acquisition, re-settlement)
- Capital Expenditure (CAPEX) and Operating Expenditure (OPEX)
- Tentative rehabilitation cost of the individual polder,
- Proximity of the Polders to be selected

These criteria shall be translated into scores for a multi-criteria analysis, in which a comparison is made between the polders to come to a prioritization. The evaluation will be done with available data, no additional studies or surveys will be conducted. The demands for accuracy in the scores are much less than for design parameters. After all, the prioritization will only define which polders will be improved sooner and which ones will be dealt with later.

With the following tasks will be undertaken:

a) **Define guiding principles/lessons learned; a list of selection criteria and geographical scope for prioritization**: Review of all related available documents and recommendations of the technical feasibility study of CEIP-1, previous Master Plan studies and projects carried out in the coastal areas, and discussions with the concerned relevant organizations, international and national development partners covering the concept and options of the tasks. The socio-economic development scenarios defined in the Bangladesh Delta Plan 2100 should also be taken into account. Also, lessons learned from CEIP-1 should be deduced from the various phases including feasibility, technical design, environmental assessment, land acquisition, resettlement, bidding and construction. These should be translated into guiding principles for successful implementation of the next phases of CEJP. Based on this review, a list of the selection criteria for the prioritization and selection of the polders for CEIP-2 shall be made. The Consultant shall also carry out a pre-screening of **Polders** based on the guiding principles, lessons learned **from CEIP-1** and other relevant information. It is envisioned that a subset of polders from the original 122 polders can be quickly selected without going in more detail based on a variety of reasons. The list of selection criteria including weighting of the criteria, and the list of polders to be evaluated in the activities mentioned below shall be agreed upon with the client.

b) **Describe the required interventions**: This activity shall start with making a description of the existing polder infrastructure of the remaining polders.

The description of the polder infrastructure will be based on available information, as e.g. from the "Multicriteria analysis for evaluation of vulnerable polders" done for CEIP-1. This could be updated and completed with information from BWDB and checked with some sample survey.

Furthermore, the morphological/hydrological/hydraulic mathematical analysis and models (which were conducted during CEIP-1 technical feasibility level study) for simulating the hydraulic, storm surge and morphologic behavior of the coastal embankments and their interaction to each other (e.g. polder to polder, polder to river estuaries, to the localized drainage and sedimentations etc.) shall be reviewed to extract the relevant information for all polders.

Next, the interventions (river bank protection, slope protection, embankments, drainage infrastructure) shall be defined on conceptual design level for 23 polders depending on the statistics of physical parameters, like water levels in storm surges/cyclones and salinity and the present and future bank erosion characteristics of the channels surrounding the polders.

For the required embankment height, one frequency for extreme events can be used based on consultation with BWBD. For the river bank protection works a pragmatic and flexible approach should be developed which allows for morphologic changes which arise in the period these interventions are planned and the actual implementation of these works.

c) **Make estimated cost of the interventions**: A cost estimate shall be made for all interventions necessary for each polder. This cost estimate shall be based on empirical facts and market prices. and general design sketches if needed, instead of making detailed designs. Cost estimates for embankments shall be prepared in this stage based on the length and height of embankment to be raised and costs per unit volume of soil from experiences in previous projects in the area. The same will be done for the drainage infrastructure (length and depth of canal improvement, number of sluices, etc.). River bank protection shall be dealt with as integral part of the polder embankment design. Therefore, bank protection shall be considered as part of the polder infrastructure. Protection costs will again be based on empirical facts. This will produce cost estimates sufficient for prioritization.

d) **Assess the economic benefits of the interventions**: The benefits of improvement works are partly related to the economic activities in the polder. Therefore, a rough economic benefit analysis shall be carried out based on available data or estimates on income, commerce and trade for each polder. In this economic analysis, due consideration must be given to the future risk on one hand and the impact of the recently undertaken (emergency) repairs through ongoing projects. An important aspect in economy and choices to be made is agriculture versus aquaculture. Not only seems growing and harvesting shrimps to be more profitable than rice cultivation, also the demands for embankments and water management infrastructure is very different. Flooding of an aquaculture area is much less problematic than flooding of rice fields, especially when salt water is concerned. This dependency shall be taken into consideration during this economic analysis. In this analysis, also future socio-economic developments will have to be taken into account.

e) **Assess the societal benefits of the polders**: The embankments also fulfill an important role to protect the people living inside the polder. Available census data and projection data for future growth can be used for this prioritization. Inundation patterns and inundation depths during a cyclone or storm surge in relation to population density, will have a large influence on the number of casualties. The same is true for the number and accessibility of shelters in the polder. Again, characteristic numbers shall be used like embankment length versus number of inhabitants in the multi-criteria analysis. The mitigating or aggravating factors (inundation depths, shelters) could be used as a correction factor on the scores. Another aspect could be the social situation in a polder. Experiences in the IPSWAM project and thereafter Blue Gold show that social coherence, well-organized communities and good governance are important for the success of an infrastructural project. This could be assessed based on interviews with officials inside and outside the polder.

f) **Assess the environmental conditions of the polders**: With regards to environmental conditions, the main focus is on salt intrusion and sediment. Salinity is an increasing threat in the coastal region, partly due to natural causes, like sea level rise, partly due to human interference, like dams and reservoirs in the upstream regions. Depending on the economic activities, this environmental condition could lead to an urgency to rehabilitate the polder. Sediment is another aspect that shall be assessed. Subsidence inside and waterlogging outside the polder are the main features. The long-term study in CEIP-1 looks to this in detail and their results will be used to assess whether sedimentation is an important problem or not, in addition to other sources and studies. Areas where severe water logging is occurring could be avoided for the first batch of selected polders if there is no direct solution at hand. However, prioritizing a specific polder could be an option for which a Tidal River Management (TRM) solution is available and experts agree on the feasibility. In addition, other elements of environmental conditions such as presence of protected areas, mangrove forests, important ecosystems, habitat of endangered species and physical cultural resources will be assessed.

g) **Assess the implementation and logistics:** There could be circumstances that can lead to favorable or unfavorable conditions based on implementation and logistical aspects. These aspects shall be assessed for all polders during this prioritization process. For example, land acquisition plays an important role for every embankment improvement project. Legacy of incomplete land acquisition for past rehabilitation works, emergency works during civil works and community agreement on alignment of retired embankments are also important factors in advancing embankment improvement projects. That can be relatively easy when land is available, but it can also be a cumbersome process. Considering this, advancement of the land acquisition process will be critical to project implementation. Another aspect could be the implementation of concurrent activities. For instance, the polder authorities want to improve the road to make exchange of people and goods easier, leading to better economic conditions. When there is a possibility to combine the construction of embankments with roads, a win-win situation will occur, making the chances for that polder more favorable. Also, other multi-purpose functionalities of interventions should be considered such as fishery and inland waterway transport when conceptualizing hydraulic structures. Finally, the logistics of the implementation will be important. A remote polder with difficult supply lines will deserve a lower score than one that is easily accessible. This is also the case when polders lie in the same area or are included in one work package implemented by a contractor.

h) **Update the multicriteria analysis of 2013**: The multi-criteria analysis developed during technical feasibility study of CEIP-1 shall be updated to guide the prioritization process as well as select specific polders for improvement. The identification of priority investments shall be based on aspects mentioned above such as technical, economic, social, environmental and implementation/ logistics considerations starting from the already constructed coastal embankment system, such as present population destiny and projected increase, economic activity of the area, value of current assets to be protected and forecast projections for the next 20-25 years, return period and frequency for cyclone surges and their probable direction, desirable level of protection, experience in stability of current embankments, availability of local materials for construction and maintenance.

The multicriteria analysis will result in a prioritization of the 23 polders (excluding the 7 polders of CEIP-1). This list of prioritized polders will then be used as input for the next task: the preparation of an optimal investment option.

Task 1.3: Selection of an optimal investment option

An optimal investment option shall be made to define a CEIP-2 project with an investment cost of about US$400 million or about 25% of the total coastal embankment system rehabilitation cost need whichever is acceptable to the GOB and the Bank.

This option shall include the 7 polders planned to be done from CEIP-1 which have been designed in detail but have not been rehabilitated as of yet. This shall be extended by another series of polders based on the prioritization results of Task 1.2., which will indicate a primary selection for 23 polders (excluding 7 Polders of CEIP-1). A maximum of 13 polders is envisioned to be added in this option (so in total maximum 20 polders). The Final 20 Polders (including 7 Polders of CEIP-1) shall be selected at the inception phase and detailed/updating of feasibility of these 20 Polders shall be carried out in the next Tasks.

The optimal option must be such that it will be optimal in terms of technical and institutional consideration and extent of disaster risks reduction, in terms of minimal environmental impact to neighboring schemes, maximum returns to the investments in first phase of the program, beneficiary participation in the program. The chosen option must be proven for its standalone optimal performance response to the investment plan.

Task 2: Preparation of Feasibility Studies for the 20 polders (including updating/reviewing 7 Polders of Package-3 of CEIP-1) **selected in Task 1**

The Feasibility Study will include technical/engineering studies, hydraulic, coastal and estuarine morphology and structural analysis, institutional and economic analysis, environmental and social assessment and management and maintenance plans. The main purpose of the feasibility designs is to have a solid basis for decision making. These designs choices shall be made on solutions like alignment of embankments, type and location of (renovated) sluices, river bank protection works, etc. Cost estimates should be accurate enough to arrange and justify investment loans by the Government of Bangladesh and the World Bank. The results shall be presented in a feasibility report

The Consultant shall integrate the (intermediate) outcomes of recent analytical work for the Bangladesh Coastal Zone as best as possible when preparing and executing the activities under this Task. Analytical work that shall be looked, but not limited to, are: 1) Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands; 2) Coastal Resilience: Developing New and Innovative Approaches in India and Bangladesh along the Bay of Bengal; Component 1: Improving empirical evidence and analytical support to future investments and 3) Developing Concept Design Solutions for Coastal Erosion In Bangladesh, and 4) Analytical study on the role of a probabilistic approach in polder and embankment design in Bangladesh. The first study is commissioned by the Bangladesh Water Development Board and the latter three are technical assistance studies from the World Bank.

Within Task 2, the following tasks are foreseen:

Task 2.1: Preparation of Feasibility Designs

Prepare Feasibility Designs for the protection of Coastal Area that would include new construction and reconstruction or strengthening of the existing structures or embankments as defined in Task 1, For preparing the feasibility detailed designs within CEIP-2, the Consultants will carry out, but not limited to, the following for the 13 additional polders:

a) **Review of earlier programs:** The Consultant shall derive lessons learned from a review of earlier programs such as Cyclone Protection Project (1992), Coastal Zone Water Management Program (2000), Integrated Coastal Zone Management Program - ICZMP (2006), Rehabilitation of seven high risk coastal polders 2004, etc., the project completion report of BWDB's Coastal Embankment Rehabilitation Project (2002) as well as Emergency 2007 Cyclone Recovery and Restoration Project (2008). The Consultant shall pay specific attention (i) achievements in increasing protection, changes in employment and incomes, and technologies used, (ii) effectiveness of institutional arrangements and role of project beneficiaries; (iii) accomplishments in improving water management; (iv) performance of implementing agencies, design and supervision arrangements, and contractors; and (v) O&M and project sustainability.

b) **Data collection/surveys:** Conduct necessary topographical bathymetric, river and khal's cross-sections, hydrometric survey and site investigation using appropriate technology on the ground such total station, DGPS, echo-sounder, ADCP and satellite imagery, GIS and other computerized systems to gather data necessary for morphological and river engineering studies as mentioned above and for improving and calibrating available hydrodynamic, storm surge, and morphological models to test for various strategies and alignments and design for coastal embankment system to provide most optimal solution for improving its performance considering technical, economic, social and environmental aspects. In this respect the Consultant shall synchronize its data with that of Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands.

c) **Hydraulic/hydrological analysis/modeling**: Carry out/update hydrologic/hydraulic modeling to define the design parameters for the interventions. In doing that, the consultants would consider various changes that have been taken place in the coastal area morphology including bathymetry of the estuary and tidal rivers between now and then in 1993 when the Master Plan was formulated and the works under CEIP-1. The consultant will use satellite imagery and mathematical modeling systems; Bay of Bengal Model and Regional models available for the coastal area i.e. dimensional (1D) and two dimensional (2D) models that would be updated during the project implementation period to examine and reassess coastal embankment system in accordance to the future changes, deciding on the exact range of sea level rise and height of storm surge and waves. Return periods and frequency for cyclone surges and their probable direction, desirable level of protection, experience in stability of current embankments, availability of local material for construction and maintenance, drainage systems for polderized system under different intensity of rains and tides, and valuation of potential impact of sea level rise and storm surge on coastal embankments. In this respect the Consultant shall synchronize it's modelling with that of Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands.

d) **Planform analysis and river bank erosion forecast:** Carry out sediment transport, erosion, and plan form analysis based on visual inspection, aerial imagery and hydraulic/morphological modelling for determining appropriate alignment of coastal embankment system in the study area and sections to be included in the Project. This analysis should include a detailed analysis of the spatial and temporal trends in river bank movements around all polders under consideration including 7 Polders of Work Package 3 from CEIP-1 to properly identify accretion/erosion trends. This task should result in a comprehensive forecast of the river bank behavior and bank erosion along the polder perimeters in the coming 10 - 25 years. The latter allowing to obtain and overview and prioritize the locations where river bank protections are urgently needed and at the same time not lead to investments which may be turning out being a disinvestment after several years. Different aspects need to be considered in the overview, not only the threats from the river dynamics. Cost-benefit analyses should indicate where extra protection is justified and where retreat would be a more cost-effective option. Also, different methods of protection have to be considered, including low-cost temporary solutions where the situation is not yet clear. Sometimes dredging and moving sediment from one location to another could be a cost-effective solution. The Consultant is expected to assess of the package 3 bank protective works design (lesson learned from CEIP-1 package 1 design: scenario changes drastically in the field due to morphological changes) and update the design if and when needed. The final overview contains locations, length, type of bank protection and costs. In this respect the Consultant shall synchronize its data with that of Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands.

e) **Assessment internal water management polders:** The coastal region is characterized by numerous morphologically active tidal rivers and creeks, which provide drainage network for a system of embanked hydrological units /polders. These peripheral rivers of the coastal polders have been experiencing siltation. Furthermore, the sea level rise will increase the water level in the peripheral rivers that will cause severe drainage congestions in the polders. The consultant should assess the likely sedimentation rate in the peripheral rivers in short term (3years) and medium term (10years) and the drainage congestions integrating peripheral rivers and polders due to climate change. Based on this, an improved drainage/irrigation plan for the polders to increase crop production shall be devised and considered during design of the interventions.

Task 2.2. Project Benefits and Economic Analysis

The Consultant shall perform an economic analysis to define the optimal project design which would be required in preparation of Development Project Proforma (OPP). In this analysis, the following activities are envisioned:

a) In consultation with the BWDB local authorities and other concerned agencies and stakeholders delineate the project area, i.e. the area which the project interventions would have impact. Describe and analyze the physical assets (e.g. roads, utilities, market, storage and processing facilities of agricultural produce, roads, schools, and health facilities) in both financial and economic terms, land use and vegetative features, rural/urban areas that will be benefit from the interventions.
b) Assess the potential impacts of floods and storm surges on the project area for various return period, type and extent of damages and losses of life and losses to various sectors, agriculture, industrial, health, education, power and telecommunication, public and private infrastructure, loss of production during storm surges and floods, etc.;
c) Provide estimates of project benefits, impact of agriculture production, reduction in damage and losses to various sectors of the economy such as housing including contents of houses, industry, health, education, transportation, communication, power, and telecommunication, other public and private infrastructure. Under alternative scenarios (such as present, future-without project and future-with project) and in financial and economic prices, prepare rate of returns to the investment, impact on income, and employment;
d) Estimate total project cost, benefits and economic and financial returns for the total project. Identify project risks and carry out sensitivity analysis, switching values and impact on the economic rate of return; and
e) Propose optimal project design considering economic return to varying level strengthening of coastal zone embankments and areas to focus the reconstruction with level of priority based on economic return and reduction of risks;

Task 2.3: Social Assessment and beneficiary participation aspects

The consultants will prepare and carry out the Social Assessment as needed by GOB and World Bank Guidelines for various project activities/works included in the feasibility study. Based on findings of the Social Assessment, if land or property is to be acquired permanently or temporarily or people including indigenous population present in the project area are affected in a significant way, the consultants will prepare Resettlement Policy Framework (RPF), Indigenous Policy Framework (IPF) and other social action plans for the project as relevant. In this context, the activities to be carried out will include, but not limited for the following:

a) **Develop objectives and scope**: Review project objectives, components and areas, and studies related to embankment improvement interventions in the coastal region of Bangladesh. Also, review legal and regulatory framework relevant to the project objectives and components and policy guidelines of the World Bank on social safeguards including applicability of Environmental and Social Standard on land acquisition, restriction on land use and involuntary resettlement (ESS 5) and on indigenous peoples (ESS 7). Review and apply the best practices outlined in the World Bank guidelines and guidance notes related to social inclusion, participation, citizen engagement, social accountability, gender, labor influx, fraud and corruption, and grievance redress mechanisms. Based on the review, develop objectives and scope of social assess/4 d method ology

b) **Beneficiaries and stakeholders mapping and analysis**: Carry out beneficiary mapping based on available secondary data supplemented with community consultation in the project area and identify communities disaggregated by gender, wealth (extreme poor, poor, middle income, wealthy), ethnicity (including indigenous population present in the project area), and other indicators of vulnerability to discrimination. Analyze characteristics of any small ethnic communities against the characteristics of indigenous peoples as per the requirement of the ESS7 to determine presence indigenous peoples in project area. Also, carry out stakeholder mapping and analysis: identify key stakeholders of the project and develop a stakeholder's engagement plan.

c) **Social participation**: Develop approaches for social mobilization, including a communications strategy and participation framework, to enable beneficiary and community engagement in the project design and implementation process.

d) **Information sharing:** Share information on the proposed project' activities and consult with potential project beneficiaries, potentially affected persons, and communities, and document their feedback according to best practices, including but not limited to those identified in the Stakeholder Consultations in Investment Operations Guidance Note; [42]

e) **Minimizing social risks and impacts:** Identify potential social risks and impacts of the proposed project on the communities and affected persons in project areas. Identify legacy of incomplete land acquisition in the existing embankments and the approach of acquiring lands for the project agreed with the communities and land owners. Carry out an alternative analysis of the proposed interventions on social risks perspectives for socially inclusive project design minimizing social risks and impacts.

f) **Participatory Rural Appraisal (PRA):** Design Participatory Rural Appraisal (PRA) in association with BWDB's field offices. Identify key problems of water management in the polder and the need for rehabilitation and improvement works following the Participatory Water Management Rules 2014.

g) **Institutional capacity assessment:** Conduct an institutional capacity assessment of the Bangladesh Water Development Board that includes an assessment of the current arrangements for land acquisition and implementation of RAPs and management of gender and other vulnerability to discrimination and risks of gender-based violence (GBV) in contracts work management. Identify capacity enhancement needs for the management of environmental and social requirements in project cycle and produce a capacity enhancement plan for the management of environmental and social requirements in project cycle to address gaps.

h) **Resettlement Policy Framework (RPF):** Develop a Resettlement Policy Framework (RPF). Develop TORs for Project/site-specific social screening and impact assessment and preparation of SMP/RAP. Organize consultation workshops at the national and district level (at a minimum) requesting feedback on the draft RPF from the implementing partners and potentially affected communities after incorporating feedback from the World Bank on the draft RPF. Finalize draft RPF following feedback

[42] Gill, Maninder; Ninio, Alberto. 2011. *Stakeholder consultations in investment operations: guidance note*. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/830941468323985308/Stakeholder-consultations-in-investment-operations-guidance-note

from the consultation process in agreement with the World Bank. Translate the final RPF into the Bengali Language.

i) **Small Ethnic Community Policy Framework (SECPF):** If the social assessment and analysis of small ethnic communities present in project area are identified to be indigenous peoples, develop a Small Ethnic Community Policy Framework (SECPF) of the project. Develop TOR for Project/site-specific social screening and impact assessment and preparation of small ethnic community development plan (SECDP) for small ethic communities with characteristics of indigenous peoples. Include consultation plan for the indigenous community keeping a free, prior and informed consent (FPIC) approach. Organize consultations with the small ethnic communities requesting feedback on the draft SECPF from the implementing partners and potentially benefited and affected communities after incorporating feedback from the World Bank on the draft SECPF. Finalize draft SECPF following feedback from the consultation process in agreement with the World Bank. Translate the final SECPF into the Bengali Language.

j) **Gender analysis and disability assessment:** Based on consultations with stakeholder groups and drawing from national and international best practices, carry out a gender analysis and assessment of persons with disabilities in the project areas. Drawing upon the analysis and assessment devise guidelines gender and disability inclusive project design and prepare specific gender and disability analysis and preparation of gender and disability action plan. The analysis will inform the development of gender and disability action plan for the project to provide guidance on detailed subproject designs and implementation methods

k) **Preparation of Gender Based Violence (GBV) Action Plan:** Gender Based Violence (GBV) and Sexual Exploitation and Assault (SEA) affects women and girls across their lifespan and takes many forms, including sexual, physical, and psychological abuse. To minimize the risk of GBV and SEA, and to put in place an effective response mechanism, the consultant will assess the risks of GBV/SEA, prepare a GBV action plan acceptable to the executing agency and the World Bank and support the executing agency in implementation of the action plan. The work shall include the following components:

   i. Assessment of overall GBV risks in Bangladesh based on existing diagnostics and country action plans, data on partner/no-partner physical violence against women, cultural practices related to gender norms and the location and availability of health service facilities for women.

   ii. GBV/SEA risk assessment for selected neighborhoods that includes i) the estimated magnitude of labor influx, ii) identification of geographic "area of influence" of the project vis-a-vis GBV, iii) identification of potential vulnerable locations in the area of influence; iv) list of existing services available from GBV Services Providers in the project area, and v) an assessment of the implementation agency to prevent and respond to GBV risks.

   iii. Community engagement in the area of influence with women's groups, groups that advocate for children and adolescent rights, and other stakeholders (including issues related to GBV and GBV-related concerns about the project). These consultations should feed into the identification of potential GBV issues and possible prevention and mitigation strategies. As part of these consultations, those affected by the project should be properly informed of GBV risks and project activities to get their feedback on project design and safeguard issues. Community consultations should never directly ask about experiences of GBV. The Consultant will follow ethical protocols should GBV be raised in the consultations-no separate consultations on GBV should be organized as part of the normal project preparation consultations.

iv. Review practices for codes of conduct (CoC) prevalent in Bangladesh with regard to GBV covering behavioral standards for people working on the project. Identify whether relevant model CoC are already in use by the private sector that can serve as a guide. If model CoC relating to this are not available then look at other countries in the region (for example, India).

v. Development of a draft 'GBV Roadmap' which provides details on (i) how the future CoCs can be shared with workers and the community impacted by the project (ii) awareness raising strategy in the local community (stakeholder engagement plan), and (iii) an 'Accountability and Response Framework', and (iv) a list of possible mitigation and response measures that can be discussed with the government and the Bank, and finalize the 'GBV

vi. The activities for addressing the risks of GBV and SEA outlined in the GBV Action Plan should be included in the contractor's Environmental and Social Management Plan (CESMP). The codes of conduct, community engagement and GBV roadmap should be tailored to the level of risks assessed for the project. At each stage the focus should be on prevention measures and in case of an incident, mitigation measures.

vii. Prepare other relevant documents as per the World Bank Environmental and Social Standards applicable to the proposed Project.

Task 2.4. Environmental Management Framework (EMF)

The Consultant shall prepare Environmental Management Framework (EMF) for the project area covered under the feasibility study. These will form the basis for the detailed Environmental Impact Assessments (EIA) for the final detailed designs to be carried out later on. It is noted that existing EA documentation from CEIP-1 can be used as templates and/or starting point.

The tasks with regards to Environmental Management Framework (EMF) include but are not limited to the following:

a) **Review environmental policies, regulations and lessons learned**: Review and identify all the pertinent laws, regulations and standards governing environmental quality, occupational health and safety, protection of sensitive areas and endangered species, siting, land use control, construction etc., at international, national, regional and local levels, which are expected to apply to the proposed project activities. The Consultant should especially take into consideration various laws, standards, treaties, rules and regulations pertaining to coastal areas of the country. Also, identify and review relevant studies, analysis and experience in coastal embankment improvement in Bangladesh and in other countries with similar environment and working conditions and determine the gaps to integrate environmental considerations in the project implementation. Finally, the Consultant also needs to review the applicable Environmental and Social Standards (ESS) of the World Bank (ESS I, ESS 2, ESS 3, ESS 4, ESSS, ESS 6 and ESSIO, although the consultant shall confirm their applicability, and also the applicability of any others not mentioned here) and describe their relevance to the project. A table will be prepared with all the necessary clearance/ permission and the World Bank safeguards that may apply to the project.

b) **Define geographic scope and project components for EMF**: Define the geographic area in which project activities will be carried out and conduct field visits as well as assembling secondary information in order to establish a preliminary baseline assessment of environmental issues and aspects pertinent to the project. Identify and describe all components of the project which may necessitate Environmental Impact Assessment, environmental screening, or other types of environmental assessment and management,) .·as per the national/regional/local regulatory framework as well as: World Bank environmental and Social Framework (ESE);

c) **Develop Environmental Management Framework (EMF)**: Develop (with project team) environmental screening and assessment methodology for the full nag of potential project activities/investments, which may broadly be considered. The EMF from CEIP-1 can be used as a starting point but should be updated accordingly since the newly developed Environmental and Social Framework (ESF) is applicable to CEIP-2. It should be noted that the EMF should be prepared to become a guiding material to prepare Polder specific EIAs. Apply the screening methodology to the typology of potential investment activities which may be supported under the project, to identify key mitigation and enhancement approaches that may broadly be considered. Provide guidelines (including procedures and institutional responsibilities) for preparation of sub-project specific environmental and social screening, assessment, management and monitoring plans, including generic environmental codes of practice (ECoPs) applicable to the range of investment activities expected under the project;

d) **Consultation and Disclosure Plan**: Develop a consultation and disclosure plan for (a) the EMF as a whole, and (b) future subproject specific assessments and plans (including inter alia: how many, where, what level, by when, documentation requirements, etc.). Also, identify the institutional mechanisms, responsibilities and budget, including for inter-agency co-ordination, needed to implement the EMF and ensure all environmental considerations, as well as prevention, mitigation and management aspects are properly operationalized;

e) **Institutional capacity and Stakeholder consultation**: Carry out an assessment of institutional capacity for proper environmental, health and safety management of the project, including implementation of subproject environmental management and monitoring plans, and propose capacity strengthening measures as required. Also, identify all relevant stakeholders (including implementing partners as well as other government actors, civil society and private sector actors) and carry out stakeholder consultations on the EMF, documenting the process;

f) **Finalization EMF**: Finalize the draft EMF incorporating the comments from the consultation process. Translate and finalize the EMF in Bengali and ensure disclosure both on the websites of relevant authorities as well as in hard copy at appropriate locations where project-affected people can access it.

g) Prepare other relevant documents as per the World Bank Environmental and Social Standards applicable to the proposed Project.

Task 2.5. Update framework for Monitoring and Evaluation

During CEIP-1, a framework for Monitoring and Evaluation has been developed. The purpose of this framework is for (a) monitoring and evaluation of project implementation performance, mechanisms for feedback to the implementing agencies, mechanisms for ensuring that the lessons learned are accounted for, and for development of management information systems to monitor the project performance effectively; (b) assessing the impacts of the project on the physical i.e. drainage and irrigation improvement, siltation in the peripheral rivers and on foreshore, riverbank erosion, water level and salinity, economic and other environmental and social aspects, monitoring indicators and establish baseline for the indicators; (c) monitoring and supervision of the environment, social and resettlement action plans; and (d) preparing required cost estimates for continuous monitoring and evaluation during project implementation and terms of reference for an independent consultancy services for M&E and supervision of EMP and RAP, etc. The Consultant shall review this framework and update if necessary, using the lessons from CEIP-1 and the specific characteristics of the next phase of CEIP.

Task 2.6. Assessment of International Waterway Aspects

The Consultant shall determine if the project is located on international waterways and if Bank Operations policy for 7.50 would apply. The consultants should determine the impact of the project outside the national boundaries, if any, and to the extent possible quantify the potential impact in accordance with the international procedures for use for projects on international waterways. Prepare a framework and assist the Government in processing project on international waterways. Experiences and lessons learned of the ongoing World Bank project for Bangladesh Inland Waterway Authority (BIWTA) should also be taken into account.

Reports Deliverables Task 2

Based on the activities in Task 2, a feasibility report shall be prepared including technical/engineering studies, hydraulic, coastal and estuarine morphology and structural analysis, institutional and economic analysis, detailed designs, afforestation program, environmental and social assessment for the 20 polders (including updating/reviewing the reports/document of 7 Polders of Package-1) selected in Task 1. The report shall justify investment loans for these polders to the Government of Bangladesh and the World Bank.

Task 3: Preparation of Detailed Design and Bidding Documents

This Task 3 will deliver detail design add bidding documents for the works of the selection option of Task 1. These works would be implemented mostly under ICB contract packages clustering a series of polders. The consultants would prepare detailed designs and harmonized FIDIC bidding documents for covering works of each package with the estimated cost of about US$ 100 million. Environmental and Social impact assessments and associated required safeguards documents are developed for all work packages.

It is noted that the Work Package 3 polders from CEJP-1 are integral part of this task. The Consultant can take the existing documentation from these polders as a starting point. The Consultant is expected to review the existing documentation (designs, bidding documents, EIAs, etc.) during this Task 2 and ensure that all documentation described below is available and updated if needed.

Task 3.1 Detailed Designs and Bidding Documents, EIA's and LAP/RAP

For preparing detailed designs and bidding documents for work components, the consultant would carry out, but not limited to, the following activities:

a) Prepare detailed designs and for that purpose carry out surveys, site investigations, analysis, and prepare detailed designs reports for function and use design covering the contracting agency's requirements with respect to the procurement, in pa11icular requirements related to the following:
   - Site conditions and circumstances;
   - Technical standards and use;
   - Technological innovations to meet the requirements with least cost solutions including technology and construction methods;
   - Architectural and aesthetic considerations
   - Functionality, durability and sustainability
   - Services according to the acceptable standards.

b) **Carry out a comprehensive site examination** and collect all information required for the evaluation of the present field conditions;

c) **Carry out topographical surveys**, additional to the ones performed within Task 2,to an extent sufficient to select the optimum alignment, grade and level of the embankment/dikes/number and dimensions of the hydraulic structures, to select the optimum location, and to facilitate the adequate determination of required quantities for the construction of the works.

d) **Carry out geo-technical field investigations**, which may be additionally required to determine the basic design parameter for the construction of embankment/structures and sluices, and to locate appropriate borrow areas (and/or disposal areas as needed) for material and concrete aggregates. In particular, the consultants will carry out technical, environmental and social impact analysis of any dredged material that may be generated during the construction activities and prepare detailed design for safe disposal of such materials.

e) **Prepare design criteria** for the detailed designs including supporting computations for the proposed embankment structures/ sluices, coffer dikes and other related works, according to recognized international standards. Drawings will be prepared to the extent that adequate cost estimates will be possible, and to facilitate contractors to prepare their bids and construction drawings;

f) **Choose appropriate materials**, optimize the designs and select least cost options that meet technical requirements and estimate quantities of construction, material, etc. for preparation of bidding documents;

g) **Prepare technical specifications, engineering drawings** needed for tender documents, bill of quantities (BOQs) and bidding documents. For international competitive bidding, the bidding documents would be prepared in accordance with Standard Procurement Document (SPD) following Bank's procurement regulations.

h) **Prepare engineers cost estimates** for the works/contracts, and requirements for construction supervision, including facilities, materials testing labs, on or off site as needed, equipment and staffing or any other special requirements;

i) **Prepare detailed designs for embankments**: Prepare detailed designs for the embankment including river bank and slope protection if necessary considering availability of local materials for construction, functionality, access and use as the embankments as road for improving communication in the area, ease in O&M, suitable for local O&M institution etc. Determine optimal criteria for setback from the shoreline at various locations and appropriate mix of straight and bends linking embankments, to reach to a best solution preventing from direct surge i.e. least cost solution that will be sustainable in long run with minimum O&M requirements. Various combinations can also be sought for more optimal design of embankment system, such as height raising and or easing of slope and forestation on the sea side to reduce the disaster risks using hydro dynamic, storm surge, drainage and morphological modeling and probabilistic design approaches. During design, special attention must be paid to have provisions for use of embankments as a road (with adequate crest width and subgrade: the width and level of compaction may vary depending upon the type of road). If river bank protection is considered, make an inventory of possible measures, including hard and soft measures (e.g. dredging with sediment supply at erosion site), and carry out cost-benefit analysis of these measures to select most appropriate option in relation with river dynamics and overall investment in polder. In this respect the Consultant shall make best use of the design criteria derived from Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands;

j) **Prepare detailed designs for drainage infrastructure and structures:** Prepare designs for the required drainage infrastructure inside the polders and the drainage structures such as drainage sluices and gates. Like the embankments, all these interventions shall be designed considering availability of local materials for construction, functionality (including agriculture and/or aquaculture use), access and use as the embankments as road for improving communication in the area, ease in O&M, suitable for local O&M institution etc. In this respect the Consultant shall make best use of the design criteria derived from Long Term Monitoring, Research and Analysis of Bangladesh Coastal Zone (Sustainable Polders Adapted to Coastal Dynamics), being carried out by JV of DHI, Denmark and Deltares, The Netherlands.

k) **Estimate materials, equipment, costs:** Prepare estimates of quantities of construction, materials, equipment, and prepare cost estimates (financial and economic) with appropriate physical and price contingencies, and breakdown by major works items. Also, prepare bill of quantities and proper engineering drawings showing the rehabilitation works that need to be carried out in each sub-project;

l) **Needs identification of improvement of other services:** Identify the need for improving other services including "Social Mobilization" and "Afforestation" in the project area to achieve the objectives of the project performance of coastal embankment system, etc. The Consultant will design an afforestation plan of foreshore plantation and social forestry in all selected Polders to provide protection from erosion and stabilize the embankments by countering floods, tidal surges, wave attacks and strong winds whilst supporting the livelihoods of local communities, directly and indirectly adopting appropriate best practices standards and social forestry provision to encourage community involvement. The plan will also include the implantation and O&M cost of the afforestation program during Project implementation. The Consultant will also prepare Polder Maps of foreshore and social forestry afforestation program.

Task 3.2 Environmental Impact Assessments (EIAs)

For the area covered under the detailed designs, the consultant will prepare Environmental Impact Assessment (EIA) including Environmental Management Plan (EMP). For the preparation of the EIA and EMP the Consultant will follow the guidelines of the newly developed Environmental and Social Framework (ESF) for Investment Project Financing by the World Bank. If need be, during the implementation of the project and based on changing conditions on the ground may revise and update the EMP. Major activities to be carried out for environmental impact assessment (EIA) for first batch of priority works package will include, but not limited to the following:

a) **Consultation plan:** Design the consultation plan and obtain clearance from BWDB and WB on the plan before commencing the consultation and undertaking public consultations, involving all relevant stakeholders especially local people and local NGOs, at all stages of the study at each polder and share the findings of each consultation with BWDB.

b) **Collect baseline information**: Update the environmental screening format and conduct environmental screening to collect the baseline information on the physical, biological and socioeconomic characteristics of the polders under consideration in this Task. The baseline data collection should consider the existing and proposed coastal polders rehabilitation in the area so that cumulative impacts can be assessed. The consultant will ensure that primary data and laboratory testing (for example: soil testing, air quality, flora, fauna, etc.) are collected for the necessary parameters at all sites. Based on the field visit baseline data needs to be cross checked with secondary sources, if available. Include information on any changes anticipated before the project commences (e.g., water logging). This section should indicate the accuracy, reliability and sources of the data and consequences for assessing impacts and their mitigation;

c) **Alternatives during project development**: Describe alternatives that were examined during the development of the proposed project and identify other alternatives that would achieve the same objectives. The concept of alternatives extends to sitting and design, technology selection, rehabilitation/construction techniques and phasing, and operating and maintenance procedures. Compare alternatives in terms of potential environmental impacts, vulnerability, capital and operating costs, reliability, suitability under local conditions, and institutional, training, and monitoring requirements. When describing the impacts, indicate which are irreversible or unavoidable and which may be mitigated. To the extent possible, quantify the costs and benefits of each alternative, incorporating the estimated costs of any associated mitigating measures. Include the alternative of non constructing the project to demonstrate environmental conditions without it;

d) **Determine potential impacts including cumulative**: The Consultant shall identify all significant changes likely to be generated by the project. These would include, but not be limited to, changes in the following: (i) Coastal erosion and accretion due to alteration of tidal currents; (ii) river morphology (iii) Changing fish migration routes and destruction of local habitats; and (iv) water logging (v) EHS risks and impacts during construction. Determine the potential impacts of the project through identification, analysis and evaluation on sensitive areas (natural habitats; sites of historic, cultural and conservation importance, ecologically important areas like Sundarbans), settlements and villages/agricultural areas or any other identified Valued Environment Component. State and distinguish between significant positive and negative impacts, direct and indirect impacts, immediate and long-term impacts, and unavoidable or irreversible impacts. Also, assess cumulative impact for the construction of polders which will include impact due to the construction of each polder/polder cluster on the existing surrounding area.

e) **Evaluate climate change impacts**: Evaluate the reciprocal impact of climate change and polder. For example, a polders height will be determined based on the sea level rise (SLR) due to climate change. However, due to polder height rise and insufficient drainage facilities water logging may happen in the surrounding area. The consultant will oversee the inter-relationship among climate change, polder rehabilitation and environmental impacts.

f) **Consultation with modeling group**: Consult with modeling group to establish conformity of the impact assessment with existing and ongoing and updated mathematical model for the polders specially for addressing reciprocal impact.

g) **Define mitigation measures**: Identify feasible and cost-effective mitigation measures for each impact anticipated as above to reduce potentially significant adverse environmental impacts to acceptable levels. Determine the capital and recurrent costs of the measures, and institutional, training and monitoring requirements to effectively implement these measures.

h) **Health and Safety for Construction workers**: Ensure to include sufficient plans and mitigation measures to address occupational health and safety for the construction workers;

i) **Public consultation**: Conduct detail public consultation in the polder areas with local NGOs, public, civil society and other relevant stakeholders on the EIA and EMP. A set of consultation meetings should be carried out at least at two stages, during scoping stage of EIA and when the draft EIA reports are prepared. The consultation workshop should be local, regional and national level. Ensure that environmental considerations are properly addressed in final civil engineering design including the outcome from public consultation;

j) **EIA report preparation**: Based on the above, prepare detailed EIA report for each polder separately. Each EIA report should set out EMP containing the comprehensive mitigation measures with institutional responsibility, schedule and associated cost. This should also include an environmental monitoring system to enable regular monitoring of the environmental performance of the project at the pre-construction, construction and operational stage;

k) **Prepare ether relevant documents** as per the World Bank Environmental and Social Standard applicable to the proposed Project.

Task 3.3 Resettlement Action Plan (RAP)

A Resettlement action Plan (RAP) would be necessary for the works to be included in first year's contracts for which detailed designs would be prepared. The RAPs prepared for works packages under the CEIP-1 and other projects, viz. Coastal Embankment Rehabilitation Project and River Bank Protection Project, would be good reference documents. The activities for the RAPs of the selection option with the polders to be rehabilitated will include, but not limited to the following :

a) Review project interventions and design including requirement of additional lands in each polder, active laws on land acquisition in Bangladesh, the World Bank operational policies on social safeguards and the RPF (see Task 2);

b) Carry out social screening of each polder, and design and carry out Social Impact Assessment (SIA) in respect of impacts of the project interventions by means of stakeholders' consultation and participation process, and socioeconomic survey of beneficiary and affected households of representative sample. Analyze social inclusion, participation and gender issues and public health implication due to project interventions for this SIA.

c) Following the RPF and the SIA, design and carry out detailed measurement of losses- affected land, structure, trees, crops, and employment, income, business and industry - and identify Project Affected Persons (PAP) including title holders, non- titled owners and users of affected property (squatters, encroachers and tenants), and affected income earners as follows:
   - land owners (residential and non-residential)
   - owners of physical assets (structures, crops, productive trees)
   - owners of business and industry
   - household/person with potential impact of loss on income and livelihoods associated with businesses, industry and rental or productive assets
   - community or group affected with their common property structures (sociocultural, religious, educational, and the like not defined as physical cultural resources)
   - any other person or group
   - The inventory of losses (IOL) data will be supplemented with onsite still and video imaging for cut-off date of recognizing losses for compensation and assistance.

d) Design and carry out 100% census of PAPs affected with their housing, income and livelihood resources and the current users of the agricultural lands to be acquired.

e) Review relevant national process and the RPF recommendations on valuation of assets and design and carry out market price survey for det ermin.in current market prices (CMP) of land, structures, trees and crops, recommend replacement cost (RC) and determine wage rate and loss of income by affected business and industries;

f) Identify the legacy of incomplete land acquisition or no acquisition of land used for existing embankments and devise approach the acquisition of land for the first works package in consultation with the affected land owners and the BWDB.

g) Identify alternatives to minimize land acquisition, resettlement and participation displacement those were considered in engineering design and involve communities for identification, and selection of relocation options, alternatives and sites suitable and acceptable to the communities

h) Design and implement a program of disclosure and of consultation and participation of beneficiaries and affected persons in identification, design and implementation of project interventions and the resettlement policy of each polder;

i) Describe legal framework for RAP, relevant local laws, customs that apply to land acquisition; describe entitlement policies for each category of impact and specify that resettlement of PAPs will be based on specific provisions of agreed RAP; describe methods of valuation used for affected property; prepare compensation and entitlement matrix; and describe grievance redress procedures for registering complaints and management of complaints;

j) Prepare institutional arrangement and capacity development of the social unit under the PMU for implementation of RAP including linkages with the PMU, BWDB field offices, local administration, NGOs and other stakeholders;

k) Prepare cost estimates of RAP implementation separately identifying the administrative costs, consulting services, equipment, and compensation under each impact categories , such as land, houses, trees, other property, cost of basic facilities for relocation sites, etc.;

l) Prepare implementation schedule including timelines for land acqms1t10n milestones, relocation and livelihood restoration of PAPs and handing over lands for civil works construction, and monitoring and supervision mechanism with pre-set indicators ;

m) Prepare other relevant documents as per the World Bank Environmental and Social Standards applicable to the proposed Project.

Task 3.4 Preparation of Land Acquisition (LA) Plans and LA Proposals:

One of the major impediments in execution of civil works, specially, construction/rehabilitation of embankment, is non-availability of land in time. This seriously hampers completion of project within the stipulated time. Non- handing over the right of access to land to the Contractor in proper time, as per Contract Condition, leads financial implications and litigation. So, it is intended to get the Land Acquisition (LA) Plans and LA Proposals prepared by the Consultant during this feasibility Phase as an advance activity. The Consultant shall prepare the Land Acquisition (LA) Plan and LA Proposals of Embankment and Hydraulic Structures (Drainage and Flushing Sluice) following "THE ACQUISITION AND REQUISITION OF IMMOVABLE PROPERTY ACT, 2017", BANGLADEH.

Major activities to be carried out for preparation of Land Acquisition (LA) Plan and LA Proposals will include, but not limited to the following:

- Identify alignment for any retired embankments and agree with the communities and affected land owners and finalize with assistance from the BWDB local offices and community leaders;
- Review project design for improvement of each polder and identify boundaries of additional land areas in respect of the footprints of existing embankment and the project interventions as per new design for improved embankment;
- Identify the mouzas within the boundaries of the proposed interventions as per new design and the existing embankments by location (Union, Upazila and District);
- Collect cadastral maps of all mouzas and information on previous acquisition of lands in favour of BWDB in each polder as of today;
- Collect names of current owners as per latest ownership records with subsequent changes through title transfer resulting from direct sale, exchange, inheritance, donation, and acquisition under the power of eminent domain of the country;
- Carry out land survey and identify the footprints of the existing and proposed embankment in terms of land ownership (private, BWDB owned, Khash etc) by land use;
- Digitize all cadastral maps with geo-references of plot boundaries, embankment footprints (toe lines of existing embankment and proposed embankments), ownership and land use (embankment, agricultural, residential, fishery, forestry, vacant, etc.).
- Prepare LA plans and LA proposals for each polder by district for acquisition of additional lands for embankment and sluices with diversion channels.

- Prepare other relevant documents as per the World Bank Environmental and Social Standards applicable to the proposed Project.

The Consultant will also map and demarcate BWDB land ownership in the foreshore area for afforestation program.

Task 3.5 Project Implementation Plan and Procurement Packaging

a) **Construction scenarios and work packages:** Considering the availability and performance of the contractors, and the construction industry as a whole, the size and nature of works based on the detailed designs, and available technology, propose suitable construction scenarios for the project taking the spread and distance between the works into co ns ide ration. In this context, identify packages of works which are to be implemented and appropriate criteria for selection of contractors should also be prepared.

b) **Implementation Plan**: For each type of package identified above, outline the basis for engineering supervision and administration arrangements including implementation arrangements for EMP and RAP etc; Prepare an overall implementation plan, and plans for each component of the project as well as operation plan for the project consulting services for supervision and administration of works, and monitoring and evaluation of the project impact; civil works; equipment, vehicles and other goods required for the project implementation. A risk assessment should also be part of the Implementation Plan in order to have insight in possible risks and how they can be mitigated in early stages of the project

c) **Implementation arrangements**: Propose project implementation arrangements including institutional structure clearly defining the role of the BWDB, Ministry of Water Resources (MoWR), Ministry of Finance, Planning, Ministry of Forests, district level authorities, potential need for a special Project Management Unit (PMU), divisional O&M Office of BWDB, field offices contractors, and supervisory Engineers. Layout an appropriate work flow using the proposed institutional setup such as technical approvals, approvals for technical design, approval for changes in technical designs during construction, for effective implementation, measurements and verification of works undertaken, payments procedure, flow of funds, etc. Also prepare a staffing plan for the PMU and other staff required for the project implementation; and

d) **Project management cost estimates**: Prepare cost estimates for project management, detailed designs, supervision services and other services required for project implementation. Based on the detailed analysis for projects and using appropriate methods to extrapolate various parameters for preparing an overall project design, prepare project cost estimates. These cost estimates would include cost of all components of the project, namely: (i) civil works for revamping the coastal zone embankments and ancillary works; (ii) other services, and equipment that are proposed to be provided under the project; (iii) monitoring and evaluation of the project implementation and project impact in long run; and (iv) surveys and detailed design of the works, construction supervision and contract management, field engineers requirement, operation of the project offices etc. consultant need to provide total proposed expenditure framework including key packages (Works/ Consulting/ Goods) as envisioned during the feasibility study.

e) **Development Project Proforma/Proposal (DPP):** Based on the optimal investment option, the Consultant shall assist PMU in preparation-of OPP of CEIP-2. These should be aligned with the World Bank's Project Appraisal Document (PAD).

Task 3.6. Operation and Maintenance (O&M)

The Consultant shall carry out the following tasks regarding operation and maintenance:

a) Review the past/present O&M model and required manpower of polder infrastructure with special emphasis on beneficiary participation and define an O&M model based on the lessons learned. Propose effective institutional arrangements, for ensuring the proper O&M of project facilities, including performance-based contracting for O&M, required manpower for O&M and define the role of public and private institutions in O&M of the project facilities and identify training requirements and develop a training program. In this respect also BWDB budgeting of maintenance during the construction of the works should be addressed in order to include all maintenance work into the contractor's contracts;

b) Estimate O&M requirements of the project facilities over the project life, estimate materials required for annual O&M implementation arrangements and cost estimates. Also, estimate required manpower for O&M of the project. Consider participation of local administration in O&M of the project facilities, of the project beneficiaries and develop mechanisms to ensure their participation, budgeting, etc.;

c) Prepare a draft O&M manual reflecting the above, with proper details, instructions and guidelines as the embankment systems are taken over by the employer and BWDB; and identify equipment, office and other facilities required for O&M of the project facilities.

Reports Deliverables Task 3

Task 3 shall deliver Final designs and Bidding documents, Environmental Impact Assessments (EIAs) / Environmental Management Plan (EMP), Resettlement Action Plans and Land Acquisition (LA) Plan & LA Proposals for the proposed packages of CEIP-2.

4. Team Composition & Qualification Requirements for the Key Experts

Staffing Requirements: The consultants are encouraged to use the expertise available in Bangladesh to the extent possible. However, international experience and experience with the World Bank Financed projects are necessary to carry out the assignment. The table below presents a tentative schedule of positions with an indicative number of man-months. The consultants are free to propose a staffing plan and skill mix necessary to meet the objectives and scope of the services. If all the required skills are not available within the consulting firms, they are encouraged to make joint ventures with other firms. Following is an indicative list of posts where the firms will propose their required man-months/position numbers but not limited to carrying out the assignment. Detailed resumes from all key experts in these tables (indicated with KI and KN) must be included in the proposal and are part of the evaluation. Non-key (NI and NN) experts should be identified and included in the organizational diagram but no resume is required for these staff members.

Key Professionals

A. International Consultant (Key Expert):

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
IK-1	Team leader	12	10.0
IK-2	Coastal and Estuarine Expert	6	6.5
IK-3	Hydraulic Structural Engineer	8	5.5
IK-4	Geotechnical Engineer	5	4.5
IK-5	Coastal zone Management Specialist	6	2.0
Sub –Total:		37	28.5

B. International Consultant (Non - Key Expert):

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
INK-1	Social Scientist / Sociologist / Resettlement Specialist	3	1
INK-2	Environmental Specialist	3	1
INK-3	Any other short-term specialists	4	-
INK-3b	MIS Specialist	-	1
INK-3c	Economist	-	1
INK-5	Project Coordinator (in country)	-	2
INK-6	Survey Coordinator (in country)	-	3
INK-7	River Modeler	-	6
INK-8	Project Director	-	1.7
Sub –Total:		10	16.7

C. National Consultant (Key Expert):

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
NK-1	Deputy Team leader	18	12
NK-2	Cyclone and Storm Surge Modelling specialist	12	1
NK -3	Coastal and Estuarine Morphologist	8	5

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
NK-4	Coastal Drainage & Flood Management Specialist	12	1
NK -5	Senior Hydraulic Design Engineer-1	15	10
NK-6	Senior Hydraulic Design Engineer-2	15	12
NK-7	River Engineer	8	3
NK-8	Social Development and Gender Specialist	15	4
NK-9	Resettlement and Indigenous Peoples Specialist	15	5
NK-10	Environmental Specialist	15	5
Sub-Total		133	58

D. National Consultant (Non – Key Expert):

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
NNK-1	Climate Change Specialist	6	1
NNK-2	Design Engineer-1	15	10
NNK-3	Design Engineer-2	15	12
NNK-4	Design Engineer-3	15	11
NNK-5	Design Engineer-4	15	10
NNK-6	Geo-technical Engineer	12	2
NNK-7	Database and MIS specialist	12	0
NNK-8	GIS/Remote Sensing Specialist	12	5
NNK-9	Procurement Specialist/Contract Management Specialist	10	5
NNK-10	Agriculture/Irrigation Specialist	6	4
NNK-11	Economist	8	5
NNK-12	Survey Engineer/Quantity Surveyor-1	10	5

SI. No.	Position	Indicative man-months	Negotiated man-months (as per revised Financial Proposal)
NNK-13	Survey Engineer/Quantity Surveyor-2	10	4
NNK-14	Survey Engineer/Quantity Surveyor-3	10	5
NNK-15	Survey Engineer/Quantity Surveyor-4	10	4
NNK-16	Land Acquisition Specialist-1	12	3
NNK-17	Land Acquisition Specialist-2	12	3
NNK-18	Communications/Community Relations Specialist	6	4
NNK-19	Mechanical Engineer	6	4
NNK-20	AutoCAD Specialist-1	16	10
NNK-21	AutoCAD Specialist-2	16	5
NNK-22	Ecologist	6	3
NNK-23	Forestry specialist	6	2
NNK-24	Any other short-term specialist	12	-
NNK-25	Fishery Specialist	-	2
Sub-Total		258	119

Qualifications and Tasks of Key and Non-Key Experts are provided in ANNEX-I.

5. Reporting Requirements and Time Schedule for Deliverables

Reporting: The schedule for various reports to be issued by the consultants is given below. All deliverables must be written in English. All environmental and social safeguard summaries would also be prepared in Bengali for dissemination and disclosure in the project area according to the guidelines. The Consultant shall allow sufficient time (at least 2 weeks) in the proposed time schedule for the Client to review draft deliverables and incorporate the comments in the final deliverables.

Draft and Final deliverables (reports, maps) shall be submitted to BWBD. The report/deliverables shall be submitted in MS Office, MS Excel, MS Project and Adobe PDF (with copying provision). Deliverables should also be submitted in hard-copy (numbers indicated below). All reports should have an easy-to-read layout, should be well-structured and well written, should include a summary and helpful illustrations, graphics, charts and maps.

Final Deliverables		Submission of Deliverable (Months from Start of Assignment)
1	Inception Report (it shall include but not limited to Executive	1st Month

Final Deliverables		Submission of Deliverable (Months from Start of Assignment)
	Summary, technical approach, exploration of available data and assessments, review of Final Report of Technical Feasibility Study and Detailed Design for Coastal Embankment Improvement Programmer (CEIP) (40 Copies). The Inception Report will also include Preliminary List of screening of 23 Polders out of 122 Polders (Task 1.1)	
2	Prioritization List of 13 Polders with detailed Report updating MCA of 2013 (Task-1.2) and the Strategic Plan report on selection of an optimal investment option including 20 Polders (including CEIP-1 Polders) (Task 1.3).	2nd Month
3	Feasibility Geotechnical Surveys Reports for max. 13 Polders (Task 2.1. b) Feasibility Bathymetric, Hydrometric and Topographical Surveys Reports for max. 13 Polders[43] (Task 2.1. b)	4th Month
4	Modelling Reports (Storm Surge Modelling and Polder, Morphological Analysis and Polder Drainage Modelling) for max. 13 Polders (Task 2.1. c, d and e)	6th Month
5	Feasibility Design Report for Flood Embankments, Drainage Canals, Protection Works and Drainage Infrastructure and Structures for max. 13 Polders	7th Month
6	Economic & Financial Analysis Report for max. 20 Polders (Task 2.2 and 2.6)	7th Month
7	Social and Environmental Reports (SIA, SMRPF, EMF) for max. 13 Polders (Task 2.3 and 2.4)	7th Month
8	Monitoring and Evaluation Report for max. 20 Polders (Task 2.5)	7th Month
9	Feasibility Report from the selection set of max. 20 polders (Task 2.1 to Task 2.6) (30 Copies)	7th Month
10	Reviewing and updating of Detailed Designs of 7 Polders of CEIP-1 Package-3 (Task 3)	9th Month
11	Draft Polder Reports for 7 Polders (Package 3 under CEIP-1) including review and upgradation of analysis/modeling, detailed design, EIA/EMP, RAP/LAP/SIA including executive summary (as per the Bank safeguard policies) (30 copies) and Bidding documents (Task 3.1. to Task 3.4) (4 draft + 20 final)	9th Month
12	Detailed Bathymetric, Hydrometric and Topographical Surveys Reports for max. 13 Polders (Task 3.1)	9th Month
13	Detailed of Geotechnical Surveys Reports for max. 13 Polders (Task 3.1)	9th Month
14	Update Modelling Reports for max. 13 Polders (Task 3.1)	9th Month

[43] As this task is expected to be affected by the monsoon period, the submission will be defined in the Inception Phase

Final Deliverables		Submission of Deliverable (Months from Start of Assignment)
15	Detailed Design Reports for Flood Embankments, Drainage Canals, Protection Works and Drainage Infrastructure and Structures for max. 13 Polders (Task 3.1)	12th Month
16	Environmental Impact Assessments (EIAs) and Environmental Management Plan (EMP) Reports for max. 13 Polders (Task 3.2)	12th Month
17	Resettlement Action Plan (RAP), Land Acquisition Plan (LAP) and Social Impact Assessment (SIA) Reports for max. 13 Polders (Task 3.3 and 3.4)	12th Month
18	Operation and Maintenance (O&M) Report for max. 13 Polders (Task 3.6)	12th Month
19	Bidding Documents for max. 13 Polders (Task 3)	12th Month
20	Draft polder reports (40 copies) for max. 13 polders, analysis/modeling, detailed design, EIA/EMP (10 copies), RAP (10 sets each), LAP (10 sets in tracing cloths + digitalized 5 sets) /SIA including executive summary (as per the Bank safeguard policies) and Bidding documents (Task 3.1 to task 3.4) (4 draft + 20 final)	12th Month
21	Development Project Pro Forma (DPP), giving final project description, cost estimates, economic analysis, institutional arrangements, etc. (Task 3.5) - (120 copies, as per requirement at different stages)	12th Month
22	Full final documentation of deliverables. (40 copies)	12th Month

Data Deliverables:

a) Store all collected primary/secondary/raw datasets including meta-data on the Geospatial Data Sharing Portfolio (GeoDASH) and also the Database or Sharepoint system of BWDB.
b) Completed and validated including meta-data, stored in GeoDASH and also the Database or Sharepoint system of BWDB.
a) Analytical results, graphs, tables shared in GeoDASH and also the Database or Sharepoint system of BWDB.
b) Technical memorandum describing the validation and completion procedures that have been used by the consultant for all type of data; for reproducibility purposes to be stored in GeoDASH and also the Database or Sharepoint system of BWDB.

Data Standards and Transfer Media:

Geospatial data must include details of projection and must be provided in a standard OGC format or well-known format. The minimum requirements to be followed for all geospatial (GIS) data are:

1. Metadata: Detailed documentation needs to be provided for each data set. This metadata must include description, source, contact, date, accuracy, restrictions. A description of attributes needs to be provided for vector and tabular datasets. There are available ISO

standards commonly used by World Bank financed projects to guide the development of metadata.

2. Vector data: Geospatial vector data must be provided in a well-known GIS format. This includes but is not limited to: ESRI *shapefile, KML, GML, WKT*. Additional formats may be used with approval. Where possible, styling information should be provided in SLD format. All files must include projection parameters.
3. Raster data: Geospatial raster data must be provided in a well-known format. This includes but is not limited to: *geoTiff, JPEG, JPEG2000, ArcInfo ASCII, Binary grid, MrSid*. Additional formats may be used with approval. Where possible, styling information should be provided in SLD format. All files must include projection parameters.
4. Tabular data: Tabular data must be provided in a readily accessible or well-known format. This includes but is not limited to *CSV or Microsoft Excel spreadsheet*. Additional formats may be used with approval.

All spatial data should meet OGC standards http://www.opengeospatial.org/standards. It is strongly preferred that the vector data be delivered as shape files with associated OpenGIS® Styled Layer Descriptor (SLD) and the Raster data be delivered in the GeoTiff format. All data should be geo referenced and projected in WGS 84 UTM zones. Metadata documentation shall be produced in an approved format compatible with the Federal Geographic Data Committee. FGDC-STD-001-1998. Content standard for digital geospatial metadata (revised June 1998). Federal Geographic Data Committee. Washington, D.C.

Media/method of transfer: All data sets must be transferred onto database of GeoDASH and also the Database or Sharepoint system of BWDB.

Licensing:

Results that are procured and developed for this project are done so on behalf of Government of Bangladesh. Usage shall be guaranteed to the Government of Bangladesh; therefore all licensing agreements must be made similarly. The license includes the right of the Government of Bangladesh (and sub-licensees) to freely use and distribute the results, through the following means:

1. Hazard, risk and environmental assessments;
2. Research into the natural and built environment;
3. Extraction of derivatives (including, but not limited to, slope and roughness) and features (including, but not limited to, building footprints, fault traces and other geomorphic features). Extracted derivatives and features will be the intellectual property of whoever extracts them;
4. Presentation in reports and presentations;
5. Presentation, distribution and analysis through the internet; and
6. Dissemination of spatial hazard and loss data (shapefiles and raster files) in national data management platforms.

On completion of the project, all final project datasets must be submitted to BWDB.

6. Client's Input and Counterpart Personnel

The Bangladesh Water Development Board (BWDB) is the contracting agency for this scope of services.

After the inception stage the Consultants shall prepare a detailed schedule and task flow diagram, which depicts the interrelationship of various tasks in the assignment which lead to the completion works and mechanism of coordination with the client and other related entities. This will be kept and update throughout the Project duration.

The Consultant shall work under the direct supervision of the BWBD Project Director with the PMU office of BWDB assisting the Consultancy Team as required, particularly to the hydrological, morphological and institutional aspect of the services. In case of any unforeseen events, be it in terms of physical or social obstacles at field levels. The BWDB concerned field offices will take initiatives to solve them and ensure good working environment. Technical and project management issues shall be discussed in meetings among PD PMU and the Consultants. Any unresolved issue, technical or otherwise, would be taken up with BWDB through the PD and BWDB, Dhaka or DG, BWDB, Dhaka. The consultant will establish their office in Dhaka and the field at a convenient location from BWDB offices to whom they will be reporting on a day to day basis.

The Consultants shall be responsible for all aspects of performance of services as set forth in the preceding sections of this TOR. For smooth completion of the study, the PD shall assist the Consultant, as far as possible, in collection of the following data, services and facilities:

- Available hydrological, meteorological, as well as morphological data.
- Available maps such as planning map, project index maps, contour maps, mouza maps etc.
- Available studies carried out by different study partners in relation to this study for generation of secondary information and future plans.
- Available agricultural and environmental data.
- Make available the input from the design office of the BWDB.
- Physical monitoring data done by BWDB etc.
- Approval process of designs to obtained from the design office of the BWDB.

Preparation of environmental and social safeguard documents by independent specialists: the company independent from the companies conducting the rest of the required tasks should be retained to carry out environmental and social related studies required in Task 1(e), 1(f), 2.3, 2.4, 2.10, 2.11 and 2.12. In addition, the consultants are requested to meet the following to carry out environmental and social related studies:

1) The company in charge of environmental and social studies should be an independent entity from the companies conducting the rest of the required tasks which would be formed for the bidding purpose;
2) Assurance should be provided by member companies that they have sufficient independence to reach the results of their work without undue interference from the other companies conducting the other tasks; and
3) The deliverables of the environmental and social studies should be separately produced and provided to PMU and the Bank prior to being consolidated into a single report of the feasibility study.
4) There will be a dotted line of reporting to the PMU by the company in charge of environmental and social studies, to maintain independent integrity.

Duration of the Assignment: Duration of the contract would be one year.. Last but not least is the undertaking of the consultants (standard) on obligatory responses to any technical related query arising from time to time after the implementation of the project but during the first year after closure (post warranty period).

ANNEX – I

Qualifications and Tasks of Key and Non-Key Experts

(Note: Certificate of equivalent educational degree will not be accepted and evaluated)

International Consultant	Qualifications and Tasks
Team Leader	S/he should have Masters' degree in Coastal Engineering/Water Resources Engineering/Hydraulic Engineering. S/he should have 15 years professional experiences and at least 10 years' experience in the relevant field like coastal engineering and coastal zone planning, including leading and managing a study team for planning and design of interventions for coastal flood protection and water management in low-lying areas/polder systems. He/she shall be familiar with World Bank procedures and processes for designing and implementing programs in developing countries. Previous experience in similar working environment will be preferred. **The consultant need to have adequate working experience in addition to his/her own country.** ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to the following: • Formulate strategy for stabilizing coastal polder systems. • Prepare project work plans, schedules • Maintain liaison with BWDB and other related agencies • Guide and supervise the project activities, • Comparison of the alternative plans and find out the suitable solutions • Formulation of implementation and O&M plan Preparation of different. reports as required for the study • Preparation of reports as needed under the contract.

International Consultant	Qualifications and Tasks
Coastal &Estuarine Expert	Masters' degree in Civil/Water Resources Engineering/Coastal Engineering having a minimum of 15 years of professional experience with estuarine and coastal morphology and 10 years' experience in sediment transport and morphological modelling for the coast. Previous experience in similar working environment will be preferred. ***Tasks**:* He/ She will be responsible for developing baseline condition of storm surge levels, waves, sedimentation and erosion process of the estuary, characteristic of shoreline migration, etc. in the Bay of Bengal. Definition of the hydraulic boundary conditions, establishment of short and medium-term forecast of shoreline in front of polders and shoreline. Assess the risk of storm surge considering sea level rise. Carry out wave analysis and wave modeling for computing wave run-up for sea-dyke. Forecast of sedimentation and erosion of peripheral rivers for short and medium-term using state of the art technology for bank erosion analysis.
Hydraulic Structural Engineer	Minimum Masters' degree in Civil/Water Resources Engineering having a minimum of 15 years of professional experience with at least 10 years' experience in planning and design of coastal hydraulic structures, embankment/sea dyke. Previous experience in similar working environment will be preferred. ***Tasks**:* The Hydraulic Structural Engineer shall be responsible for design of the alternative structures/measures suitable for the solutions of the drainage and flood management problem of the coastal polders and river and sea dyke considering the risk of storm surge, waves and seal level rise. His/her major responsibilities shall include but not necessarily be limited to the following:

International Consultant	Qualifications and Tasks
	• Design of the alternative structures recommended for the solutions of the drainage and flood problem • Design of link canal, peripheral embankment and other ancillary structures • Preparation of cost estimates of the structures on the basis of recent actual schedule of rates, including annual expenditure schedules • Assist in preparation of different reports as required for the proposed study.
Geo-technical Engineer	Master degree in Civil /Geo-technical engineering/Geology having a minimum of 15 years of professional experience with at least 10 years' experience in embankment and hydraulic structures design in low-lying environments with weak soil conditions. Previous experience in similar working environment will be preferred. **Tasks:** His/her major responsibilities shall include but not necessarily be limited to the following: • Assess and define needs of geo-technical information for geotechnical analyses • Lead geotechnical analyses and designs for embankment, hydraulic structure, river bank protection works, specialty geo-structures, deep foundations and ground improvement programs • Preparation of different reports as required for the proposed study
Social Scientist/ Sociologist/Resettlement Specialist	Minimum Masters' degree in sociology/ economics/social welfare. He/she should have minimum 15 years professional experience and at least 8 years working experience in planning and design of Resettlement Action Plan (RAP) for the project affected persons (PAPs). Identification of the PAPs and assessment of their loss of assets and incomes. Carry out survey including focus group discussions for collecting local information on social condition, cultural values. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to: • Assessment of affected assets, loss of land and migrated people. • Carry out focus group discussions / discussions for

International Consultant	Qualifications and Tasks
	collecting local information on social condition, cultural values etc. • Designing a survey for identifying the project Affected Persons (PAPs), assessing their lossess, prepare a compensation matrix following the World Bank Guidelines. • Prepare a Resettlement Action Plan (RAP) in association with the national Consultant.
Environmental Specialist	Minimum Masters' degree in Environmental Engineering/or Water Resources Engineering/Geography with special training in carrying out EIA and preparation of EMP. He/she should have minimum 15 years professional experience with at least 8 working experience in similar assignments. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to: • Assess the baseline environmental condition • Assess the potential impacts of the project activity on surrounding environment • Prepare an EMF, EIA and EMP for each package of works under the project. • Assist in preparation of different reports as required by the team leader
Coastal Zone Management Specialist	Minimum Masters' degree in Coastal management/Water Resources Engineering having a minimum of 15 years of professional experience with at least 10 years' experience in planning and prioritizing of coastal zone interventions. Previous experience in similar working environment will be preferred. ***Tasks***: The Coastal zone management specialist shall be responsible for the prioritization process of polders for interventions. He/she is responsible for including lessons learned from the prioritization of CEIP-1 and develop an updated methodology for this prioritization process. He/she shall work with the various technical specialist (design, environmental, social, costing) to integrate these factors into the prioritization process which shall result in a shared agreement on the polders to be prioritized. His/ her major responsibilities shall include but not necessarily be limited to the following: • Review of the prioritization methodology of CEIP-1

International Consultant	Qualifications and Tasks
	• Set up methodology for prioritization of the polder system taking into account lessons learned from earlier programs • Liase with BWBD on the prioritization process • Assist in preparation of reports as required for the proposed study

National Consultant	Qualifications and Tasks
Deputy Team Leader	He/ She should have Masters' degree in Coastal/Civil/Water Resources /Hydraulic Engineering. He/ she should have 15 years overall professional experiences with at least 10 years experiences in coastal water resources management, including leading and managing a study team for water resources planning and design, drainage management. He/ She should have experience in risk assessment and devising mitigation measures for risk reduction in the coastal area. ***Tasks**:* His/her major responsibilities shall include but not necessarily be limited to the following: • Coordinate all the component of the study • Review the available reports on damage assessment and study reports in the coastal area • Prepare work plans, schedules • Maintain liaison with BWDB and other related agencies • Assist the team leader in guiding and supervising the project activities, • Devise potential options for water management and risk assessment • Formulation of implementation and O&M plan • Preparation of different inception progress and other reports • Preparation of Final Report as needed under the Contract. In absence of the Team Leader, he/she will perform the tasks of TL as "Acting Team Leader" in addition to his/her own tasks and shall keep liaison with BWDB, World Bank and other Stakeholders.
Cyclone and Storm Surge Modelling Specialist	Masters' degree in Coastal/Civil/Water Resources Engineering having a minimum of 12 years of professional experience with at least 5 years' experience in hydrodynamic and storm surge modelling for coastal area. Previous experience in similar working environment will be preferred.

National Consultant	Qualifications and Tasks
	Tasks: He/She will be responsible for developing storm surge model and updating and improving of available storm surge model for the Bay of Bengal. Hind casting of historical cyclone storm surge and devising worse scenario for assessing the risk and design parameters for coastal embankment. Assess the risk of storm surge considering sea level rise. Carry out statistical analysis for storm surge level in establishing the return period and corresponding storm surge level. Simulate storm surge considering mangrove forest at foreshore to find the surge height reduction and planning forestation. Prepare the report on storm surge.
Coastal &Estuarine Morphologist	Masters' degree in Civil/Water Resources Engineering/Coastal Engineering having a minimum of 15 years of professional experience with estuarine and coastal morphology and **5** years' experience in sediment transport and morphological modelling for the coast. Previous experience in similar working environment will be preferred. ***Tasks***: He/ She will be responsible for developing baseline condition of sedimentation and erosion process of the estuary, characteristic of shoreline migration. Establishment of short and medium-term forecast of shoreline in front of polders and shoreline of Chars. Forecast of sedimentation and erosion of peripheral rivers for short and medium-term using state of the art technology.
Coastal Drainage and flood management specialist	Minimum Masters' degree in Civil/Water Resources Engineering/Hydrology. He/she should have at least **15** years working experience including **5** years in hydrological analysis, development of drainage models and application of drainage models in flood control and drainage management in tidal environment. ***Tasks***: His/her major responsibilities shall include but not necessarily be limited to: • Hydrological analysis and establishment of design flood event Development of drainage model for different scenarios to find out design parameters for the interventions • Assess the drainage performance of the drainage systems under different scenarios using numerical

National Consultant	Qualifications and Tasks
	model • Find the design parameters for hydraulic structure • Contribute in preparing the report of the study and workshop materials • Attend meeting as and when required
River Engineer	He/she should have Master Degree in Civil/Water Resources Engineering having a minimum of 15 years of professional experience with at least 5 (five) years' experience in river engineering works that include design of bank protection and embankment systems to protect against flooding. Previous experience in similar working environment will be preferred. ***Tasks***: His/ her major responsibilities shall include but no necessarily be limited to the following: • Design of the alternative approach recommended bank protection, embankments, and hydraulic structures, protecting land against flooding without causing harm to the environment; • Preparation of cost estimates of embankments, river bank protection protecting land against flooding on the basis of recent actual schedule of rates, including annual expenditure schedules • Assist in preparation of different reports as required for the proposed study.
Climate Change Specialist	Minimum Masters' degree in Civil/Water Resources Engineering/ Hydrology. He/she should have at least 12 years working experience including 5 years in hydrological analysis, climate change and sea level analysis and hydrological modelling. ***Tasks***: His/her major responsibilities shall include but not necessarily be limited to: • Review of climate change scenario and available reports on climate change • Rainfall-runoff analysis for the coastal area/polder systems; • Assessment of potential impacts of climate change and sea level rise using numerical modelling technique • Assist drainage and flood modelling specialist and tide and wave specialist in specification of climate change into hydraulic boundary conditions
Hydraulic Structure/ Senior Design Engineer	Minimum Masters' degree in Civil/Water Resources Engineering having a minimum of 15 years of professional experience with at least eight years' experience in design of coastal hydraulic structures, embankment/sea dyke. Previous experience in

National Consultant	Qualifications and Tasks
	similar working environment will be preferred ***Tasks**:* The Design Engineer shall be responsible for design of the alternative structures/measures suitable for the solutions of the drainage and flood management problem of the coastal polders and river and sea dyke considering the risk of storm surge, waves and seal level rise. His major responsibilities shall include but no necessarily be limited to the following: • Design of the alternative structures recommended for the solutions of the drainage and flood problem • Design of link canal, peripheral embankment and other ancillary structures • Preparation of cost estimates of the structures on the • basis of recent actual schedule of rates, including annual expenditure schedules • Assist in preparation of different reports as required for the proposed study
Design Engineer	Bachelor degree in Civil /Water Resources having a minimum of 8 years of professional experience with at least 3 years' experience in design of coastal hydraulic structures, embankment/sea dyke. Previous experience in similar working environment will be preferred ***Tasks**:* The Expert shall be responsible for design of the structures/measures suitable for the solutions of the drainage and flood management problem of the coastal polders and river and sea dyke considering the risk of storm surge, waves and seal level rise. His major responsibilities shall include but no necessarily be limited to the following: • Design of the structures recommended for the solutions of the drainage and flood problem • Design of link canal, peripheral embankment and other ancillary structures • Preparation of cost estimates of the structures on the • basis of recent actual schedule of rates, including annual expenditure schedules • Assist in preparation of different reports as required for the proposed study (design reports, bidding documents)
Geo-technical Engineer	Bachelor degree in Civil /Geo-technical engineering/Geology having a minimum of 15 years of professional experience with at least five years' experience in soil investigation, geotechnical analyses and other geological aspects in environments with weak soil conditions for design of civil structures such as

National Consultant	Qualifications and Tasks
	embankments, hydraulic structures and bank protection. ***Tasks:*** His major responsibilities shall include but not necessarily be limited to the following: • Plan and coordinate geotechnical & geophysical investigations, instrumentation programs, and in-situ & laboratory testing programs (soils & rock, construction materials, geosynthetics) • Characterize material properties for geotechnical modeling, analyses and design • Originate geotechnical analyses and designs for embankment, hydraulic structure, river bank protection works, specialty geo-structures, deep foundations and ground improvement programs • Assess and need based Geo-technical information • Preparation of different reports as required for the proposed study
Database &MIS specialist	Graduate in Water Resources/Civil Engineering/Computer science and Technology with minimum 15 years of professional experience and at least 10 years working experienced in Database and GIS related project management and development. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to: • Knowledge and experience about the status, scenarios and possibility of available data • Planning and design of database • Provide technical advice for GIS/Database building • Design protocol for the work. • Develop the database hierarchy, protocol, tools and web portal of the database
GIS/ Remote Sensing Specialist	Minimum B. Sc. Degree in Civil Engineering/Water Resources Engineering/Urban and Rural Planning/Hydrology / Masters In Geography. He/She should have at least 8 years' experience in producing GIS coverage, contour map, Digital Elevation Model. ***Tasks:*** His/her major responsibilities shall include but not

National Consultant	Qualifications and Tasks
	necessarily be limited to: • Preparation of Arc view based contour maps of the polders, inundation depth map • Remote sensing analysis for extracting data • Analyze satellite images to find the past accretion and erosion rate • Preparation of project map showing existing and proposed infrastructures • Preparation of maps for workshops and reports Assist the study team
Procurement specialist / Contract Management Specialist	Minimum B. Sc. Degree in Civil Engineering/Water Resources Engineering /Hydraulics Engineering/Masters in Economics/Commerce. He/she should have minimum 15 Years professional experiences with at least 12 years working experience in processing the procurement of goods, works and services, following GOB and WB procurement guidelines. ***Tasks:*** • Prepare specifications/terms of reference for procuring all kind of goods, equipment, works and services in accordance with the policies and guidelines. • Prepare documents for the pre-qualification • Prepare bidding documents for the next batch of CEIP and assist BWDB up to the point of Contract award.
Social Development Specialist	Minimum Masters' degree in sociology/economics/social welfare. He/she should have minimum 15 years professional experience and at least 8 years working experience in planning and design of social management plan (SMP), Resettlement Action Plan (RAP) for the project affected persons (PAPs), indigenous people's development planning, gender and GBV risks analysis and grievance management. Identification of the PAPs and assessment of their loss of assets and incomes. Carry out survey including focus group discussions for collecting local information on social condition, cultural values. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to: • Assessment of affected assets, loss of land and migrated people. • Carry out focus group discussions / discussions for collecting local information on social condition, cultural values etc.

National Consultant	Qualifications and Tasks
	• Designing a survey for identifying the project Affected Persons (PAPs), assessing their losses, prepare a compensation matrix following the World Bank Guidelines. Prepare a Resettlement Action Plan (RAP), Indigenous peoples plan, and preparation/coordination of preparing Gender action plan and GBV risks management plan, in association with the national Consultant.
Resettlement and Indigenous Peoples Specialist	Minimum Masters' degree in Sociology/Social Welfare/Social Science. He/she should have at least 15 years working experience in involuntary resettlement and knowledge of indigenous peoples and their vulnerability in Bangladesh. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to: • Review of national laws on land acquisition and the World Bank ESS5, identify gaps and develop legal and policy framework for the project; • Review the national legal and regulatory framework on small ethnic communities/ tribal peoples in Bangladesh with respect to the Bank ESS7, identify gaps and develop legal and policy framework on small ethnic communities under the project; • Assessment of affected assets, loss of land and migrated people. • Carry out focus group discussions / discussions for collecting local information on social condition, cultural values etc. • Designing a survey for identifying the project Affected Persons (PAPs), assessing their loses, prepare a compensation matrix following the World Bank Guidelines. • Develop RPF and SECPF for the project and Resettlement Action Plan (RAP) and if required, SECDP for the first works package in association with the international Consultant.
Environmental Specialist	Minimum Masters' degree in Environmental Engineering/ or Water Resources Engineering/Geography/Ecology with special training on preparation of Environmental Impact Assessment (EIA)/Environmental Mitigation Plan (EMP). He/she should have at minimum 15 years professional experience with at least in Environmental Impact Assessment. Knowledge on EIA for embankment construction, ecology and river morphology and GIS will be an added advantage. Familiarity with World Bank safeguard policy and experience with EIA of water related World

National Consultant	Qualifications and Tasks
	Bank funded project is mandatory. ***Tasks:*** His/her major responsibilities shall include but not necessarily be limited to the following: • Assess the baseline environmental condition • Assess the potential impacts of the project activity on surrounding environment • Prepare an Environmental Impact Assessment (EIA) and Environmental Mitigation (EMP) for each package of work under the project. • Assist in preparation of different reports as required by the Team Leader
Ecologist	The key staff should have a postgraduate degree in Ecology / Biology or related field with 10 years professional experience in the field of ecological survey and assessments. ***Tasks:*** This key staff shall be responsible for but not limited to: • Design, plan, implement and/or supervise Ecological Survey • Collect the ecological baseline information. • Evaluate ecological risks and impacts related to construction activities especially in the coastal areas, and propose mitigation measures according to mitigation hierarchy • Actively participate in stakeholder engagement activities • Preparation of reports required by the Team Leader
Agriculture/ Irrigation Specialist	He/she should have at least Masters' degree in agriculture/agronomy/irrigation/water management with minimum 15 years' experience including at least 5 years' experience in project preparation/ feasibility studies, appraisal of agriculture/water resources projects. ***Tasks:*** The Agriculture/Irrigation specialist will work in consultation with the Project Economist and the Team Leader to assess the present cropping pattern and suggest a future cropping pattern, farm budget and cost estimates for economic evaluation of the project. His/her major responsibilities shall include but not necessarily be limited to the following: • Assess the present cropping pattern and and crop water demands and availability (both in terms of quantity and quality)

National Consultant	Qualifications and Tasks
	• Suggest future cropping pattern considering land, soil, water, socio-economic issues • Assess the drainage requirements and options for mitigating the drainage congestion of the project • Assess the costs and benefits of crop production, estimate the crop loss due to drainage congestion • Assist Team Leader in drafting / preparation of reports
Economist	He/she should have at least Masters' degree in Economics with minimum 15 years' professional experience including at least 5 years' experience in economic analysis/appraisal of agriculture/water sector projects. A significant portion of this experience may also include natural resources management, physical and monetary valuation of possible environmental impacts. ***Tasks:*** The Economist will assist mainly by appraisal of project worthiness in terms of economic viability. His/her major responsibilities shall include but not necessarily be limited to the following: • Elaboration of the feasibility level cost estimates, contingency amounts, detailed price escalation estimates on the expected implementation schedule; administration costs and tax and duties shown as separate line items and the method of calculation of these costs • Estimation of Benefits; the benefits will include profits from extra agriculture production as a result from reduce flood damage and drainage congestion, higher cropping intensities and use of high yielding varieties based on the cropping prepared by agronomist • Estimates for BCR, EIRR and NPY; benefits and costs of each planning option will be estimated based on the with and without project situation • Assessment of risk to the projects viability; this will include social risks as well as traditional benefits and implementation schedule assumptions • Assessment of costs arising out of mitigation measures (or external dis-benefits) • Conclusion of socio-economic viability of each planning option and the project as a whole • Assist Team Leader in drafting / preparation of report
Survey Engineer/Quantity Surveyor	Bachelor's Degree in Civil Engineering/Water Resources Engineering/ Hydraulics Engineering. He should have minimum 15 years professional experiences with at least 10 years'

National Consultant	Qualifications and Tasks
	experience in hydrographic, topographic and hydrometric survey and knowledge on using DGPS, ADCP, hydrpro, Arcview, and other technology like Tearra model for processing surveyed data. ***Tasks***: His/her major responsibilities shall include but not necessarily be limited to the following: • Preparing detailed specification for all field survey activities • Conduct and supervise the survey activities • Ensure the quality of the survey • Guide in processing and analyzing the data • Preparation of Survey Report • Find out the quantity of earth for re-construction/re-sectioning of embankment and re-sectioning of drainage channels. • Find out the quantity of construction materials from the design of the drainage/flushing sluices and protective works, • Find out the quantities of different items of work from the designs of Embankment, Regulators, Protective Works, etc. for preparation of Bill of Quantities (BoQ) of the respective packages.
Land Acquisition Specialist	He/she should have Master's degree in Geography/Geology or any other subjects from any recognized University in Bangladesh or abroad with at least 15 years of professional experience with 10 years of experience in the relevant field. Experience in the similar nature of works in the similar area will be given preference. ***Tasks:*** His/her major task includes but not limited to the following: • Identify the footprint of the embankment in terms of land ownership (private, BWDB owned, Khash etc) by land use. • Collect of Mouza/cadastral maps and digitize them with the assistance from the GIS Expert. • Prepare embankment footprint maps for each polder showing existing and proposed embankment boundaries with current ownership. • Prepare the Land Acquisition Plan (LAP)s and Proposals of embankment and sluices with diversion channel following **"THE ACQUISITION AND REQUISITION**

National Consultant	Qualifications and Tasks
	OF IMMOVABLE PROPERTY ACT, 2017", BANGLADEH • Identify area suitable for **foreshore afforestation**. • Identification of **borrow area** with collection of soil **sample** of Borrow Pit and River bed along the periphery of polders at 10 km interval and tested from laboratory for suitability of earth materials; • Identification of proposed suitable location for (i) **stock yards** of soil heap; (ii) **construction yards** and (iii) disposal sites for unsuitable excavated material in connection with embankment upgrading and khal excavation.
Communications / Community Relations specialist	Minimum masters' in Sociology/Political Science/ Mass or Development Communications. He/ She should have minimum 10 years' professional experience with at least 5 years' experience in informational campaign and development communications. Previous experience in coordinating the study and workshops of development projects will be preferred. ***Tasks***: The specialist will assist the study team mainly by formulating a communications strategy for the proposed intervention to ensure secured environment for the population and intensive agriculture. His/her major responsibilities shall include but not necessarily be limited to the following: ➢ Carry out Field Visit and apprise the local peoples on potential interventions of the CEIP-2 and identify the views of the local peoples, their present socio-economic activities, problems including present land-use patterns in the study areas in respect to potential intervention ➢ Identification of future probable social negative impacts of the project and possible social impact. Consultation with local people about the potential scenarios of drainage improvement
Mechanical Engineer	He/she should have B. Sc. Degree in Mechanical Engineering having 10 years of professional experience with 7 years' experience in the relevant field. Higher degree and experience in the similar area and environment will be preferred. ***Tasks:*** His/her major task includes but not limited to the following: - Prepare the designs of flushing/drainage gates of different sizes in accordance with the design of drainage sluices and flushing sluices.

National Consultant	Qualifications and Tasks
	- To prepare the designs for repairing the gates (Flap gate, Vertical Lift gate, Hoisting devices etc.) of different sizes for regulators and flushing inlets etc. - Explore the sustainable designs of gates of regulators suitable for saline water (e.g. using different materials); - Initiate to obtain approval of the designs of gates from the competent authority; - Assist in the preparation of the project report
AutoCAD Specialist	He/ She should have Minimum Bachelor Degree on Civil/Water Resources Engineering having minimum 7 years professional and 3 years relevant experiences working knowledge of CAD standards, PC application software and drafting/ engineering practices for preparation of different types of drawings of hydraulic structures. His/her major task includes but not limited to the following: - Coordinate with designers and other personnel to incorporate concepts and information into drawing packages - Prepare different kinds Drawings of Structures under the supervision of Design Engineer. - Prepare Drawings of drainage canals/Embankments of polders. - Assist the team Leader or any other Consultants when necessary
Forestry Specialist	He/she should have Master's degree in Forestry/Forest Management/Silviculture or Masters in related field with a minimum of 10 years of work experience of which at least 7 years should be directly related to the relevant technical, social, environmental and economic tasks of coastal foreshore afforestation (mangrove afforestation) and social forestry activities. The expert must have demonstrated sound technical expertise in international good afforestation and social forestry practices and have proven track record of providing forest management, planning, monitoring, and capacity building oversight functions. Knowledge of World Bank/Asian Development Bank or similar development partner's procedures and guidelines will be preferred. S/he must have excellent communication and writing skills with higher level computer skils in windows operating system (Word, Excel, Power Point, etc.) and other application. His/her major task includes but not limited to the following: - Prepare foreshore and social forestry afforestation plan in all selected Polders adopting appropriate best practices, standards and social forestry provisions, to encourage community involvement during implementation.

National Consultant	Qualifications and Tasks
	- Prepare Polder Maps of afforestation program (chainage-wise) - Liaison and collaborate with key stakeholder groups (NGOs, CBOs and WMOs), Project personnel and government authorities (MoWR, BWDB, Ministry of Environment and Forestry, BFD and local government) to to deliver project inputs, activities, outputs, outcomes and impacts. - Assist the team Leader or any other Consultants when necessary
Any other short-term specialist	As and when it will be required

Appendix 2 List of documents reviewed

Overview of documents reviewed:

1. Coastal Embankment Project (CEP – 1958 to 1990)
2. Cyclone Protection Project – II (CPP-II – 1985)
3. Coastal Embankment Rehabilitation Project (CERP - 1995 to 2003)
4. Second Coastal Embankment Rehabilitation Project (2nd CERP)
5. Integrated Coastal Zone Management Program (ICZM) and 2nd CERP
6. Coastal Zone Water Management Programme
7. Coastal Embankment Rehabilitation Project (stage-II)
8. Fourth Fisheries Project.
9. Emergency Cyclone recovery and restoration project (ECRRP – 2008 to 2018)
10. Coastal Embankment Improvement Project Phase 1 (CEIP-1)
11. Long Term Monitoring Project under CEIP-1
12. Blue Gold Programme (March 2013 - ongoing)
13. Integrated Planning for Sustainable Water Management (IPSWAM 2002 to 2005)
14. Meghna Estuary Study (MES)
15. World Bank TA's
16. ECOBAS

Coastal Embankment Project (CEP – 1958 to 1990)

The Coastal Embankment Project (CEP) was implemented to protect the low-lying agricultural land and isolated chars (Island) of the Coastal belt of Bangladesh from inundation and intrusion of saline water during high tides and to increase the land under agriculture in the coastal region and increase the agricultural production from existing areas under cultivation. Implementation of the programme was started in 1958 by the then EPWAPDA (now BWDB) with assistance of US AID. After independence in 1971, the Government of Bangladesh (GoB) resumed the programme through the Bangladesh Water Development Board. As per BWDB's information, under this programme, about 5665.00 km of embankment with about 1697 nos. Regulators and about 1202 flushing regulators were constructed. Thanks to these implementations, an area of about 1.22 million ha, including nearly 1 million ha of cultivable area, has become protected from inundation of saline water.

Implementation of the Coastal Embankment System improved the internal drainage capability of the polders, reduced salinity in the area within the embankment and significantly reduced the vulnerability of the local people by increasing the protection from natural disasters like cyclones. Furthermore, the CEP improved economic opportunities by ensuring increased agricultural production and improving local transporation by making use of embankment top as a road.

Over time, due to lack of proper maintenance coastal polders have become vulnerable to storm surge, flood,river bank erosion of adjacent rivers,internal drainage congestion,, siltation and sea level rise. In some area of the Coastal Embankment Project, such as polder-25 in Khulna district for instance, siltation on the bed of the drainage channels and on the adjacent river bed have created a huge drainage problem. Many previously built structures have become either inadequate to meet the present needs or have become inoperable. Changes of land use in other areas than crop production also have created unexpected water management problems. The natural and man-made interventions stated above have increased the degree of vulnerability.

Lessons learned
The previously implemented CEP aided to save lives and improve both agriculture and economic activities in the coastal area. Over time, due to a lack of maintenance, the polders became vulnerable to high tide and cyclone surge and drainage channels have become inoperable. As CEIP-2 shares many similarities with the CEP and it is of vital important to learn from the CEP.

- To prevent the polders to return to their current state over time, proper maintenance will be of vital importance.
- After the implementation of CEIP-2, maintenance of the embankment, drainage sluices and periodic re-excavation of drainage channels, in particular on the channels outside of the polder, will have to be carried out.
- Furthermore, the requiredmaintenance budget will have to be allocated from the revenue budget.

Cyclone Protection Project - II (CPP-II - 1985)

Following the Cyclone of May 24-25, 1985, several proposals were initiated for studies of cyclones and protection measures against cyclones. BWDB compiled a "long term plan for structural measures against cyclone surges", a summary of which was issued June 1985. The plan consisted of two components:

- A Mid-Term Plan for the rehabilitation and strengthening of existing coastal embankments;
- A Long-Term Plan for extending the system of coastal embankment to cover also the newly accreted lands.

The plan aimed at project implementation over a total period of 5 years i.e.1986-90 with the Mid Term Plan covering the first 3 years.

Apart from schemes of emergency repair of the damaged areas, the various proposals resulted in a financial agreement in 1987 between GoB and the EEC, for a feasibility study and design study of the Cyclone Protection Project CPP-II for taking protection measures against cyclone flooding based on the BWDB Mid Term and Long-Term Plan. The review of this report has enriched the idea for development of coastal polders on the basis of the latest scenarios of natural calamities which in turn has helped to prepare Planning & Design of CEIP-1.

As CEIP-2 is the following phase of project CEIP-1, Planning & Design of CEIP-2 will carried out following the idea CPP-II.

Coastal Embankment Rehabilitation Project (CERP - 1995 to 2003)

During the preparation of the feasibility and design study under CPP-II, a severe cyclonic storm hit the coast of Bangladesh in April 1991. So, instead of the planned improvement conceived in CPP-II for the coastal embankment system, it became immediately necessary to rehabilitate the damaged embankments and the Cyclone Protection Project-II was renamed as Coastal Embankment Rehabilitation Project (CERP).

The polders covered by the Mid-Term Programme were spread over the coastal belt of Bangladesh from Satkhira to Teknaf of Cox's Bazar. At the early stage of the project, 28 polders were selected for study in the Mid Term programme. Later, the polders in the Khulna area, in total seven polders, were excluded from the Mid-Term programme for some genuine reasons and the remaining 21 polders were selected for feasibility studies and implementation.

Following the cyclone of April 1991, the Mid-Term Programme consisting of 21 polders was divided into two projects;

- Emergency Cyclone Protection Project (known as PWP, the Priority Works Programme) consisting of 10 polders (Polder Nos. 72, 62, 63/1A, 64/1 A, 64/2B, 61/1, 71, 69, 66/3, 64/1C);
- Mid Term Programme-Phase-II, (known as CERP-II) consisting of 11 polders (Polder Nos. 35/1, 40/2, 48, 59/2, 59/3B, 59/3C, 60, 73/1B, 70, 66/1, 68) including minor works, afforestation etc. for all the 21 polders.

Priority works were taken up and completed with joint financing from Japan, Saudi Arabia (SFD) EC and through amendment of 4 IDA credits.

While the implementation of CERP-II was going on, again a cyclone, in May, 1997 hit the coastal area of Bangladesh and caused severe damage. The cyclone accounted for several hundred lives lost and heavy damage to infrastructure of polders. In this cyclone, 15 of the 21 CERP polders were affected, in addition 46 other polders (50 including sub-polders) were assessed to have suffered damage in Cox's Bazar, Chittagong, Bagerhat, Khulna and Satkhira area.

Another factor that hampered the success of the project was the partial progress toward mitigating inadequate embankment maintenance and lack of progress on reforming systemic institutional problems. However, the project clearly demonstrated that improved technical design of the coastal embankments combined with social forestry made the structure more robust and reduced its rate of deterioration.

The main risks involved in the project were the following:

- The sustainability of coastal polders is dependent on better-planned O&M activities including well-maintained plantations on the embankments and foreshore. If O&M long-term plans are not properly implemented the cost efficiency is expected to decrease and additional charges have to be considered.
- Toe erosion is an initial indicator towards non-sustainability of the embankments and has been recognized as a major problem in coastal embankment systems.

The main lessons learned derived from this project were the following:

- Coastal defenses should be renovated to higher engineering standards in homogenous units. This not only has greater sustainability than isolated repairs of existing infrastructure but it also provides a model that can be monitored to test the success of the innovation - an important design consideration.

- Settlement on the embankment as against routine maintenance work is an approach towards cost sharing eventually reducing the O&M expenditures.
- Implementing agencies should continue the experimental toe protection works (conventional engineering design coupled with vegetative protection) and organize systematic monitoring to develop models for different situations. This would reduce the operational and maintenance costs of the coastal embankment system

Big or small cyclones hit in the coastal area in almost every year and it damaged the existing polders and there ongoing works. So, during implementation of CEIP-2, there has every possibility that a big cyclone may hit the ongoing project. It will be good practice if a financial provision for addressing the probable damage may be made by a cyclone, which will ensure the smooth completion of CEIP-2.

<u>In addition some other lessons learned</u>

General

- Delay between the preparation of cost estimates and the commencement of the work should be avoided as these may lead to significant change in the cost. For example, if further damage occurs at the site of the proposed works in the interim period, additional works may be necessary, leading to complications with the contracting process.
- The evaluation process for awarding contracts must be completed within the validity period of the tender security in order to avoid the possibility that, after the validity period, bidders will not accept a contract for work at the price tendered.
- Contracts should not be awarded, even if the evaluation process has been completed within the validity period of the tender security, unless land required for the works is free of encumbrances and able to be handed over to the contractor.
- Resettlement Action Plan (RAP) formalities, including payment of compensation and the time allowed for owners to vacate land, are time consuming and takes about 2 to 2.5 years to be done properly. The construction programme must be planned taking this into account. Planning and implementation may be facilitated if the works are broken down into segments, each segment to be implemented separately.
- Where embankment vegetation is to be developed by Embankment Settlers (ES), all the required facilities (raised homestead plots, pit latrines, tube wells, etc.) should be included in the civil works contract and be completed before the ES take possession of their plots.
- Hinges for flap gates and hoist arrangements for lift gates need to be modified to make them strong enough to withstand the forces they face.

Land acquisition

- Land acquisition is a slow, complicated and lengthy process. Therefore, in the case of new or retired embankment it is important to ensure that the land acquisition plan is well prepared to meet design requirements as well as social, heritage and other constraints. In the case of re-sectioning, it is necessary to check that the land originally acquired for the embankment is sufficient for the modified embankment.

- Where ES are to be settled on the embankment, land acquisition needs to include a strip of land for the embankment settlers' plots.
- Because of the difficult and time consuming nature of land acquisition, alternative modes of acquiring land for embankments, such as long term leasing, should be investigated in detail.

Engineering

- Toe erosion occurs at the embankment locations where the set back distance is inadequate. The set back distance should be established based on morphological conditions in each area and a proper hydraulic engineering study of the site.
- Special attention needs to be paid to toe erosion. Where the embankment is being eroded and is in danger of being destroyed, retirement is the cheapest engineering option (but social costs may be high). When the embankment is not in danger of being destroyed, low cost toe protection works may be used.
- Appropriate protective works are required where it is not possible, for social or economic reasons, to have an adequate set back distance or adequate foreshore afforestation to protect the embankment from waves and storms.

Foreshore and embankment afforestation

- When planting is planned for the foreshore, a detailed programme should be prepared taking into account the suitable land available, the preferred species, ownership of the foreshore and implementation procedures. Mangrove belts should, preferably, be established before embankment works are started.
- Afforestation on the embankment should follow Government guidelines of 1 June 1998, although these may need some updating. Steps should be taken to strengthen forestry know-how with BWDB.

Resettlement Action Plan

- Under IDA operation directive OD 4.30, RAP are a requirement for IDA financing. In principle, no project affected person should be worse off after the project has been completed than in the pre-project situation. Proper planning to ensure that RAP are completed satisfactorily in a timely manner is therefore essential.
- Measures to simplify land acquisition and RAP procedures would greatly facilitate project implementation.

Technical assistance and NGOs

- The project approach should be incorporated as much flexibility as possible into the planning and implementation of project activities.
- Select the locally most experienced NGO's and sufficient budget and time for their services. Substantial training requirement to be imparted. Joint venture NGO should not be accepted. Ensure effective co-ordination of NGO activities.
- Project planning should involve all those concerned with project implementation: BWDB staff, NGO partners, local leaders, stakeholders and the TA team.

- As far as possible, funds for training should be included in the project TA, since this facilities the timely allocation and use of funds and the flexible response of the project to actual training needs.

Improved O&M

- A special fund for O&M to be established.
- Improved O&M for the embankment portion using ES & EPG concepts, should only be introduced to those embankments, which need no or little repair. Consider the embankment as a productive piece of land for the ESs. Realize the daily need of ESs in the mix of plants. Size of a farm for ESs may be reduced to 0.5ha.
- Too much and too soon from the local people should not be expected about improved and sustainable O&M.

Emergency Situation

- To meet the emergency situation of immediate repair & rehabilitation after the onslaught of a cyclone, local stand – by contractors should be pre-selected observing IDA guidelines.
- Emergency maintenance reserve fund should be established to met emergency repair/rehabilitation cost so that no time is wasted for arrangement of such fund.

Condition of Contract

- The employer should delegate more responsibility to his representative, "the Engineer" regarding approval of variation order, extension of contact time and claims. This should be well defined in the chapter of particular application of the tender/contract document, so that the "Engineer" can promptly take decision and the project implementation runs smoothly.
- Simplify pre-qualification, tender procedure and pre-select local stand-by contractors for emergency and minor works.

General

- The overall development plan for each polder & the CEs should include in addition to engineering construction of embankment and drainage system along with foreshore and embankment forestry program, also homestead plat-form for ESs, possible education and health care facilities, development of the infrastructure in general, local administration, cyclone shelters, killas, escape routes, safe drinking water supplies, emergency food stores, cattle grazing areas, cattle and road crossing arrangements like ramps with hard cover where necessary, embankment crest pavement for vehicle movement, fishing harbor, fish drying area, crop harvesting, drying and storage facilities etc. in the polder.

Second Coastal Embankment Rehabilitation Project (2nd CERP)

Following the cyclone of May 97, the World Bank Mid-Term Mission that visited Bangladesh during November 1997, January 1998 to assess the after-effects of the May-97 cyclone and the project under implementation i.e. CERP (now known as 1st CERP), the idea of a 2nd CERP was launched. This project took care of the above issues through feasibility studies and detailed engineering.

The major components of the project were proposed:

- Rehabilitation and improved operation and maintenance (O&M) of the sea and estuary facing Coastal Embankments by Bangladesh Water Development Board (BWDB), including embankment and foreshore afforestation;
- Rehabilitation and improvement of medium size water sector infrastructure in coastal polders and management transfer to Local Government Institutions;
- Rehabilitation and improvement of small water infrastructure in coastal polders (mainly drainage channels and regulators) and management transfer to Water Management Association (WMA);
- Project Management.

It is learnt from this Project that delay between the preparation of cost estimates and the commencement of the work should be avoided as these may lead to significant change in the cost. The evaluation process for awarding contracts must be completed within the validity period of the tender security in order to avoid the possibility that, after the validity period, bidders will not accept a contract for work at the price tendered. Resettlement Action Plan (RAP) formalities, including payment of compensation and the time allowed for owners to vacate land, are time consuming. The construction programme must be planned taking this into account. Land acquisition is a slow, complicated and lengthy process. Therefore, in the case of new or retired embankment it is important to ensure that the land acquisition plan is well prepared to meet design requirements as well as social, heritage and other constraints. In the case of re-sectioning, it is necessary to check that the land originally acquired for the embankment is sufficient for the modified embankment. Further, because of the difficult and time-consuming nature of land acquisition, alternative modes of acquiring land for embankments, such as long-term leasing, should be investigated in detail. Appropriate protective works are required where it is not possible, for social or economic reasons, to have an adequate set back distance or adequate foreshore afforestation to protect the embankment from waves and storms. A special fund for O&M to be established. It is to be noted that an ideal O&M operational procedure has been formulated but it has been noted it is not truly followed in the polders which is also one of the reasons for the drainage problems within the polders. It is certain that the review of the above reports has enriched the knowledge of study for rehabilitation of improved O&M, rehabilitation of medium & small size infrastructures in the coastal polders. More specifically, in relation to the protection works, they have been completed with 1mx0.8mx0.6m C.C. Blocks with random dumping as suggested in the above CERP have been found to be effective for protection against wave action in Patenga and Anowara of Chattagram but the Octagonal Hollow ones found not to be very effective and above all none of these two sites were tested against Sidr. Moreover, the protection works below and above randomly dumped C.C. Blocks are largely disturbed in Patenga site's work and hence, this called for a review of CERP designs if necessary.

Large part of sea dyke of 64/2B is in precarious condition and similar in 66/1. Hence all these call for review. This can be reviewed on e.g. height, R/S or sea side slopes, C/S slopes, set back distance and protective works.

Details of the lessons learnt are annexed in Appendix-3.

In CEIP-2, the embankment design will be carried out following the outcomes of models, so embankment will be strong enough. If any protective work for a sea faced embankment will required to design, the experience of this project about the size of C.C. blocks could be included.

Integrated Coastal Zone Management Program (ICZMP) and 2nd CERP

The GOB with assistance from the World Bank, the Netherlands Government and other development partners has initiated an Integrated Coastal Zone Management Programme (ICZMP) to address the needs of the coastal area. All development activities in the Coastal Zone will be implemented under the ICZMP umbrella; this should help to ensure that:

- The coastal zone is developed in a systematic way;
- Scarce resources are utilized in a sustainable manner;
- Fragile eco-systems are protected to the fullest possible extent.

The review of the report was useful to define the primary objectives of the CEIP-2. Many Government and non-Government Institutions are engaged in the development activities of coastal zone. There are many needs in the polders such as strengthening of embankment, supply of potable water to drink, roads, electricity supply, construction of cyclone shelters, proper drainage facility, education, health service and agriculture. But for safety consideration, strengthening of embankments get 1st priority. So, CEIP-2 will be very relevant.

A number of sub programmes will be implemented under ICZMP of them three have been identified. These are:

- Coastal polders;
- Safe havens;
- Disaster management.

  The key elements of the ICZMP approach are participation, partnership, targeting, developing priority investment programme (PIP) and assessment. A short description of each approaches are given bellow:
- Participation: In order to facilitate participation of coastal communities, the "livelihoods approach" will be adopted. This approach provides a framework where coastal communities can discuss their priorities and participates in the decision-making and implementation process.

  The CEIP-2 will provide scope for participation of the stakeholders in the meetings to be organized in the polders for exchange of views regarding all sorts of things related to planning and implementation of this project.
- Partnership: The partnership approach is a process under which organization works together and gets things done in a collaborating way for the common good. Broadly, four elements constitute the foundation of partnership: commitment, mutual benefits, governance structures and networking. Such partnerships can be functional by involving local administrative bodies and grass-root organizations in planning and implementation.

The participation of different Government and non-Government Institutions and NGOs to take partnership approach in this program and to involve the local people in the works particularly in O & M activities are some of the objectives.

- Targeting: ICZM is not a single generic recipe for the entire coast nor does it seek to address all problems and issues. Taking into account the present 'institutional environment', the limited resources available and the incipient stage of the ICZM process, targeting is important, especially in relation to areas, social groups, issues and opportunities:
- Developing PIPs. PIPs were developed by group of government agencies through multi-level consultation, which will also be implemented by these agencies. This is an important component of institutionalizing ICZM approach that depends on networking with government and non-government organizations, local government institutions and development partners.
- Assessment. Achievement of targets is assessed against indicators developed to measure progress on different dimensions. An important mechanism is to periodically monitor progress on the basis of the indicators and use the findings as feedback to the project cycle to remove eventual bottlenecks.

In general, the planning and implementation of CEIP-2 shall be guided by the directives for those which are relevant for this project.

The objectives of CEIP-2 align with those of the broader objectives of the ICZMP, with CEIP-2 focussing specifically on water resources and safety against cyclone surges and river erosion.

Coastal Zone Water Management Programme

This Programme is the output of the Second Coastal Embankment Rehabilitation Project (2nd CERP) preparatory consultancy which was running from July 1999 to December 2000. The proposal of this project was to prepare a coastal embankment rehabilitation project. The principally intended output of this project was to carry out the feasibility studies, detailed designs and tender documents for a limited amount of rehabilitation works. Later on, the scope of consultancy was extended to include also a planning component to define a five year investment programme and setting it within the longer-term context of a development plan, plus preparation for the co-ordination of this embankment work with other coastal zone activities by a separate newly formed initiative under the name Integrated Coastal Zone Management Plan (ICZMP). The said study was ultimately carried out a part of the preparation of a 15 years programme.

The Coastal development approaches as learnt from the above study are that the planning should be done for whole coastal zone and its polders as sub-units, rather than planning on the basis of individual polders. Furthermore, the rolling plan for the entire coastal area has to be envisioned and Designed to consider for the whole coastal zone and its polder unit, instead of a piecemeal design, on the basis of hydraulic modelling.

The programme should be of extended duration instead of a limited duration. The integrated programme should be done under ICZM with the involvement of several line agencies (BWDB, LGED, DF etc.) ratherother than just a single line agency. Similary, funding has to be considered over a long period rather than over a short term. Involvement of stakeholders in O&M through WMC's, EMG's, ESG's.

The Coastal development approaches as learnt from the above study in comparison with the traditional studies are furnished below:

Institutional aspects

- Programme of long duration instead of limited duration;
- Integrated programme under ICZM with more line agencies (BWDB,LGED,DF etc.) other than one line agency;
- Full people's participation in all stages of programme development, i.e in planning, implementation, operation and maintenance.

Management aspect

- Long term funding over long period instead of short term as well as limited funding.
- Involvement of stakeholders in O&M through WMC's, EMG's, ESG's;
- Maintenance organized into preventive, routine and periodic maintenance and emergency works other than maintenance by rehabilitation only.

Planning aspects

- Planning for whole coastal zone and its polders as sub-units other than planning on the basis of individual polders.
- Rolling plan for the entire coastal area.
- Design for the whole coastal zone and its polder units on basis of hydraulic modelling.
- Planning includes foreshore, cyclone shelters, disaster preparedness, forestry, jetties, etc.
- Modern GIS database, recent Finnmaps instead of insufficient hydrological and topographical old data.
- Full attention to environment without any compromise.
- Zoning of land use for agriculture, forestry, shrimps, salt other than erratic planning of shrimp cultures.
- Extensive people's participation in all planning activities through workshop, seminar etc.
- Synchronization of land acquisition, settlements, embankment plantations, engineering construction etc.
- Monitoring.

Technical aspects

- Different embankment design criteria for different conditions instead of one design criteria for all embankments.
- New improved designs for embankments and sluices other than classical CEP design.
- Design should be based on more extensive and expanding database supported by GIS and hydraulic and hydro-morphological modelling.Appropriate set of new and reliable benchmarks installed in whole coastal area.
- There should be afforested foreshore behind the embankment.
- Soft shore protection involving vegetation and combinations of hard and soft protection.
- Embankments to be upgraded to roads with brick soling to attract vehicular traffic causing compaction and thus less maintenance instead of flood protection only.

Fourth Fisheries Project.

BWDB has so far implemented more than 800 projects including Flood Control, Drainage and Irrigation Projects (FCDI) in the country since 1954-55. The main concept behind the formulation of these FCDI projects were to increase agricultural production. These projects have been implemented without a comprehensive assessment of their impact upon fisheries. Interruption of natural cycle of flooding and recession of flood in channels by Flood Control Drainage & Irrigation (FCDI) works adversely affected the natural fish production system. It is a fact that the important routes of fish migration and movement from one habitat to another had been blocked as a result of the implementation of the FCDI projects of BWDB.

Similarly, BWDB completed 139 polders in the coastal zone. The basic concept of constructing these polders was to protect the polder area against the salinity intrusion and was being used for rain fed Aman paddy cultivation. With the increase of demand of shrimps in the international market, enterprising farmers started shrimp cultivation in summer season within the polders constructed mainly in Khulna area. Gradually, the area under shrimp cultivation is increasing day by day in the polders which are located near the Bay of Bengal and the peripheral rivers water is saline even in the monsoon season.

The shrimp farmers are now practicing shrimp cultivation by constructing pipe inlet in the coastal embankments for taking saline water into their fields. The construction of these unauthorized inlet in the embankments are going on in an unplanned manner, affecting the stability of the embankments. The present shrimp cultivation in the polder has been being expanding without following any planning or criteria that are necessary for the development of shrimp production. In order to take up the polder under shrimp cultivation in a planned way, the needs of the people have to be assessed.

To mitigate the adverse impacts of FCDI projects on fisheries, BWDB carried out Feasibility Study to provide fish pass and fish friendly structures in the completed BWDB projects under 4th Fishery Project.

In conclusion can be stated that:

- The 3rd Fisheries Project with many deficiencies is still a successful project to the shrimp farmers. It has been able to satisfy the major needs of shrimp culture in the polders, where the projects have been implemented. Specially, the embankment of those polders has been saved from major damage. The embankment is as good as life blood for the residents living inside the polders. The economy of shrimp culture is improving living standard in the polders, though the production per hectare is much lower than the output in other shrimp producing countries;
- Polder-15 in Shyamnagar, Satkhira is also widely being used for shrimp culture, though not planned. The embankment was in a miserable condition. On implementation of the rehabilitation works and construction of new structures, the polder was saved from major damages. Further, due to planned water supply and drainage, the unit area production was increased substantially;

Thus, in view of social and economic context of shrimp culture, Consultants of 3th Fisheries project strongly recommend the implementation of a shrimp and aquaculture component in the 4th Fisheries Project.

To ensure protection against intrusion of saline water in polder, fish pass cannot be provided in any polder of CEIP-2. If any polder in this project is suitable for shrimp culture, people of the polder are desired for shrimp culture, to avoid the conflict of interest of different group of stakeholders, on the basis of proposals from local Agriculture, fishery and Upa-zila Nirbahi officer are made compulsory for creating provision of entering saline water in it.

Emergency Cyclone recovery and restoration project (ECRRP- 2008 to 2018):

The Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP) was launched to support the Government of Bangladesh's efforts to facilitate recovery from the damage to livelihoods and infrastructure caused by Cyclone Sidr and to build long-term preparedness through strengthened disaster risk reduction and management. Cyclone SIDR hit in thirty (30) southern districts of Bangladesh on Nov15/2007 and damaged infrastructures of the polders of Coastal Embankment Project (CEP) along with the lives and properties of the local residence of those polders, of them Patuakhali, Barguna, Pirojpur and Bagerhat were the worst affected districts. Joint Damage, Loss and Need Assessment were carried out by Government of Bangladesh (GoB) with the support of International Communities and the estimated loss was assessed US$ 1.7 Billion (BDT 136Billion). Two- third of it was the physical damage. Considering the need for restoration and recovery, Emergency Cyclone Recovery and Recovery Project (ECRRP) was conceived and approved by GoB in December 2008. The project was implemented with 5 components of which component ''C" covers rehabilitation of Coastal embankment implemented by BWDB. Under the project 29 polders were rehabilited with inclusion the cost of repair of damage made by Cyclone AILA to those polders.

The project objective was to facilitate recovery from the damage to livelihoods and infrastructure caused by Cyclone Sidr and to build long-term preparedness through strengthened disaster risk reduction and management.

The expected outcomes to be achieved with this proposed project were:

- Recovery from damage to livelihoods and building long-term disaster preparedness
- Recovery from damage to infrastructure and building long-term disaster preparedness

Recovery of Agriculture Sector and Improvement Program: This component was primarily designed to improve resilience of communities and households in cyclone prone areas through introduction of technologies to improve land use during dry seasons when salinity levels are high, and introduction of high-yield crops. This component was to, only to a limited extent, provide short and medium-term agriculture recovery assistance to Sidr-affected communities and thus improve livelihoods.

Reconstruction and Improvement of Multipurpose Shelters: This component was designed to provide greater protection to vulnerable population and livestock in cyclone-prone areas against future disasters. The component supported construction of new multi-purpose shelters, repairs and improvement of existing shelters that were damaged and/or unusable, and reconstruction of road network to access shelters.

Rehabilitation of coastal embankments: This component was designed to prevent saline inundation during normal weather and to sustain crop production by reducing cyclone damage through rehabilitation and improvement of coastal embankments damaged during Cyclone Sidr.

Long-term Disaster Risk Management Program: This component was designed to strengthen disaster risk mitigation and reduction through (i) capacity building of the Disaster Management Bureau (DMB), support for detailed multi-hazard risk vulnerability modeling and assessment, and strengthening of emergency preparedness at the community levels, and (ii) preparation studies for future projects for River Bank Improvement (RBIP) and Coastal Embankment Improvement (CEIP) and for disaster shelters.

Monitoring and Evaluation of Project Impact: The component was designed to provide oversight monitoring and evaluation (M&E) activities for providing feedback to the Government, Project Steering Committee (PSC), and implementing agencies on project performance and impact of its various components, so that corrective actions could be undertaken in a timely manner. This included supervision of ESMF and ESMP implementation.

Project Management, Technical Assistance, Strategic Studies and Training, and Emergency Support for Future Disasters: This component was designed to support the Government in implementing the project and coordinating all project related activities, and provide resources for needed strategic studies, technical assistance and training. It would also provide support for emergency recovery if a future disaster were to occur during implementation of ECRRP (emergency fund).

<u>Lessons learned</u>

Factors contributing to the success of the project: The Project benefitted from high-level government commitment during preparation and implementation. During implementation, the project undertook a dynamic feedback-based adaptation approach and made improvements

Factors contributing to underperformance of the project:

- Original targets were ambitious given the limited funding and capacity of the implementing agencies at the time, known climate related challenges and poor contractual capacity in the country.
- Institutional Capacity. The Planning Commission, agency responsible for coordinating a complex multi-sectoral project had not implemented any Bank funded project.
- At the time of preparation, the government did not have adequate capacity to undertake a multi-sectoral project spanning multiple ministries
- Delays in initial contracting for works and consultancies significantly delayed implementation after effectiveness
- Contractor capacity, seasonality and remoteness posed considerable challenge to smooth implementation.
- Delay in resettlement and land acquisition payments, completion of rehabilitation work was delayed

- Cyclone Aila hit the Southern Coastal belt on 25 May 2009 which caused additional damages to polders targeted by ECRRP, requiring additional financing and time extensions.
- Difficulty in transporting material to remote locations, that were only accessible by boat.

Several lessons learned are derived from reviewing the project documents

- Supporting country systems to better prepare for emergency projects is critical for a timely and impactful response
- Multi-sectoral projects require adequate planning for multi-sectoral coordination and implementation arrangements. The project demonstrated that building strong capacity of Project Coordination and Monitoring Units (PCMU) to support line ministries can help mitigate risks associated with complex implementation arrangements
- There is a need to accelerate and strengthen land acquisition procedures for emergency situations. In Bangladesh, current legal land acquisition and compensation process can take at least 12-15 months, which poses a challenge when undertaking critical emergency work
- Preparing a well-defined results and M&E framework for emergency projects enhances achievement of outcome. Institutions in countries like Bangladesh can immensely benefit from development of standardized guidelines/products to help prepare more nuanced and fine-tuned M&E for disaster recovery projects.
- Regular community consultations throughout the project can guide the appropriate choice of investments and generate practical improvements to increase impact.
- Sustainable recovery not only requires timely implementation of rehabilitation and reconstruction activities, but also preparation of a program that places these activities adequately within the longer-term goal of reducing overall disaster vulnerability.
- Emergency recovery operations should have a simple design, taking into consideration local implementation capacity and the fact that this capacity may be strained in the aftermath of a natural disaster;
- Timely completion of projects in climate vulnerable and remote regions require enhanced contract management measures. Critical Path Based Planning (CPB) can be undertaken with seasonality built into it. Well-trained and dedicated contract management capacity at all levels, separate from procurement, is critical to timely delivery of project outcomes.
- During implementation of cyclone damage rehabilitation project, hit of another cyclone is very common in Bangladesh and damage existing polders and there ongoing rehabilitation works. So, during implementation of CEIP-2, there has possibility that a big cyclone may hit the project area. It will be good practice if a financial provision for addressing the probable damage may be made by a cyclone, which will facilitate the smooth completion of CEIP-2.

Coastal Embankment Improvement Project Phase 1 (CEIP-1)

The most recent program, implementation of which physical components has been going on to reduce the vulnerability of the coastal polder system is the Coastal Embankment Improvement

Project – Phase 1 (CEIP-1). This project has been initiated after Cyclone Sidr (2007) and Aila (2009). The objectives of this project are to: a) Increase the area protected in selected polders from tidal flooding and frequent storm surges, which are expected to worsen due to climate change, b) Improve agricultural production by reducing saline water intrusion in selected polders; and c) Improve the Government of Bangladesh's capacity to respond promptly and effectively to an eligible crisis or emergency. The long-term objective of CEIP is to increase the resilience of the entire coastal population to tidal flooding and natural disasters by upgrading the whole embankment of coastal polders. With an existing 6,000 km of embankments of all 139 polders, the magnitude of such a project is enormous. Hence, a multi-phased approach will be adopted over a period of 15 to 20 years.

CEIP-1 is the first phase of this long-term program. To achieve the development objectives of the project in a complex and changing environment and to pilot innovative concepts in design and implementation. Based on the success of the CEIP-1, a series of projects that capture the lessons learned from CEIP-1 can potentially be designed for other exposed areas along the coastal region of Bangladesh. As part of the strategic polder assessment, a multi criteria analysis was developed for 139 Polders to guide the prioritization process of selection of polders. Based on this assessment, a first priority group of 17 polders (see figure 1) were selected for CEIP Phase I.

The implementation of CEIP-1 has been split into three packages. Implementation of two packages has been going in but Package 3 of CEIP-1 includes 7 polders (14/1, 15, 16, 17/1, 17/2, 23, 34/3) can't be started for difficulty in arrangement of additional costs for implementation.

As CEIP-2 is the following phase of CEIP-1, the procedures followed in planning, design, preparation of estimates, preparation of tender documents, problems encountered during land acquisition, resettlement etc. are the part of lesson learn for CEIP-2.

<u>Lessons learned</u>

Current practices regarding bank protection works:
As aforementioned, currently 10 polders are being constructed and the remaining 7 polders will be implemented in the near future. The polders are subject to strong river currents and wave action which can rapidly change the shape and position of the shoreline. Among others, the problems addressed are the following:

- Riverbank erosion: The peripheral rivers around the polders are of all sizes, varying from large rivers like the Baleswar, Sibsa and Pussur to the smallest tidal creeks. These larger rivers, though the flow is dominated by the tide, have a tendency toward a (relatively) small amount of lateral movement of their banks. These small movements could be translated into a serious bank erosion problem, particularly on large rivers. Bank erosion is already threatening some embankments having already consumed the setback and berm. Protection works are necessary, if not the embankment has to be relocated more inland and create sufficient distance between the embankment and the bank line; such an embankment is often referred to as "retired embankment";
- Wave erosion of embankment slopes: Erosive waves can be generated by high winds at high tide on embankments that face the sea or one of the large estuaries.

The riverbanks and embankments are at risk of erosion from waves and river flows. The protection works have been designed against the following conditions:

- 1 in 25-year cyclone wave and associated surge level (including an allowance for climate change to 2050), or;
- 1 in 25-year monsoon flows and associated water levels (including an allowance for climate change to 2050).

There are a few locations where bank retreat is rapidly progressing and action has to be taken to protect (or move) the embankment. In most places, however, the bank retreat is temporary, and the most practical solution would be to provide adequate setback rather than provide expensive bank protection, unless the danger to the embankment is imminent. The value of the land that needs to be acquired to accommodate the retirement of an embankment is usually much less than the cost of providing bank protection. Thus, the only consideration that would allow implementation of bank protection works is the disruption of settlements and displacement of people. It is noted that it is not only the cost and disruption, but also bureaucratic and legal processes can be time consuming.

The design of bank protections, slope protection and embankments under CEIP-1 follow the design guidelines introduced in the eighties and are still used by the BWDB and leaves some room for improvement and allow for design approaches developed and applied elsewhere. Under the CEIP-1 program several design optimizations are now gradually being implemented in view of practices and type and quality of material used.

It is furthermore noted that new design guidelines for design of coastal interventions should follow a more adaptive approach which takes functional requirements, land use zoning and safety levels into account like e.g. is done in the Netherlands.

It should be noted that the act of raising and strengthening polder embankments do not have any adverse impact on river sedimentation. However, failure or breach of an embankment could cause disastrous erosion problems, mainly local to that point of failure and bring a massive amount of sediments into the river during the recession. The unusual flows that occur in the river system during the passing of a cyclone do not take place for a long enough period to cause significant morphological change.

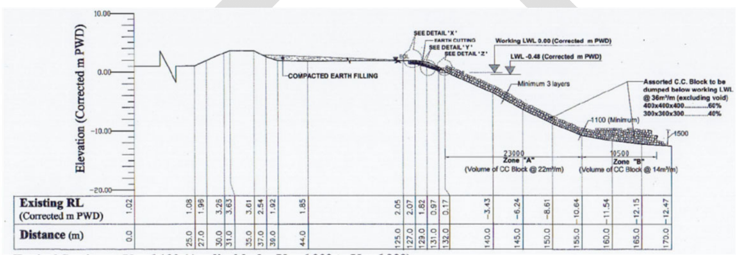
Overall, it is clear that the implementation of improved embankments and related infrastructure has been contributing to a significant drop of the risks associated to loss of lives and properties within the Polders through reduction of tidal flooding and wave overtopping. However, the issue of erosion is not directly addressed which constitutes a significant factor hampering the stability of the newly constructed embankments.

The cost of the slope protection constitutes approximately 15% of the total works in each polder, depending of the level of exposure and the river dynamics in each polder. The percentage of CEIP-1 bank protection works is significantly higher amount to 23% for Contractor's Package

No. 1 [44] and 33% for Contractor's Package No. 2[45]. Bank protection works are constructed to reduce or stop the erosion process along the bank line. They protect the riverbanks and the coastline against wave and current induced loads and covering the lower part of the embankment. The cover layer of works should resist the impacts of currents and waves. Unless the toe is well protected, it may be undermined resulting in sliding of the slope. Sliding of the slope endangers the overall stability and function of the entire embankment. Generally, the construction materials of bank protection works are hard rock, CC blocks, boulders, mattresses, and sand-filled geo bags. Under CEIP-1 initially hard rock was considered for the bank protection works, however, due to the limited availability of rock in Bangladesh, CC blocks are now being used under the implementation of CEIP-1 (see photos below). The average cost ratio per unit of length for the afore mentioned Contractor's Contracts read as follows: new embankments : slope protection works : bank protection works = 1 : 10 : 60.

Dumping of CC blocks for bank protection works under CEIP-1

Design of bank protection works under CEIP-1 consisting of CC blocks in Polder 32



The design of bank protections, slope protection and embankments under CEIP-1 follow design guidelines introduced in the eighties and are still used by the BWDB and leaves some room for improvement and allow for design approaches developed and applied elsewhere. Within that context, the designs of the CEIP-1 bank protections works and slope protections works have recently been reviewed by an Independent Expert Team[46] and which recommended amongst others to:

- Reduce number of revetment parts;
- Ensure quality of geotextiles and concrete blocks;
- Ensure overlap geotextiles and structural parts;
- Reduce weight of the toe and deeper foundations;
- Use of geo-bags in filter layers;
- Construct edge transitions to reduce risk of damage to the pitching.

Constraints hampering the harmonic implementation of the works

Dely of Land Acquisition by the concern DC office. The Project is being fully controlled by a team of Detailed Design, Construction Supervision and Project Support Consultants (DDCS & PMS) consisting of International and Nation experts. Under the Team, there is a number of field consultants for land acquisition headed by a Land Acquisition/Re-settlement Specialist and Social/re-settlement specialist. This team is responsible to prepare the Land Plan (LAP),

[44] Contract Agreement CEIP-1 Package-1, BWDB, CEIP-1/W01, November 2015
[45] Contract Agreement CEIP-1 Package-2, CEIP-1/W02, March 2017
[46] Bank protection optimization in coastal Bangladesh, Summary of Quick Wins, Kees Dorst and Erik Mosselman, 2019

Preparation of Re-settlement Action Plan (RAP) and Social Management & Re-settlement Policy Framework (SMRPF).

The above Team conducted tremendous field Survey and prepare the LAP & RAP and obtain the recommendation of the BWDB and finally submit the LAP to the Concern DC office. The DC office took unexpected long time for review. The DC office fix up a schedule date for Joint Verification (JV) along with BWDB, Consultants and representatives of the concern DC office. After that they prepare the LA case and send to the Ministry of Lands(MOL)and thereafter PM office. After getting approval from those offices an estimate is submitted to the Project Director, PMU for his approval and placement of fund as per estimate. After placement of Fund by the PD, the DC office prepare the actual affected person and issue Notice under section- 8 for the payment of compensation to the affected person.

The payment of compensation to the affected land owners takes abnormally long time for which the contractor cannot get the Physical Possession at site. As a consequence, the works in the field is abnormally delayed which continues years together. So, the work plan should be prepared with the consideration of the time to be required for getting access to the site.

Unexpected delay of mobilization of the International Contractors: Two International consultants were recruited for contract Package W/01 and Contact Package W/02 for implementation of 10 Polders. Both the contractors were participated independently in the contract without having consortium with domestic contractor. They took long time for mobilization to the site and also to be familiar to the local environment, location of the site and the local people. They had to take lots of troubles to establish the camps in each Polders. For this reason, lots of time were elapsed for taking decision to physically comments the works.

3

Non-familiar of the Project area and local people by the International Contractor:

Both the group of International contractors were not at all familiar to the sites which are located at a remotest corner of the project area. As per contract, the construction/re-sectioning of embankment had to be carried out by taking earth by their own initiatives. There were no free borrow pit area adjacent to the alignment from which the contractor could collect the earth. The contractor had to make the earth available with the help of local people where they had to face local cheaters who sometimes took money without fulfilling their commitment. For this reason, the contractor has to face acute troubles for smooth continuation of the works which results extreme poor progress of works and also misuse of time & money. This was the common phenomenon for both group of contractors.

4

Mobilization of construction equipment importing from China

The nature of works necessitated different kinds of construction equipment such as Automated CC Block Manufacturing Plant, Bull Dozers, Dump Trucks, Trolly, Excavators, Concrete Mixing Plants, Speed Boats and Vehicles etc. The number of these equipment are very large for which long time was required for importing this equipment from China. In finalizing the location for installation of Automated CC Block Manufacturing Plant, very big area of plain lands are required for creating stack yard. The contractor had to make these areas available at different locations near the working area which took long time and troubles also. In this way the contractor had to elapse long time to commence works physically and ultimately, they had to compel in lagging behind the progress of works. However, in finalizing working plan these issues have to be taken in consideration.

5

Frequent erosion of peripheral riverbank causing erosion of defined alignment and consequently shifting of alignment

The Polders under rehabilitation are situated by the side of the mighty river Sibsha, Passure, Baleshwar, Paira and also by the side of the Bay of Bengal. The bank of all those Polders are subjected to be serious erosion frequently which cause rapid reduction of set-back distances of the adjacent embankment and ultimately the existing embankment through which the original alignment was fixed during the study period of 2012-2013 had engulfed into the adjacent river. As a consequence, the original alignment through the existing embankment had to change and decided to construct retired embankment & subsequently revised LAP had to propose which is extremely a lengthy process and took long time to get the physical possession of lands for continuation of the ongoing works. As a whole, the progress of works was seriously hindered causing the unlimite delay of completion of the Polders. So, proper care should be taken in fixing the alignment.

6

Very often expansion of length of river bank protection works beyond planned length due to elapse of time causing contract variation.

The location of river bank protection works are identified during the study period based on which the design length is fixed and detailed design also prepared accordingly. Later on, a substantial long time is required for preparatory works such as, preparation of detailed designs, preparation of BOQ, Floating Tender, Evaluation of Tender, Finalization of contract and approval of the BID and subsequently issuance of Work Order and commencement of physical works. By this time the location as well as length of the planned bank protection works become radically changed due to dynamism of the river morphology. As a result, the contract value becomes drastically increased from the accepted contract value resulting contract variation. For this reason, the identification of the location and length of the river bank protection works should be carefully done so that the length and volume of work is remain within the contract value to avoid frequent contract variation during execution of works.

7

Major Change of approved design from tender design

For Package W/02, the tender was called for construction of Drainage Sluice and Flushing Sluice on the basis of the tender design for the pressure of the employer. To cope up with the demand of the employer, the consultant was compelled to prepare the BOQ based on the tendered design. But when the design was approved by BWDB design office, major changes were made by them who are entitled for approval of the design prepared by the Consultants. This change of design made after the finalization of the contract. As a consequence, big variation proposal had to prepare & submit to the employer and took the troubles of the approval by the competent authority. In this regard, it is suggested that under no circumstances, the BOQ should be prepared based on the tender design. It must be prepared & tendered based on approved design.

8

Very short span of execution period

In Bangladesh, the dry season exists only 4 to 5 months (December to April) which is the appropriate time for execution of construction works. But in fact,the construction of embankment cannot start before January and continue after April. Hence, execution time for construction of embankment is only 4 months. Over and above, major land problems arised during execution of Embankment. The Construction of hydraulic structure can be started in the month of October/November. In order to complete the construction of structures, full preparation with free land, construction materials, equipment are required to be ready to complete the structural activities in one dry season. Delay of structural works may create immense sufferings of the beneficiaries for flushing and drainage congestion inside the Polder area. However, it is recommended to start the works of embankment and hydraulic structures in such a time so that works can be completed by April. Hence, the duration of Project period should be assessed in accordance with the short span of working period in Bangladesh.

9

Absence of domestic contractor with the international contractors

The contractors of both the Packages participated in the contract independently without making consortium with any domestic Firm for which the running contractor had to face lots of troubles to be acquainted & adjusted with the local people and local environment. They faced acute communication problems with local people who neither speaks and understand English & Chinese. Whereas, the Chinese contractor had to get excess to the site and arrange huge volume of earth by purchasing the lands from the local people and very often needed to talk with them. In this regard, the domestic contractor could assist them in many of these aspects. However, provision should be made in the Bidding Document to submit the tender with the consortium of domestic contractor to assist the International contractor in many aspects.

10

Absence of involvement of the field Executive Engineers of BWDB with the Project as per provision of the Loan Agreement

In some package, there was no involvement of field executive Engineer for which the land acquisition issue could not be properly addressed with Deputy Commissioners. As a result, the land acquisition issue could not be resolved easily. On the other hand, in case of preparation of documents for re-settlement payment, the concern Field XEN of BWDB has given the responsibilities for checking & approval of rate for re-settlement compensation, organizing meeting of Grievance Readdress Committee (GRC), Checking of list of Entitled Person (EP) etc. Without accomplishment of the above-mentioned issues by the XEN, BWDB, the payment of compensation benefit to the entitled person cannot be made in time and subsequently, the ongoing works will seriously be hampered and delayed. So, independent XEN BWDB should be posted specially for CEIP Project.

Long Term Monitoring Project under CEIP-1

After the feasibility study of the first phase CEIP-1, it was recommended that certain gaps in 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.

The objectives are:

- Create a framework for polder design, based on understanding of the long term and large scale dynamics of the delta and on sustainable polder concepts. These polders should offer their inhabitants a safe environment to live in and sufficient opportunities for their livelihood. Land use (agriculture, aquaculture, housing etc), ground level, sedimentation balance inside and outside the polder, and salinity in rivers and groundwater are the key parameters in coming to these concepts, taking climate change into account;
- Present an overview of values of relevant parameters at locations in the polder area, now and in the future, as boundary conditions for polder design and management;
- Develop a long term investment plan for implementation of the proposed design and management improvements;
- Build the analytical foundation and technical capacity of BWDB & partners to engage in data driven decision making on tidal flood, storm surges and drought hazards in the coastal region of Bangladesh.

The vision is also to expand the analytical capacity and data driven decision making into an "ecosystem" in which professionals cooperate, and exchange knowledge and information in a community of practice, using a common infrastructure, to be housed in BWDB and other organization would have access to data system. Starting with the researchers directly involved in the coastal area and the polders, the future extension will be to bring onboard the whole delta and the Bangladesh water community.

Some of the bottlenecks during implementation of the project are:

- The lack of interest for the project created several delays in its implementation and this caused it not running parallel to the CEIP-I project, which was the initial concept;
- Management of the polders is a challenge;
- Lack of O&M funds;
- Every key stakeholder in the project involved a different objective. In order for the project to be successful practical objectives need to be defined;
- Several additions have been proposed after the initiation of the project which diverts the project from its main scope such as the improvement of the offtake from Jamuna and Brahmaputra rivers;

- Regarding macro-modelling, there are several contractual problems which are causing delays in the project implementation.

The innovations used in the project can be described as follows:

- There are several ideas that still need to be studied into more depth such as the placement of flood walls on top of the embankments.
- Tidal River Management (TRM) is implemented. The concept is that polder get filled up to revive the peripheral rivers that are silting up. Tidal river management is elegant in utilizing the tides themselves to carry out the deposition of sediment and silt to raise the level of low-lying lands and reclaim them for agricultural use.

Blue Gold Programme (March 2013 – on-going)

The Blue Gold programme covers 25 polders with a combined area of 160,000 ha and will establish and empower rural community co-operatives to sustainably manage their sea defenses, drainage and irrigation infrastructure. The overall objective of the Programme is: "To reduce poverty by creating a safe living environment and a sustainable socio-economic development for 150,000 households living on the 160,000 ha of polders."

Blue Gold Programme is implemented by the Ministry of Water Resources, through Bangladesh Water Development Board (BWDB) – Lead Agency and Department of Agricultural Extension (DAE) and financed by the Government of the Netherlands and the Government of Bangladesh.

The specific objectives of the Program are:
- Increased sustainability of the development of the polders through effective community participation. The community organizations (primary societies and their associations) will become the driving force for the natural resources-based development (agriculture, fisheries and livestock), whereby environment, gender and good governance are effectively addressed in their operations.
- Effective use of the water resources and protection against flooding. Embankments will be rehabilitated, and an effective water distribution system established with close participation of the users.
- Increased farmers' income and strengthened livelihoods through improved farm productivity: production system, harvesting, processing, storage and marketing. Improved production and access to markets will be the two entry points and for each polder a Business Plan will be developed with the value chain analysis for matchmaking as important stepping stones.
- The living environment will be improved and nearly 100% coverage for drinking water and sanitation will be realized and sexual reproductive health rights (SRHR), balanced nutrition, and good governance issues are well understood and applied. This will be implemented by a separate project (Max-value for WASH).

The program consists of 5 components:
- Component 1 - Community Mobilization and Institutional Strengthening.

- Component 2 - Water resources development (six-step approach to participatory water resource management)
- Component 3 - Food Security and Agricultural Development (support to WMGs in responding to existing or potential market demands for the end goal of generating additional income for rural households).
- Component 4 - Business Development and Private Sector Involvement (market development for the farmers in the polders)
- Component 5 – Livelihood Improvement and Cross Cutting Issues

The plan is to create 600 new co-operatives – to work alongside the 250 that have already been formed – and equipping them with technical, advocacy, communication and project management skills to strengthen water management assets. Furthermore, advise will be given on irrigation, drainage, land and fisheries management techniques to improve agricultural and aquacultural productivity to create more income.

<u>Lessons learned</u>

The bottlenecks which hindered the success of the project can be summed as follows:

- Delays in starting contracts for rehabilitation and replacement of polder infrastructure
- DPP didn't include new works or budget for land acquisition, so a major revision was required before new works could be contracted
- The DPP with DAE defined all interventions in minute detail, limiting flexibility and adaptivity
- Natural disasters

The project has a special innovation fund (BGIF) and several innovations have been tested. Most of these relate directly to livelihood improvement, but one relates directly to flood protection: "Roads for Polder Water Management and Flood Protection". Several new agricultural techniques have been adopted from Farmer Field Schools such as Use of new HYV for paddy and other crops, improved paddy seedbed management (with lower seed rates) and several others. Therefore, it is imperative that for high quality embankment the selected soil must be carried from a distance, placed in layers and then compacted with machines, with frequent tests to check the % compaction achieved. All trees, houses and shops must be removed from the embankment, all depressions at least up to 10m from the toe of the embankment must be filled up. In many cases, it was found that the riverside embankment toe is very close to the river, which is very vulnerable to erosion and sliding. In that case embankment slope must be protected or the embankment should be retired far inside. All post construction farming, plantation and construction houses/shops on the slopes, and cutting of the toe to increase agricultural land must be prohibited. Any plantation should be on the berms.

Another lesson learned in the coastal area is that the deadline for earthwork is usually April 30 or maximum May 15. So, when the contractor completes embankment in April or early May, it becomes difficult to grow turf without rain, though irrigation is specified but nobody does it. So, for embankment construction there should be a rolling plan of minimum 2 years so that turfing can be done by LCSs with some re-dressing in July-August under a separate contract.

In general, there are many ditches and ghers both on the countryside and riverside of the embankment, which needed to be filled to limit the seepage path and to make stable and sustainable embankments. It was also observed that borrow pit soils, flooded twice daily with high tides, were not good enough for embankment filling with manual compaction even having laid the soil in thin layers. Moreover, breaking of large wet chunks of clay soils was very difficult, and allowing time for spreading and drying was also not practical.

As said, one of the key elements in the approach of the Blue Gold Program is working with / enhancing the Water Management Groups (WMG) within a polder. An evaluation report in 2017 concluded: "Basically, WMGs do not have the mandate nor resources to drastically improve their situation even if being provided major support. Yet, some relevant project effects were observed".

Additionally, the following lessons learned are noted:

- From early planning phase, work with proxy water management organisations and Union Parishads;
- WMOs to be joint signatories (with BWDB) in authorizing payments for construction works
- Water Management Groups and Associations are stakeholders in main infrastructure and initiators of small-scale water management infrastructure;
- Participatory Water Management (combining infrastructure, stakeholder partnerships and agricultural commercialization) should be part and parcel of future water sector investments;
- WMG lending operations are not a good idea for WMGs and are of little benefit to their members. WMG should be discouraged from undertaking this activity;
- O&M Agreement required setting down respective roles and responsibilities of BWDB and WMA;
- Include a proper planning phase where multiple scenarios of interventions can be decided upon by (local) stakeholders.

The concepts implemented within Blue Gold could be upscaled to other polders specifically where it concerns operation and maintenance. Given the proven potential of participatory water management for enhancing development, the following is suggested:

- Participatory water management (infrastructural, institutional and agricultural development) must be initiated and supported.
- Water Management Groups and Associations flourish when working closely with Local Government Institutions and line agencies. This partnership must be extended to the whole country.
- Water Management Groups and Associations develop small-scale infrastructure but also are stakeholders in main infrastructure. The planning of small and large-scale infrastructure must be optimized to complement each other.
- New legislation establishes local and regional water resource committees. Such bodies must enhance the synergy between national, regional and local interest.

Integrated Planning for Sustainable Water Management (IPSWAM 2002 to 2005)

The Integrated Planning for Sustainable Water Management (IPSWAM) Programme has been planned based on the lessons learned in the Bangladesh water sector, which have led to the gradual development of a current policy framework articulated in a number of interrelated documents, most notably the

- National WATER Policy (NWPo, 1990);
- Guidelines for participatory Water Management (GPWM, 2000);
- National Water Management Plan (NWMP),

The IPSWAM programme is drawing systematically on the experiences of past projects and its major task is to be a pathfinder project to strengthen institutional capacity in terms of local water management organizations (WMOs) as well as relevant local government institutions and national bodies such as the Bangladesh water development Board. As a key part of IPSWAM activities, nine polders have been identified for the practical development of participatory water management. Major water management issues in the polder are: seasonal drainage congestion, seasonal water shortage and saline water intrusion. In particular, strengthening of embankment especially at 3 erosion points, repair of sluices and re-excavation of major khals have been identified as crucially important interventions. The components are:

- Participatory water management in nine polders (Polder 22, Polder 43/2A, Polder 43/2E, Polder 29, Polder 30, Polder 43/2D,Polder 43/2F,Polder 43/1A, Polder 43/2B)
- Institutional development of BWDB.

<u>Lessons learned</u>

Institutional possessions broadly constitute "social capital". These are developed through:

- networks and connections;
- membership of formalized groups or traditional social entities; and
- relationship or trust, reciprocity and exchange.

An important lesson learned is to take advantage of and build on existing institutions instead of imposing new ones. A consensus building approach yields more fruitful results that involve dialogue between all stakeholders, though they may have conflicting objectives and roles.
At the local level, 'decentralization', and not 'de-concentration, is what is sought for. Community- driven development is the key phrase. This means:

- Enabling institutional environment: Development of policy and institutional reforms oriented toward increased participation in decision-making and control of resources by communities through elected and functional local governments.
- Participatory local governance: Representatives of direct stakeholders including the elected local government make decision on planning, implementation, operation and maintenance in partnership with all stakeholders in the community.
- Community control and management of investment funds: Community groups make decisions on planning, implementation, monitoring and maintenance of infrastructures, and also manage investment funds.
- At the national level, a multispectral and multi organizational platform is indeed necessary and has been conceived. While many sectorial and organizational activities go independently as they are, issues and activities with multispectral dimension demands multispectral approach to planning, management and monitoring. This is the core issue in ICZM. The crux of the situation is to create a culture of working together for a

common goal in a society where resources are scarce, majority people are poor and their expectations are sky-high.

The IPSWAM subprojects have contributed to more efficient water management, but further improvements are required to exploit the full potential for agricultural production in the polders.

Meghna Estuary Studies (MES)

Meghna Estuary is the easternmost sector of the Ganges delta. The Estuary conveys the joint discharge of the Ganges/Padma, Jamuna/Brahmaputra, and Meghna Rivers. Hereby,large volumes of water (some 1,200 km^3 per year) and sediment (some 1,100 mio. t per year) pass the area. The catchment area is 1,520,000 km^2. It covers parts of India and China, all of Nepal and Bhutan, and almost all of Bangladesh. The development objectives of Meghna Estuary Study (MES) were (1) to increase the physical safety and social security of the some two million inhabitants of the study area; and (2) to promote sustainable development in the coastal areas and on the islands. The immediate objectives were (1)to enhance and strengthen operational knowledge of hydraulic and morphological processes in the Meghna Estuary; (2) to find suitable land reclamation and bank protection methods; (3) to increase the capacity of BWDB to reclaim new land and protect the eroding river banks; and (4) to prepare a plan with priority projects and programmes for flood protection, agricultural and socio-economic development for early implementation. The objective of the MES estuarine surveys was to supply a part of the basis for assessment of the physical behaviour of the estuary. The produced data served as a supplement toresults and data from other sources, such as ongoing routine monitoring by BWDB, BIWTA, and Department of Meteorology, as well as satellite imagery, and historical data, notably from the Land Reclamation Project and the Cyclone Shelter Preparatory Study.

World Bank TA's

The World Bank undertook two TAs on Coastal Resilience: Developing New and Innovative Approaches in Bangladesh. Component 1 refers to Improving empirical evidence and analytical to support future investments and Component 3 to Operationalizing Knowledge into Ongoing Projects on Investments in Coastal Resilience in Bangladesh: Developing Concept Solutions for Coastal Erosion. Throughout these TAs, an extensive list of studies and projects dealing with coastal resilience and coastal erosion have been analysed, focusing on the understanding of the physical system, the practices used and most importantly, the lessons learned. The latter have been used to come up and develop sensible designs and investment strategies which fit into the Bangladesh setting considering multiple aspects.

The current design practice in Bangladesh of coastal interventions is mainly based on a design approach introduced in 1983[47] under a Dutch funded technical assistance program. Traditional coastal protection works have been mostly used which consist of 'hard' structures (such as embankments, revetments) that reduce or stop natural dynamics and, in this way, also the erosion processes. In many cases, such hard structures are the only viable option they can also lead to negative side effects to the natural system, like e.g. downdrift erosion, which can be

[47] Design Manual Procedures for Designs of Polders in Tidal Areas in Bangladesh, Md. Abdul Quassem, P.F. Raijmakers, J. Burger, Delta Development Project Bangladesh Water Development Board, 1983

combatted by other 'soft' solutions. Although from time to time new technologies have been introduced, the basic design and monitoring approaches are still traditional when compared to global practices.

For a better understanding of the suitability and effectiveness of innovative designs following the 'enhancing the nature concept', concept designs have been defined based on a solid understanding of the physical and socio-economic system and tested at a number of specific erosion hotspots for different scenarios.

In order to arrive at concept designs for each of the three selected hotspots, Consultants started with an overall system analysis of the Bangladesh coast, and then zoomed in to coastal morpho-dynamics of Polder 48, Polder 35/1 and coastline of Cox's Bazar to Teknaf along the Marine Drive.

Physical system analysis (through modelling simulations and expert judgement) has been carried out in each of the three hotspots which enhanced the understanding of the threats and drivers of erosion as well as socio-economic conditions, leading to "fit-for-use" innovative designs.

As said, the Bangladesh design guidelines and criteria leave room for enhancement whereas it concerns implementation of new concepts from elsewhere. At the same time the TAs have shown that a proper and joint dialogue between the main stakeholders can further improve this and pave the road for actual implementing new concepts in Bangladesh.

<u>Lessons learned</u>

Component 1: Improving empirical evidence and analytical to support future investments

Lessons learned on performance of embankments

Char development projects in the Meghna Estuary, which can be regarded as the first stages in polder development, significantly improved the livelihood conditions of the local settlers. The polder concept also has the advantage that it can be implemented in a phased manner, polder by polder, which allows for a balanced investment over time.

In general it can be concluded that polder development in Bangladesh impacted coastal resilience in a positive manner and is embedded and accepted in the Bangladesh setting. Nevertheless, there remain significant challenges, especially:

- Water management inside the polders suffers from impeded drainage through the ever-declining drainage gradients between sinking land and rising water levels and concepts should be developed to maintain gravity drainage and avoid or postpone installing pumps in the near future.
- Embankment improvements, that are required to increase protection from flooding, can be costly and time consuming because of bank and slope protection works and often requires land acquisition and resettlement. Also, insufficient attention is being paid to monitoring the erosion processes that could destabilize the embankments. The use of proper morpho-dynamic studies and modelling should be increased when planning and designing bank

protection works. These are both technical and institutional challenges that need to be addressed.

- Insufficient embankment maintenance and undercutting of dikes due to riverbank and coastal erosion necessitated the repeated implementation of polder improvement and rehabilitation projects. Lack of O&M funds and insufficient monitoring of embankment stability remains an issue. This could jeopardize the generally positive economic outcome of the polder projects. In the future, costs of maintenance during construction, may be considered in the Development Project Proforma (DPP).
- Gaps are identified in the context of lack of ownership, responsibilities and participation. Polder development should have a substantial component on community awareness building and mobilization, so that the community could be motivated and prepared to undertake the ownership and to get involved in O&M to ensure long term sustainability of the interventions.

Lessons learned for sustainable operation and maintenance of embankments and recommendations

- An important prerequisite for embankment works is the required safety level which determines the embankment height. A policy should be developed which, among other things, describes how to protect the coast against storm surges and associated erosion and flooding. For example, future climate change should be anticipated, with focus on targets on 2050 with a further time horizon to 2100 as defined in the Bangladesh Delta Plan 2100, and based on figures on generally accepted climate scenarios. Adaptive strategies and flexible measures make it possible to respond to any new knowledge and gained insights and at the same time, safety levels have to be established for different coastal zones taking into account on socio-economic development and future land use. The Dutch Delta Programme, e.g. provides a good example of such policy.
- Embankment rehabilitation projects should include components on improved (internal) water management. The CEIP-1 project in Bangladesh could serve as an example where through an NGO support is provided to the BWDB on setting up Water Management Organizations (WMO's) to introduce Integrated Water Resources Management (IWRM) practices and this can be built forward. This also includes social afforestation and integrated pest management approaches.
- Resilience of the Bangladesh coast can be enhanced if O&M would be done in a more systematically and timely manner, however, is often limited due to budgetary constraints. Poor operations and maintenance have led to damaged hydraulic structures, poor condition of the embankments and silting up of drainage canals. The lack of funding for operation and maintenance lead to the common approach of application of temporary and emergency protection works in the locations where a failure/breach is identified. The impact of the super-cyclone Amphan to Polder 35/1 is a recent example of application of such emergency protection works in locations were the impacts of erosion were significant and the stability of the previously implemented emergency work has failed. The cost of emergency protection works is in the order of 200,000 USD/km annually.

Application of a EEWS, will allow interfering in a cheaper manner by anticipating eventual changes and identifying the vulnerable stretches in advance. In other words, the O&M costs will be reduced significantly by monitoring the integrity of the embankment. Additionally, the large costs resulting from the application of the non-sustainable emergency and temporary works will be avoided.

Reduced required O&M funds making the allocation of required funding more feasible. The latter could be achieved through incorporation of such costs in the DPP.

Component 3: Developing Concept Solutions for Coastal Erosion

The lessons learned from the erosion hotspot analysis can be summarized as follows:

- From the overall system analysis together with the more detailed assessment of the three hotspots an increased understanding of the coastal morpho dynamics has been obtained and as such allowing to conceptualize solutions for combatting erosion which are "fit-for-use" for each hotspot with their own specifics; the latter in terms of physical conditions, threats and present and (potentially) future land use;
- It is felt by Consultants that a proper system analysis allows a designer to focus on specific solutions which are technically solving the primary causes of erosion. The various workshops conducted throughout the TA have provided valuable feedback from the stakeholders to verify not only the technical viability but also appreciation in terms of culture setting and socio-economic development. Within this interactive setting, the road was also nicely paved to introduce new concepts like nature based and integrated solutions for combatting erosion. In connection to these new concepts it is noted that these have already proven their viability elsewhere in the world like beach nourishment (Polder 48 and Cox's Bazar), dredging to change river profile (Polder 35/1), multifunctional embankments (Cox's Bazar) and groyne systems (Polder 48);
- When comparing a mega nourishment with the solution of a smaller scale sand nourishment, if the mega nourishment is properly linked to monitoring of its evolution, it can generate a good understanding of the system, adjusting the nourishment strategy when erosion is changing into sedimentation, and thus maintenance frequency can be reduced. Thus, proper monitoring of the physical conditions related to an intervention could certainly lead to reduced maintenance costs, by having built a thorough knowledge of the system leading to valid predictions and thus intervening before the system needs it;
- It is recommended to survey the mobility of the initial nourishment and apply new nourishments when needed. In this way, the principle of learning-by-doing is applied, with the advantage that too large initial nourishments can be avoided. Too large nourishments are not beneficial, because they require a large investment and because the beach may become very wide initially, which may not appear practical for tourism. It could also be possible that after about 10 years the trends in the area have changed, and the necessity of a second nourishment may be re-evaluated at that time;
- Hybrid solutions such as combination of a multifunctional embankment and a sand nourishment and/or groynes fields with additional nourishments entail proper strategies which share their benefits. More specifically, the solution of a sand nourishment on the one hand maintains the width of the beach, serves as a buffer for storm erosion and

subsequently prevents the loss of invaluable properties and on the other hand it benefits the multifunctional embankment by reducing the required crest level and decreasing the designed overtopping volume. Additionally, this combination can sustain and enhance the attractiveness for reactivation at the water front;

- Prestigious stakeholders from authorities such as BWDB, LGED, Project Directors and others have responded positively to the proposed innovative concepts. The shared feeling relates to the willingness of the authorities to embrace such innovative designs if properly integrated in the Bangladeshi setting.

ECOBAS

ECOBAS stands for ECO-engineered Coastal Defense Integrated with Sustainable Aquatic Food Production in Bangladesh.

The low-lying, densely populated coastal areas of Bangladesh are under threat due to increasing risk of storm-flooding and sea level rise (Karim & Mimura, 2013). Loss of land due to erosion is a chronic problem in many coastal areas and offshore islands (Maminul et al., 2014). Traditional engineering with hardened or earthen embankments often fails and is non-resilient, expensive and often sub-optimal with respect to other functions (as providing a source of food, income and other ecosystem services).

The objective of the ECOBAS project is to provide the coastal people of Bangladesh with an alternative approach for adaptation to coastal erosion and flooding. By using the concept of "eco-engineering" the natural resistance of shellfish reefs is used to combat the hydrodynamic forces and reduce human vulnerability to coastal erosion and flooding while at the same time delivering a source of aquatic food.

The project investigated the technical, sociological and economic feasibility of eco-engineered coastal defense along the south east coast of Bangladesh, through: Phase 1 (2012) involving small-scale ecological field trials, socio-economic (field) studies and morphodynamics analysis, including hydrodynamic modelling; Phase 2 (2013- 2014) with construction and testing of a pilot oyster reef at Kutubdia Island, mathematical modelling and dissemination of results.

In the first phase of the ECOBAS project, the suitability of the Bangladeshi coast for oyster reef development was investigated through a habitat suitability analysis and field visits. Subsequently, to acquire practical information about oyster settlement and growth, different substrates (i.e. dead oyster shells, living oysters, window pane shells and stones) were tested in a field experiment at Kutubdia and Moheshkali Island in 2012. Substrates were fixed in bamboo mattresses and placed on the intertidal mudflats of two sites. This experiment provided data on spat settlement, growth and survival of oysters. However, the reefs made of bamboo frames have proven vulnerable to destruction by hydrodynamic forces, in particular in the monsoon season, and also smothering of fine sediments and silt on the substrates, suffocating the oysters.

In the second phase, a new reef structure was constructed on the south-east coast of Kutubdia Island made out of a concrete structure. The structure mimics the dimensions of a full grown oyster reef in such a way that effects on local hydromorphology can be evaluated. At the same time the structure offers a suitable substrate for oyster settlement, as it is sufficiently elevated above the surface.

Lessons learned

The main success factors were the following:
- The novelty of the concept
- The interest it has generated among stakeholders and in the media
- The successful application for continued research (i.e. NUFFIC fellowship at PhD level)
- The active involvement and participation of local community
- The cooperation and adequate flow of information between all consortium partners

The main underperformance factors were the following:
- Extreme environmental conditions resulting in a more time-consuming experimental phase
- Challenging data collection because sufficient and modern monitoring equipment was not always at hand and logistics support was limited

Upscaling opportunities
On the final conference in November 2014, the Minister of Water Resources responded very enthusiastically to the concept on eco-engineering and also advocated further development of these concepts in Bangladesh. Also, the Embassy of the Netherlands expressed its interest and is sincerely willing to support future initiatives. Besides, meetings with potential interested clients for up-scaling, such as the Bangladesh Water Development Board, Blue Gold program, CEGIS, IWM, DUET etc., resulted in general in positive reactions. So far, however, this has not resulted in concrete assignments for up-scaling.
IMARES-Wageningen UR together with the University of Chittagong will continue further research on oyster reefs for coastal defense in Bangladesh.

In a next phase, it is recommended to put emphasis on further optimizing and implementing the concept of eco-engineering for risk reduction and climate change adaptation along the coast of Bangladesh. The aim is realizing the full impact of ECOBAS, to broaden the approach, and to provide insight in the conditions under which coastal ecosystems can be valuable for coastal protection and to design (restore or develop) these systems in such a way that ecosystem services are maximized.

Applied innovations
The concept is increasingly emerging in high-ranked journals and publications but needs further implementation and understanding through real-world applications and examples. Coastal ecosystems provide many benefits to humans, and ECOBAS is one of the first projects where coastal protection and food production (in an experimental way) were combined. Sustainable aquaculture provides an important complimentary source of food security, human nutrition and poverty alleviation in many rural areas worldwide, and ECOBAS showed that coastal ecosystems like oyster reefs can provide

such benefits. Especially in Bangladesh not many people are familiar with oysters and cooking of oysters for home consumption. Therefore, the project initiated a number of cooking classes and published a cook book for local sea food.

Lessons learned

The main findings of the field experiments were:

- Window pane shells, live oysters, oyster shells and stones were suitable substrates for natural spatfall and growth of *Crassostrea madrasensis* with window pane shells being the most successful
- Environmental conditions (salinity, pH, temperature, TSS etc.) were favourable for growth of oysters;
- Sedimentation and smothering with sediment were the main threat for oysters during monsoon period; the structures directly onto the mudflat suffered more from suffocation with silt and mud compared to the structures placed 25 cm above.
- Bamboo as a reef structure has not proven strong enough to withstand the high-water dynamics in the monsoon period, therefore demolition of some of the structures appeared during the monsoon period.
- A more solid substrate with high vertical relief (to prevent smothering of the structure by mud) was recommended as reef structure.

From a hydro-morphological perspective, the main findings are:

- Oyster reefs result in accretion of sediment on the lee side of the reef;
- As a result of the accretion behind the oyster reef, salt marshes and mangrove development can be enhanced;
- Effects of the reef are indirect. Due to the accretion behind the reef a more extended foreshore is created. As a result, wave damping occurs and the primary defense (i.e. the earthen embankment) is less affected.

The lessons learned from the Social Cost Benefit Analysis:

- The combination of Earthen Embankments with oyster reef structures and mangroves has the highest benefits (compared to the current situation).
- If benefits which are not yet valued in monetary units (e.g. crab, wood, honey) are included, Earthen Embankments with oyster reef structures and Mangroves have an even higher cost benefit balance.
- Earthen Embankments with oyster reef structures and mangroves provide more climate adaptation possibilities than the other measures analyzed.

Appendix 3 Review of Policies, Rules/ Regulations

A3.1 Policies

Overview of policies reviewed:

1. National Water Policy (NWPO – 1991)
2. Coastal Zone Policy (CZPo – 2005)
3. Coastal Development Strategy (CDS – 2005)
4. National Environmental Policy (NEPo -1992)
5. National Land Utilization Policy (2001)
6. National Agricultural Policy (2013)
7. National Adaptation Programme of Action (NAPA – 2005)
8. National Biodiversity Strategy & Action Plan (NBSAP – 2007)
9. Bangladesh Climate Change Strategy and Action Plan (BCCSAP – 2009)
10. National Water Management Plan (NWMP – 2004)
11. Bangladesh Delta Plan 2100

National Water Policy (NWPo - 1999)

The National Water Policy (NWP0) of the Government of Bangladesh aims to provide direction to all agencies working with the water sector, and institutions that relate to the water sector in one form or another, for achievement of specified objectives. The policies set forth herein are considered essential for addressing the objectives of improved water resources management and protection of the environment. Every public agency, every community, village and each individual has an important role to play in ensuring that the water and associated natural resources of Bangladesh are used judiciously so that the future generations can be assured of at least the same, if not better, availability and quality of those resources.

The main objective of the NWPo is:

- To address issues related to the harnessing and development of all forms of surface water and groundwater and management of these resources in an efficient and equitable manner;
- To ensure the availability of water to all elements of the society including the poor and the underprivileged and to take into account the particular needs of women and children;
- To accelerate the development of sustainable public and private water delivery systems with appropriate legal and financial measures and incentives, including delineation of water rights and water pricing;
- To bring institutional changes that will help decentralize the management of water resources and enhance the role of women in water management;
- To develop a legal and regularly environmental that will help the process of decentralization, sound environment management, and improve the investment climate for the private sector in water development and management; and
- To develop a state of knowledge and capability that will enable the country to design future water resources management plants by itself with economic efficiency, gender equity, social justice and environmental awareness to facilitate achievement of the water management objectives through broad public participation.

As water is essential for human survival, socio-economic development of the country and preservation of its natural environment, it is the policy of the Government of Bangladesh that all necessary means and measures will be taken to manage the water resources of the country in a comprehensive, integrated and equitable manner. The policies enunciated herein are designed to ensure continued progress towards fulfilling the national goals of economic development, poverty alleviation, food security, public health and safety, decent standard of living for the people and protection of the natural environment.

As the CEIP-2 project area is located in the saline zone, so, provision for use of a portion of surface run-off generated sweet water from rainfall inside the polder to agriculture and aquaculture can improve the living standard of people of the polder. Provisioning increased storing capacity in the drainage network without affecting the proper drainage could helpful to achieve the objective.

Coastal Zone Policy (CZPo - 2005)

The Coastal Zone Policy (CZPo) 2005 has set the goal of Integrated Coastal Zone Management (ICZM) to create conditions in which the reduction of poverty, development of sustainable livelihood and the integration of the coastal zone into national processes can take place.

The Government considers the following three reasons for initiating the coastal zone policy:

a) the coastal zone is lagging behind in socio-economic developments on many aspects;

b) Poor initiatives to cope with different disasters and gradual deterioration of the environment;
c) the coastal zone has the potential to contribute much to national development.

The govt. has made the coastal zone policy statements in relation to development objectives. These policies provide general guidance so that the coastal people can pursue their livelihoods under secured conditions in a sustainable manner without detailing the national environment.

The realization of CEIP-2 which is a part of the larger CEIP will satisfy several of the aspirations highlighted in above policy.

Coastal Development Strategy (CDS- 2005)

The Coastal Zone Policy (2005) states that a Coastal Development Strategy (CDS) shall be developed and adopted in line with national strategy documents as a commonly agreed frame work documents. The coastal zone (CZ) is generally perceived as a zone of various vulnerabilities. Moreover, it contains several important and critical ecosystems and by harnessing and exploiting its opportunities, the CZ can make a substantial contribution in achieving the national goals of accelerated poverty reduction and millennium development goals. The coastal zone is also at great risk from both global climate change and tsunami because of its very low elevation and exposure to various water related hazards. Coastal resources are especially endangered by the projected climate change and consequent sea level rise.

The CDS is the "Linking Pin" in the ICZM process, linking the Coastal Zone Policy (CZPO) with concrete development programme and intervention. The objective of CDS are: to select strategic priorities and actions in implementation of the CZPo with emphasis on the creation of an institutional environment that will enable the GoB to embark on a continuous and structured process of prioritization, development and implementation of concerted interventions for the development of the CZ.

The objectives of CEIP-2 aim to fulfil several of the objectives of the CDS.

National Environmental Policy (NEPo - 1992)

The Environment Policy 1992 was formulated by the Government of Bangladesh following the Rio Earth Summit and acknowledged that sustained development of the country is based on the wellbeing of the environment and ecosystems since they provide services necessary to fulfill the socio economic needs of communities, which in turn contribute to climate change mitigation and adaptation. The impact of environmental degradation on soil fertility, the quantity and quality of available water, air quality, forests, wildlife and fisheries were widely recognized. The objectives of the policy are to maintain ecological balance and overall development via protection and improvement of the country and thereby protect the country against natural disasters. Activities which pollute and degrade the environment are identified in the document. The policy outlines the need to ensure environmentally sound development in all sectors via sustainable use of the country's natural resources. The objectives of National Environmental policy are as follows:

- Maintenance of ecological balance and overall development through protection and improvement of the environment;
- Save the country from natural disaster;
- All activities liable for environmental degradation to be detected and controlled;
- Ensuring of environmentally sound development in all sectors;
- ensuring of sustainable long-term and environmentally sound use of all national resources;
- Active participation in all international initiatives regarding environmental issue will be ensured.

Following are the key subject matters covered under the National Environment Policy, 2018:

- Ensuring sustainable development through reducing human pressure on nature and natural resources
- Considering environment protection as integral part of the development programs planned to meet the need of the present and future generation
- Making natural resources extraction, use, environmental conservation etc. to be based on science
- Considering environmental impacts and risks in extracting and using natural resources
- Evaluating economic contribution of ecosystem services simultaneously to that of natural resources
- Giving priority to poor and under privileged group of people in order to ensure their participation, equity, justice, accessibility to the use of natural resources and getting ecosystem services on which, they are dependent

- Taking initiatives to prevent misuse and ensure optimum of water, land, natural gas and other natural resources in the production process as well as day-to-day purposes
- Encouraging sustainable use of new and renewable resources
- Enhancing long term poverty alleviation and food security through conserving biological diversity
- Realizing compensation from persons and institutes those who are liable to environmental pollution through applying polluter pay principle
- Including environmental conservation and preservation in all national policies and ensuring implementation of the environment policy at both government and non-government level
- Giving priority to preventive measures over curative measures in environmental conservation
- Including adaptation and mitigation program in all development projects in order to address adverse impacts of climate change
- Ensure sustainable utilization of ecosystem goods and services
- Implementation of 3R principle in utilization of resources
- Strengthening institutional and legal capacity of institution (Government, local, private and technical) relevant to the enforcing and implementation of rules and regulation relating to environment policy and environment conservation
- Ensuring considerations of climate change and challenges of calamities in all kind of infrastructure projects
- Reducing of all SLCP (Short-Lived climate pollutants) which are harmful to health and environment
- Taking development programs considering sustainable production and consumption as integral part of environmental conservation to meet the need of present and future generation
- Allocating necessary funds to all areas of environmental conservation, preservation and control
- Taking up programs in favor of flourishing environment friendly economy
- Including environmental and ecological conservation particularly to introduce the environment and ecological concept in the environmental academic curriculum and textbooks of schools and colleges

The NEP, amongst other aims, seeks to ensure that transport systems, including roads and inland water transport, do not pollute the environment or degrade resources. The policy states that environmental impact assessment should be conducted before projects are undertaken. The NEP 2018 includes additional elements addressing climate change mitigation and adaptation as key environmental issues facing the country and integrating a comprehensive 3R approach to the massive and growing problem of industrial and household waste that has swelled along with the country's urbanization.

National Land Utilization Policy (2001)

The National Land Use Policy, 2001, has been declared to protect the agriculture land from other use. Objectives of policy are relevant to the coastal embankment project CEIP-2. Objectives of policy are as follows:

- Prevent the current tendency of gradual and consistent decrease of cultivable land to ensure the production of food for growing demand of increasing population;
- Ensuring usage of land in harmony with natural environment;
- Usage of land resources in the best possible way for poverty alleviation and increase employment;
- Issue of directives for land use following the nature of land in all area of the country;
- Ensure Protection of khash land for future development works;
- Prevention of land pollution; and
- Ensure minimal use of land for urbanization and construction of projects and ensure not to acquired more land than the actual requirement.

The policy aims to prevent the current tendency of gradual and consistent decrease of cultivable land to ensure that the production of food can meet the growing demand of the increasing population. The objective of CEIP-2 is also increase food production, which will helop the government with their implementation of the policy.

National Agricultural Policy (2013)

The National Agricultural Policy 1999 was revised in 2013 and approved with the objectives to:

- Ensure sustainable and profitable agricultural production through appropriate and adequate research, technological innovations and its use and capacity building of the farmers;
- With the ensuing impacts of climate change agricultural products need to be diversified and adaptable to changes for which proper planning and implementation need to be ensured;
- The quality and nutritious content of agricultural products, packaging and processing needs to be improved for export
- Improve the returns for farmers on their products.
- Agri-based industries should be promoted to meet the demands for agri-products within Bangladesh as well as abroad.

CEIP-2will ensure a favourable environment for agriculture. Thus, the implementation of this project will help to achieve the abovementioned objectives of this policy.

National Adaptation Programme of Action (NAPA- 2005)

The GoB has recognised climate change as an important issue and attempts were being made to incorporate potential response measures for reducing impacts of climate change into an overall development planning process. It was recognized that the adverse impacts of climate change in an already vulnerable country such as Bangladesh will put additional stress on overall development of the country. The issue was also recognised at the higher political level of the country.

The basic approach to NAPA preparation was along with the sustainable development goals and objectives of the country where it has recognized necessity of addressing environmental issue and natural resource management with the participation of stakeholders. The NAPA is the beginning of a long journey to address adverse impacts of climate stimuli including variability and extreme events and to promote sustainable development of the country.

The following adaptation measures have been suggested for Bangladesh to address adverse effects of climate change including variability and extreme events based on existing coping mechanisms and practices. The suggested future adaptation strategies are:

- Reduction of climate change hazards through coastal afforestation with community participation;
- Providing drinking water to coastal communities to combat enhanced salinity due to sea level rise;
- Capacity building for integrating climate change in planning, designing of infrastructure, conflict management and land-water zoning for water management institutions;
- Climate change and adaptation information dissemination to vulnerable community for emergency preparedness measures and awareness raising on enhanced climatic disasters;
- Construction of flood shelter, and information and assistance centre to cope with enhanced recurrent floods in major floodplains;
- Mainstreaming adaptation to climate change into policies and programmes in different sectors (focusing on disaster management, water, agriculture, health and industry);
- Inclusion of climate change issues in curriculum at secondary and tertiary educational institution;
- Enhancing resilience of urban infrastructure and industries to impacts of climate change;
- Development of eco-specific adaptive knowledge (including indigenous knowledge) on adaptation to climate variability to enhance adaptive capacity for future climate change;
- Promotion of research on drought, flood and saline tolerant varieties of crops to facilitate adaptation in future;
- Promoting adaptation to coastal crop agriculture to combat increased salinity;
- Adaptation to agriculture systems in areas prone to enhanced flash flooding in North East and Central Region;
- Adaptation to fisheries in areas prone to enhanced flooding in North East and Central Region through adaptive and diversified fish culture practices;
- Promoting adaptation to coastal fisheries through culture of salt tolerant fish special in coastal areas of Bangladesh;
- Exploring options for insurance and other emergency preparedness measures to cope with enhanced climatic disasters.

Implementation of this project will helpful for implementation of this policy.

National Biodiversity Strategy & Action Plan (NBSAP- 2007)

As a Contracting Party to the Convention on Biological Diversity (CBD), Bangladesh is committed to initiating and implementing conservation and sustainable management of its national biological diversity according to the CBD principles for the sustenance of her present as well as future generations. The NBSAP document embodies Bangladesh's strategic approach to conserving the nation's biological diversity as well as the action plan for fulfilling our obligations as a signatory to the CBD. The NBSAP is a national framework for initiating and executing activities leading to the conservation and sustainable use of biodiversity, and establishing mechanisms to ensure equitable sharing of the benefits derived from such activities. A major focus of the plan is to ensure cross-sectorial linkages, reflecting the fact that in Bangladesh, more so than most other countries, biodiversity conservation is closely inter-woven with social and economic development. The implementation of the strategy is based on partnerships and coalitions between specialised government organisations, NGOs, conservation partners, the private sector, academia and other exponents of the civil society.

The major objectives of the NBSAP are to:

- Conserve, and restore the biodiversity of the country for wellbeing of the present and future generations;
- Ensure that long-term food, water, health and nutritional securities of the people are met through conservation of biological diversity;
- Maintain and to improve environmental stability for ecosystems;
- Ensure preservation of the unique biological heritage of the nation for the benefit of the present and future generations;
- Guarantee the safe passage and conservation of globally endangered migratory species, especially birds and mammals in the country; and stop introduction of invasive alien species, genetically modified organisms and living modified organisms.

Bangladesh Climate Change Strategy and Action Plan (BCCSAP -2009)

The Bangladesh Climate Change Strategy and Action Plan is a part of the overall development strategy of the country. The climate change constraints and opportunities are being integrated into the overall plan and programs involving all sectors and processes for economic and social development.

The Strategy will be achieved through implementation of an Action Plan, which is based on six pillars:

i) food security, social protection and health;

ii) comprehensive disaster management;

iii) infrastructure development;

iv) research and knowledge management;

v) mitigation and low-carbon development; and

vi) capacity building and institutional development.

The Action Plan will also be an integral part of the national development policies, plans and programmes including the Sixth Five Year Plan. The Action Plan will be coordinated by Climate Change Unit (CCU) specially created for the purpose by the MOEF. The Unit operates under the overall guidance of the National Environment Committee headed by the Prime Minister and the

National Steering Committee on Climate Change headed by the Minister, MOEF. All relevant sectorial ministries will have Climate Change Focal Points which will look after, design, and help in implementation of sectorial policies, programmes and projects from climate change perspectives as and when so required within the framework of the planned development process.

Prepared to provide guidance to reduce vulnerability and increase resilience against climate change impacts, the BCCSAP 2009 emphasized adaption more than compared to mitigation. Particular vulnerabilities of coastal areas are increasingly frequent and severe tropical cyclones with higher winds speeds and storms surges leading to more damage in the coastal region, sea level rise leading to submergence of low-lying coastal areas and intrusion of saline water and reducing fresh water availability. The actions indicated in BCCSAP (2009) are particularly relevant for Ecological Critical Areas. Areas within Polder No. 32, 33, and 35/1 lie within ECA being a fragile environment that supports a growth centre for livelihood and being located in the front line of natural disasters like cyclone and storm surge.

Since the project area is situated in the coastal vulnerable area it may be relevant to coordinate with the CCU for necessary suggestions/guidance. CCU actively promotes mainstreaming of climate change considerations into national development policies, plans and programs.

As BWDB's polders are subject to the adverse effects of climate change, the implementation of CEIP-2 project will be helpful to implement the action plan of this policy.

National Water Management Plan (NWMP - 2004)

In line with the principles of the NWPo, the National Water Management Plan (NWMP) provides a framework at the national and regional level within which the line agencies, local government and other stakeholders will plan and implement their activities and projects in a coordinated manner to achieve the national and sectorial objectives. The NWMP aims at institutional development for promoting integrated water resources management and sustainable service delivery systems with decentralization, increased stakeholders and private sector participations in O&M and sound management of environment and diverse social concerns.

Bangladesh Delta Plan 2100

The Bangladesh Delta Plan (BDP) 2100 is a long-term integrated techno-economic mega plan that integrates delta related sector plans and policies, enveloping a Delta Vision and strategies that make it possible to integrate sector plans and polices for the long term and to present actionable interventions with a road map for realization.

Bangladesh is a rapidly developing country with economic growth exceeding six percent on average over the last five years. Bangladesh is well on its way to fulfil its goal to be a higher middle-income country by 2030 and aims to be a developed country by 2041. To fulfil its ambitions, there is a strong need to improve living conditions through better water management.

The overall objective of the project concerning the formulation of BDP 2100 was to realize a sustainable and commonly agreed strategy with all relevant stakeholders for an optimum level of water safety and food security, as well as sustained economic growth of Bangladesh and a framework for its implementation. By formulating the Bangladesh Delta Plan (BDP) 2100 the government aims at tackling the challenges in an integrated and coherent manner and to take concrete short-term (2015-2025), medium-term (2025-2040) and long-term (2040-beyond) steps towards developing a safe, resilient and prosperous delta. Preparation of the BDP 2100, led by the GED (General Economic Division) of the BPC (Bangladesh Planning Commission), started in August 2014 and the Government has approved it on 4 September, 2018. The Delta Plan considers the delta as a whole and takes into account the effect of delta management on all sectors, empowering Bangladesh to make optimal, efficient use of limited resources. It enables the Bangladesh government to integrate climate change adaptation and plan for a future delta that ensures water safety, food security and economic growth. By employing adaptive delta management, Bangladesh becomes able to conduct robust planning in the context of a rapidly changing environment.

During formulation and implementation, the BDP 2100 will function in compliance with the existing FYP cycles of the country, but it will also be in alignment with the relevant sectoral plans such as the National Water Management Plan (2004), Integrated Coastal Zone Management Plan (2005), Master Plan for Hoar Areas (2012), Master Plan for Agricultural Development in Southern Bangladesh (2013) etc., whereas the FYP provides directives for the country’s Annual Development Programme (ADP) and sectoral plans.

The Bangladesh Delta Plan (BDP) 2100 was approved at the National Economic Council (NEC) meeting, presided over by the Prime Minister and Chairperson of the NEC, on 4 September 2018. Bangladesh is the first country in the world to develop such a comprehensive plan including an investment plan for an entire delta using Adaptive Delta Management.

BDP2100 has to achieve the goals provided in 2 National Level Strategies, on i) Flood Risk and ii) Freshwater Management. BDP has also developed six Hotspot Specific Strategies, on i) Coastal Zone, ii) Barind and rought Prone Areas, iii) Haor ad Flash Flood Areas, iv) Chattogram Hill Tracts, v) River Systems and Estuaries and vi) Urban Areas. BDP also provided eight Thematic Strategies for cross cutting issues, on i) Sustainable Land Use and Spatial Planning; ii) Agriculture, Food Security, Nutrition and Livelihood; iii) Trans-boundary Water Management; iv) Dynamizing Inland Water Transport System; v) Urban Water Management; vi) Advancing the Blue Economy; vii) Renewable Energy and viii) Earthquakes.

<u>Taking forward BDP2100 to CEIP-2 (perhaps add in lessons learned Annex)</u>

The dream Padma Bridge with huge and most sophisticated rail and road links to the SW and SC regions will greatly enhance the economic activities and livelihood in the area. With the tremendous future development potential in these regions, CEIP will need to plan and strengthen its embankment system considering these development scenarios and the required road networks as a result of the Padma Bridge and the Payra Port. So, in combination with raising and strengthening the embankment, CEIP will also need to widen the embankments to accommodate the future traffic load in connection with the associated development of a targeted middle-income country. CEIP also needs to consider the impact of this development on the future cost and scarcity of land for acquisition. It may also happen that this development scenario and the export/import potential will increase the investment in the existing shrimp/fish ghers inside and outside the embankments which might complicate the planned width and alignment of the embankments, and this issue should be well addressed in he planning.

Given the uncertainties of long-term climate change and socio-economic development, a flexible and adaptive approach is key to achieve the vision and goals. BDP 2100 focuses on climate resilient development and uses the approach of Adaptive Delta Management (ADM) and best available information to develop short-to-medium term strategies under different scenarios. The scenarios and strategies need to be updated frequently, as new information will be available on a 5-year cycle. This adaptive approach to delta planning including the selection of investment projects provides the link of the short-to-medium-term development targets and investment programs with the long-term goals of sustained development based on climate sensitive management and economic growth. ADM focuses on feasible adaptation pathways to plan for different future conditions, taking into account possible tipping points in major drivers and developments – requiring concerted action to avoid irreparable damage and seeks to avoid over- or underinvestment. This also underscores the importance of further elaborating the Delta Knowledge Portal and doing sound monitoring and evaluation to assess delta progress and shortcomings. Decision-support, such as envisaged in the Meta-model and the ESPA Deltas project, are also tools to support the knowledge portal, project preparation and approval processes

A3.2 Rules and Regulations

Overview of rules and regulations reviewed:

1. Bangladesh Water Development Board Act (2000)
2. Bangladesh Water Act, Act No. 14 (2013)
3. Environmental Conservation Act and Amendments (ECA – 1995)
4. Environment Conservation Rules (ECR – 1997) and Amendments (2003)
5. Department of Environment's IEE/EIA Guidelines (1997 and 2021)
6. Bangladesh Wildlife (Conservation and Security) Act (2012); Previously known as Bangladesh Wildlife (Preservation) Order (1973)
7. Protection and Conservation of Fish Act (1950) and Amendments (1963, 1970, 1982, 1995, 2000) & Protection and Conservation of Fish Rules (1985) and Amendments (1987)
8. The Embankment and Drainage Act (1952)
9. National Disaster Management Act (2012)
10. Open Place, Park & Wetland Conservation Act (2000) and Amendments (2002)

Bangladesh Water Development Board Act (2000)

The Bangladesh Water Development Act-2000 is an Act that aims to ensure development and management of water resources by rescinding provisions of the Bangladesh Water and Power Development Board Order of 1972 under the Bangladesh Water and Power Development Boar Order, 1972 (P.o. No. 59 of1972)]. The Act enforced from the date of its publication 11-07-

2000. Under this Act, the Bangladesh Water Development Board in its present form has been created.

Powers and Responsibilities of the Board:

(1).Subject to the provisions of different Sections under this Act, the Board may undertake activities for the whole of Bangladesh or any part thereof for development and efficient management of water resources as well as for performing the activities stated in Section 6.

(2). Without impairing the generality of the power and authority given under sub-section (1), the Board shall exercise the following powers and responsibilities, namely:

a) Subject to private rights, exercise the right of the Government with its concurrence to control the flow of water in all rivers and channels and underground aquifers.

b) Develop standards and guidelines for the operation and maintenance of all water management structures pursuant to Section 6.

c) Sign contracts for procurement of plant, machinery, equipment and other ancillary material for project implementation.

d) Sign contracts with local public agencies of with local and international consulting firms or experts for advice and assistance in the preparation, execution and other related matters of projects on the basis of approved project documents.

e) Levy and collect service charges, with prior approval of the Government, for operation and maintenance and cost recovery of FCDI projects.

f) Undertake the execution of any water related project on behalf of any public agency, as "deposit work" with full technical, administrative and financial control of the project.

Functions of the Board

(1) Subject to fulfillment of conditions under this Act anti guidelines provided by the National Water Policy and the National Water Management Plan, the Board shall perform the following activities and towards that end shall carry out all activities relating to preparation of needed projects, their' implementation, operation, maintenance and evaluation.

(2) Structural Functions

a) Construction of dams, barrages, reservoirs, embankments, regulators or other structures for development of rivers, flood control, drainage, surface irrigation, and drought prevention.

b) Re-excavation/ de-siltation of water channels and removal of obstacles from the mouths of rivers for improvement of water flows or diversion of water for assisting fisheries, navigation, forestry, wildlife development and up gradation of the environment.

c) Works for soil conservation, land accretion, land reclamation and estuary control.

d) River training and river bank protection for the protection of towns, bazaars, haats and places of historical and public importance from the hazards of land erosion.

e) Construction and maintenance of coastal embankment.

f) Prevention of salinity intrusion and desertification.
g) Harvesting of rainwater for irrigation, environmental preservation and supply of drinking water.

(3) Non-structural Functions
a) Flood and drought forecasting and warning.
b) Hydrological survey and investigation.
c) Development of forestry and fishery on land available round Board's infrastructure and construction of reads on embankments in conjunction with relevant government agencies, for the preservation and improvement of the environment as well as for poverty alleviation.
d) Basic and applied research on all aspects of the Board's activities.
e) Establishment of water user's association and other water users/stakeholders' organizations, their training and participation, in project planning, implementation, operation and maintenance and cost recovery for long-term sustainability of benefits to the beneficiaries of completed projects.

The Bangladesh Water Development Board Act,2000 is the legal safeguard for BWDB and according to the Act, implementation of CEIP-2 project is a part of its structural functions.

Bangladesh Water Act, Act No. 14 (2013)

This Bangladesh Water Act, 2013 provides for the right to water when it is used for the purposes of drinking, sanitation and sewage disposal, water control, protection and conservation of water resources. In addition, it regulates land ownership requirements, surface water, etc. These are subject to the provisions of this Act on the following matters:

- water, waste prevention, protection and preservation, the executive committee may issue a protection order against the landlord and the right to use such water without the permission of the competent authority shall not be transferable.

This Act also deals with:
The creation of the National Water Resources Council, and the Water Executive Committee, establishing their composition, duties and responsibilities, entitled to carry out the following activities:

- promoting the National Water Policy and National Water Resources Planning, Monitoring and Evaluation;
- developing and using integrated water resources, balanced water supply, protection and implementation of the water policy;
- ensuring integrated development of water resources of the National Water Resources Plan providing guidelines; disseminating a variety of data exchange and analysis on water resources;
- a joint international survey on the river, and its chemical and biological pollution studies, and joint research activities; developing water resources of international rivers, retrieval and distribution activities;
- training programmes related to water resources in light of international and regional co-operation exchange.

The Government of National Water Policy by the competent authority may include water pricing and other issues relevant to the inclusion of the following matters, namely for the following purposes:

- use of water for irrigation; actual cost of water extraction and supply;
- comprehensive use of surface, ground water and rainwater;
- any other relevant matters considered by the Government in order to control the flow of rivers flooding, based on the Executive Committee survey results, so that any wetland, in the interest of national and local communities, is declared flood controlled zone.

In view of water resources protection and conservation, the Act adopted a timely decision to address the water needs in irrigation and urban areas in the context of available surface water, groundwater, and rainwater. The Act provides provisions for punishment and financial penalty for non-compliance with the Act, including negligence to abide the government policy, ordinance, non-cooperation with government officials, refusal to present necessary documents, providing false information, affiliation with perpetrators, and protection measures for water resources management.

Environmental Conservation Act and Amendments (ECA- 1995)

The Environmental Conservation Act aims provide forconservation of the environment, improvement of environmental standards and control and mitigation of environmental pollution. The Government of Bangladesh established the Department of Environment (DoE) exercising the power of the Act and authorize the Director general to take measures as he considers necessary and expedient for the conservation of the environment, and improvement of environmental standards, and for the control and mitigation of environmental pollution, and he may issue necessary directions in writing to any person for the discharge of his duties under this Act. The Act includes amongst others the following:

- Declaration of Ecologically Critical Areas;
- Procedure for obtaining Environmental Clearance Certificates;
- Regulation with respect to vehicles emitting smoke harmful for the environment;
- Regulation of the establishment of industries and other development activities for conservation of environment;
- Determination of the standards of air, water, sound, soil and other components of the environment in relation to different areas for different purposes:
- Determination of the standards for effluent and discharge; and
- Formulation and publish environmental guidelines relating to the control and mitigation of environmental pollution, conservation and improvement of the environment.

Amendments to the ECA in 2000, 2002 and 2010 added significant substantive and procedural scope, defining the following new areas of authority:

- ascertaining responsibility for compensation in cases of damage to ecosystems;

- increased provision of preventive measures, including fines and imprisonment, and the authority to take cognizance of offences;
- restrictions on polluting automobiles;
- restrictions on the production and sale of environmentally harmful items like polythene bags;
- obtaining assistance from law enforcement agencies for environmental actions;
- definition and enforcement of punitive measures;
- authority to try environmental cases;
- prohibition on hill cutting except were established to be in the national interest;
- authority to regulate management of hazardous waste produced by ship breaking yards;
- prohibition of filling or alteration of waterways except when judged to be in the national interest; and
- additional powers to compel compliance with emissions standards.

A strip of 10 km width all along the northern border of the Sundarban has been declared as an Ecologically Critical Area (ECA) in 1999 under the Bangladesh Environment Conservation Act 1995. The northern boundary of the Sundarban along the right bank of the Pussur River (Polder 33) lies within the ECA.

Environment Conservation Rules (ECR - 1997) and Amendments (2003)

The Environment Conservation Rules consist of a set of rules under the Environment Conservation Act (ECA), 1995 that enable the enforcement of the Act. The rules among others include (i) the National Environmental Quality Standards for air, water, industrial effluent, emission, noise, vehicular exhaust etc., (ii) procedures to obtain Environmental Clearance, and (iii) requirements for Environmental Impact Assessment (EIA) according to categories of industrial and other development interventions. These includes others standards and guidelines for:

- Industries and development projects on the basis of actual and anticipated pollution load;
- Requirements for undertaking Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA), as well as formulating an Environmental Management Plan (EMP) according to categories of industries/development projects/activities;
- Procedure for obtaining Environmental Clearance Certificates;
- Environmental quality standards for air, surface water, groundwater, drinking water, industrial effluents, emissions, noise and vehicular exhausts.

The Environment Conservation Rules (ECR), 1997 is the main subsidiary legislation of the Environmental Conservation Act (ECA), 1995 which outlines various procedures or measures that need to be taken for compliance with the related provisions of the ECA (see Table below).

Table 6-4: Principal Provisions of the ECR, 1997

Rule	Provision Under Rule
Rule 3	Outlines factors (such as human habitat, archaeological site, ancient monument, national park, mangrove, etc) that the Government will take into account to declare an area as Ecologically Critical Area (ECA) and specify the activities or processes that cannot be continued or initiated in an ECA.

Rule 5	Outlines procedures for any person affected or likely to be affected as a result of pollution or degradation of the environment to apply to the DG for remedy of the damage or apprehended damage.
Rule 7	Outlines procedures for obtaining an Environmental Clearance Certificate (ECC).
Rule 7(1)	Classification of industrial units and projects for purpose of issuance of into four categories: (a) Green; (b) Orange – A; (c) Orange – B; and (d) Red.
Rule 7(4)	For Orange-A, Orange-B, and Red categories, require a Site Clearance Certificate (SCC) and thereafter an ECC to be obtained.
Rule 7(5)	Prescribed form for application of SCC or ECC.
Rule 7(6)	Outlines documents for various categories of industrial units and projects. Those within Orange-B and Red categories require submission of an Initial Environmental Evaluation (IEE), while an Environmental Impact Assessment (EIA) report is required for the latter category.
Rule 7(9)	Specifies type of activities that may be undertaken with approval of SCC.
Rule 8	Indicates period of validity of ECC for Green projects (3 year), and for others (5 year). Renewal is to be made at least 30 days before expiry of certificate.
Rule 9	Sets procedures for appeal against any notice, order or directive to the Appellate Authority.
Rule 12 & 13	Prescribed emission and environmental standards to be complied with are outlined in various schedules.
Rule 14	Schedule 13 - prescribes fees for issuance or renewal of ECC.
Rule 16	Outline of procedures for payment of fees.
Rule 17	Require any accident that poses serious threat to the environment to be informed to the DG.

The Environment Conservation Rules, 1997 were the first and still most important set of regulations giving procedural substance and tools of enforcement to the aims articulated in the ECA. The Rules specify standards for air quality and emissions, water quality and discharges, and noise, and establish norms enabling the inspection of industrial facilities, including collection of environmental samples, by the DOE. Importantly, the Rules (Schedule I) lay out a standard framework for categorizing, assessing and regulating new industrial projects using a four-level typology of impact potential. This typology is the basis for defining the national impact assessment requirements and necessary environmental clearances in relation to all proposed industrial facilities and infrastructure. Implementation of the environmental clearance and assessment processes as defined in the Rules by project proponents and consultants is given further practical guidance by the EIA Guidelines for Industries (2021), which indicate how to produce the assessment documents required to support environmental clearance applications. The Noise Pollution Control Rules (2006) replaces the Noise standards set in ECR 1997 therefore replaces the Schedule 4 and Schedule 5 that are mentioned in the Table below.

Table 6-5: Environmental standards specified in the Environment Conservation Rules 1997

ECR Schedule	Standard name
Schedule 2	Standards for Air
Schedule 3	Standards for Water

ECR Schedule	Standard name
Schedule 4*	Standards for Sound
Schedule 5*	Standards for Sound Originating from Motor Vehicles or Mechanized Vessels
Schedule 6	Standards for Emission from Motor Vehicles
Schedule 7	Standards for Emission from Mechanized Vessels
Schedule 8	Standards for Odor
Schedule 9	Standards for Sewage Discharge
Schedule 10	Standards for Waste from Industrial Units or Project Waste
Schedule 11	Standards for Gaseous Emissions from Industries or Projects
Schedule 12	Standards for Sector-Wise Industrial Effluent or Emission

*Replaced by Noise Pollution Control Rules 2006.

Department of Environment's IEE/EIA Guidelines 1997 and 2021

The Government of Bangladesh, with a view to providing for conservation and improvement of environmental quality as well as controlling and mitigating pollution of the environment, enacted the Bangladesh Environment Conservation Act (BECA), 1995, which became effective from June 1, 1995. Section 12 of this Act stipulates that "No industrial unit or project shall be established or undertaken without obtaining environmental clearance from the Director General, Department of Environment (DoE) in the manner prescribed by the rules". Section 12 (4) of the Act (as amended in 2010) provides the guidance to adopt detailed rules on, inter alia, Environmental Impact Assessment (EIA) Report, Preparation of Environmental Management Plan, Judging of Public Opinion, Public Access to Information, Structure and Function of the Environment Clearance Committee, Minimum Necessary Conditions for Clearance, Appeal, etc. within the context of obtaining the Environmental Clearance Certificate. The Environmental Conservation Rules (ECR), 1997, the main subsidiary legislation of the BECA, provides specific rules and procedures for various categories of projects in relation to their approval prior to construction and operation. For projects and activities listed within the Red category, the ECR requires that an Initial Environmental Evaluation (IEE) be first submitted for approval. This should be accompanied with the terms of reference for an EIA, which is to follow the IEE. The EIA study is to be based on terms of reference that have the prior approval of the DoE. Conducting an EIA study and preparation of an EIA report are the responsibilities of a project proponent who may get this done either through in-house resources or through consultants. Further, the responsibility for carrying out review of the EIA report before according clearance, rests on DOE. Right after promulgation of the ECR, 1997, DoE published the EIA Guidelines for Industries in 1997 outlining simpler procedure to be followed for preparing EIA and their review. Now DoE considers it desirable to revise that book of guidelines by taking into account the present environmental status as well as the need for rapid economic development of Bangladesh. These considerations have essentially been kept in view while revising the handbook of general EIA Guidelines for Industries.

Depending upon location, size and severity of pollution loads, projects/activities have been classified in ECR, 1997 into four categories: Green, Orange A, Orange B and Red covering no impacts, minor, medium and severe impacts on important environmental components (IECs) respectively. Red listed industries are those that can cause 'significant adverse' environmental impacts and are, therefore, required to submit both Initial Environmental Examination (IEE) and an EIA report. These industrial projects may obtain an initial Site Clearance on the basis of an IEE based on the DoE's prescribed format, and subsequently submit an EIA report for obtaining Environmental Clearance. The present project is listed as 'RED' and hence an EIA and Environmental Clearance from DOE are mandatory.

The CEIP-2 project will be implemented in an Ecologically Critical Area, hence an EIA will be conducted to obtain Environmental Clearance from DoE.

Bangladesh Wildlife (Conservation & Security) Act (2012); previously known as Bangladesh Wildlife (Preservation) Order (1973)

This is an Act to provide for the conservation and safety of biodiversity, forest and wildlife of the country by repealing the existing law relating to conservation and management of wildlife of Bangladesh.

The Act establishes the Wildlife Conservation and Security Basic Legislation. The Government shall, by notification in the official Gazette, constitute a Board to be called the Wildlife Advisory Board. The duties and functions of the Board constituted under sub-section (1) shall be as follows, namely:

a) a) to review the activities on conservation, development and management of biodiversity, wildlife and forests and to provide necessary directives;
b) b) to prepare an incentive scheme to increasing awareness among people for the conservation of biodiversity, wildlife and forests;
c) d) to approve any proposal submitted to the Government for constitution of technical any other committee, for carrying out the purposes of this Act;
d) e) to approve the annual report with recommendations submitted to the Government.

The Act. deals with Protection of Wild Animals and Plants, as follows:

- No person shall hunt any wild animal without a license or pick, uproot, destroy or collect any plant mentioned in Schedule IV.
- The Government may prohibit hunting of any specified or all wild animals in a specific forest area or throughout Bangladesh for a specific period. Determination of vulnerable, endangered and critically endangered species mentioned in schedule I, II and III and plants mentioned in schedule IV are vulnerable, endangered or critically endangered according to scientific data and internationally acceptable provisions or customs in consultation with the scientific committee.

  Every warden shall register the wild animal or part of wild animals, trophy, uncured trophy or any specified plant mentioned in schedule IV or part or derivatives thereof in the custody or possession of any person in his jurisdiction within 180 (one hundred and eighty) days from the date of commencement of this Act and put appropriate registration mark and intimate the Chief Warden in detail mentioning the number and location of such stock in the form of a report. Chapter IX specifies Offence and Penalty for illegal activity.

The Act includes a revised schedule for the protection of wildlife which now includes many species that were previously not listed as protected. Some of these animals occur within or adjacent to the polders like Gangetic dolphin and smooth-coated otter.

Protection and Conservation of Fish Act (1950) and Amendments (1963, 1970, 1982, 1995, 2000) & Protection and Conservation of Fish Rules (1985) and Amendments (1987)

The Act provides authority to take protective measures for the protection and conservation of all type of fish including all cartilaginous, bony fishes, prawn, shrimp, amphibians, tortoise, turtles, crustacean animals, molluscs, echinoderms and frogs in water body of natural or artificial, open or closed, flowing or stagnant (such as river, haor, baor, beel, floodplain, canal etc.) where activities for growing fish, or for conservation, development, demonstration, breeding, exploitation or disposal of fish or of living organisms related to such activities are undertaken. Under this Act, catching and selling of certain fish species as well as the use of specific types of nets can be prohibited for certain periods. Prohibiting the erection of fixed nets (net, cage, trap or other contrivance for catching fish, fixed in the earth or made stationary in any other way) in rivers and canals; prohibiting the destruction of fish through the use of poison or explosives; and licensing and regulations around frogs. There has provision for penalty for violating the clauses of the Act. The Act. recognition that fish fry collection from nature may result in long term ecological destruction. So, government prohibited the collection of fry or post larvae of fish, shrimp and prawns of any kind, in any form and in any way, in estuary and coastal waters, diverting or blocking water flow that hinders fish movement/migration in 2000. The Rules contain a provision for conservation by empowering the government to declare any fish reserve in which fishing and any other detrimental activities can be prohibited.

The Embankment and Drainage Act (1953)

The East Bengal Act No. 1, 1953 was amended in 1953 which has been adapted by the People Republic of Bangladesh, by the Bangladesh Order (adaptation of Existing Laws), 1972 (President's Order No. 48 of 1972). The Act consolidates the laws relating to embankments and drainage, providing provision for the construction, maintenance, management, removal and control of embankments and water courses to improve the drainage of lands and for their protection from floods, erosion or other damage by water. The specific Sections and Articles relevant to the Project are mentioned below:

- Section 4 (1) of the Act states that the embankment, water-course, and tow-path, earth, pathways, gates, berms and hedges of the embankments shall vest in the Government of the Authority (BWDB).
- Section 56 (1) states that, person will be subject to penalty (500 taka or imprisonment… if he erects, or causes of wilfully permits to be erected, any new embankment, or any existing embankment, or obstructs of diverts, or causes or wilfully permits to be obstructed or diverted, any water course.
- Section 15 allows for the engineer (engineer in charge of Divisional level BWDB) for constructing new embankment or enlarging, lengthening or repairing existing embankments.

- The other sections of the Act give powers and access to the Government or Authority or Engineers to commence necessary Project activities, for land acquisition (through the Deputy Commissioner), and site clearing activities including removal of trees or houses (if necessary).

After implementation of CEIP-2, the Act will be applicable to protect the project's components.

National Disaster Management Act (2012)

The National Disaster Management Act forms the legal basis for thecoordination of activities that involve disaster management, setting policies and formulation of rules and to build up infrastructure for effective disaster management to fight all types of disasters. It also described the national disaster management principles and planning by reducing the overall vulnerability from different impacts of disaster through risk reduction activities; conduct of humanitarian assistance programs efficiently to enhance the capacity of poor and disadvantaged as well as strengthening and coordinating programs undertaken by various government and NGOs related to disaster risk reduction and emergency response. The Department of Disaster Management (DDM) is responsible for the Disaster Management Act and to mandate the implementation of the objectives.

Open Place, Park & Wetland Conservation Act (2000) and Amendments (2002)

The Act was published in the Bangladesh Gazette, extra-ordinary issue of 18-9-2000. The Act includes the country's municipal areas, playgrounds, open spaces, parks and natural water reservoirs (= wetlands), with an extra focus on those located in metropolitan cities, divisional towns and district town's municipal areas. The Act stresses for the conservation of wetlands and open spaces. According to the Act natural water reservoirs or wetlands include rivers, canals, beels, ponds, stream, fountains indicated in the Master Plan by government gazette or government and flowing water and land that conserves/holds rain water are also included. The Act imposes restrictions on changing the class of open space, park and play ground.

A3.3 Multilateral environmental agreements

The CEIP project intervention Legislative bases for environmental assessment in Bangladesh are the Environmental Conservation Act 1995 (ECA'95) and the Environmental Conservation Rules 1997 (ECR'97). Department of Environment (DOE), under the Ministry of Environment and Forest (MOEF), is the regulatory body responsible for enforcing the ECA'95 and ECR'97. According to the Rule 7 (1) of the Environmental Conservation Rules 1997; for the purpose of issuance of Environmental Clearance Certificate (ECC), all industrial units or projects, in consideration of their site and impact on the environment, will be classified into the four categories and they are: Category I (**GREEN**), Category II (**Orange-A**), Category III (**Orange B**) and Category IV (**RED**). According to the categorization, all construction/reconstruction/expansion of flood control dikes etc. falls under Red Category. Therefore, Project intervention in polder 35/1 falls under the 'Red' category.

It is the responsibility of the proponent to conduct an EIA of development proposal, the responsibility to review EIAs for the purpose of issuing Environmental Clearance Certificate (**ECC**) rests on DOE. The procedures for "Red" Category include submission of:

- An Initial Environmental Examination (**IEE**)
- An Environmental Impact Assessment (**EIA**)
- An Environmental Management Plan (**EMP**)

Environment clearance must be obtained by the respective implementing agency or project proponent (private sector) from Department of Environment (DOE). The environmental clearance procedure for Red Category projects can be summarized as follows:

Application to DOE →Obtaining Site Clearance →Applying for Environmental Clearance →Obtaining Environmental Clearance → Clearance Subject to annual renewal

Table 01: Policies relevant to the Environment

Policy	Key Features	Applicability
The National Forest Policy, 1994	▪ Afforestation of 20% of the land ▪ Biodiversity of the existing degraded forests ▪ Strengthening of the agricultural sector ▪ Control of Global warming, desertification ▪ Control of trade in wild birds and animals ▪ Prevention of illegal occupation of the forested land, tree felling, and hunting of wild animals	Applicable when considering global warming and the protection of forests
National Land-use Policy, 2001	▪ Deals with several lands use including agriculture (crop production, fishery, and livestock), housing, forestry, industrialization, railways and roads, tea, and rubber ▪ Identifies land-use constraints in all these sectors	Applicable as land-use changes from saltpans to industrial land
The National Water Policy, 1999	▪ Protection, restoration, and enhancement of water resources ▪ Protection of water quality, including strengthening regulations concerning agrochemicals and industrial effluent ▪ Sanitation and potable water ▪ Fish and fisheries ▪ Participation of local communities in all water sector development.	Applicable for the preservation of surface water bodies, and flood plains in the surrounding area of the Project.
The Energy Policy, 1996	▪ Provides for utilization of energy for sustainable economic growth, supply to different zones of the country, development of the indigenous energy source, and environmentally sound sustainable energy development programs	Applicable. The project is for the development of energy generation.

Policy	Key Features	Applicability
	▪ Highlights the importance of EIA's for any new energy development project	
The Power Policy, 1995	Is an integral part of the Energy Policy and deals with a policy statement on demand forecast, long term planning and project implementation, investment terms, fuels and technologies, load management, institutional issues, private sector participation, technology transfer, and research program, environmental policy, and legal issues.	Applicable
Industrial Policy, 1999	Deals with industrial development, direct foreign investments, investment by the public and private sector, introduction of new appropriate technology, women's participation, infrastructure development, and environmentally sound industrial development	Applicable as the Project is a private sector, industrial development

The detail DoE clearance procedure will be presented in the Environmental Management Framework. The project intervention for polders falls under Category A project, due to the complexity of environmental issues associated with project activities involving major civil works by reconstruction and rehabilitation of the coastal embankment to protect against tidal flooding and storm surges. Since the coastal area is of high ecological sensitivity and vulnerability certain negative environmental impacts may occur during the implementation and operational phase on overall polder system. There may be localized impact on the natural habitats especially on the fish spawning site and protected areas, during the implementation of the civil works.

The environment assessment (OP/BP 4.01), natural habitats (OP/BP 4.04) and forests (OP/BP 4.36) policy have been triggered for the proposed operation. Although no direct impacts on physical cultural resources are expected, screening mechanism incorporated into the EA process will identify subprojects with archaeological, paleontological, historical, religious, or unique natural values, chance and find procedure will be followed to address physical cultural resources (OP/BP 4.11). The interventions under the proposed Project may result in an increased availability of irrigation water through cleaning and excavation of water courses in the Polder. This increased water availability can in turn potentially increase the usage of chemical fertilizers and pesticides. During regular environment monitoring during operational phase if the water and soil pollution is observed, the proponent will be responsible for preparing Pest Management Plan with prior approval from Bank. No Project activities are to be carried out in the rivers except some transportation. However, this will not have any effect whatsoever on the upper riparian water usage or availability.

Appendix 4 List of 123 Polders

From the field office Polder 6-8 & 6-8 Ext. has been shown as one polder. So, excluding CEIP-1 polders, nos. of polders remain for improvement are 121 in place of 122. Construction of a new polder is going on (sl. 122) and including it, nos. of polders become 122. Some of the polders which were rehabilitated under ECRRP were also partially damaged by cyclones of last three years. Those may be considered for CEIP-2.

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
1	1	Assasuni, Debhata&Satkhira	28381	21143	21143	6500	0	96.96	25	3	0	
2	2 & 2 Ext.	Assasuni, Satkhira	11290	11000	6547	4495	0	62.95	25	0	65.22	
3	3	Debhata, Kaliganj	22267	17004	11504	5500	0	64.40	30	3	0	
4	4	Assasuni	10500	8400	3360	5040	0	80.00	26	0	70.00	
5	5	Kaliganj, Shymnagar	55061	48583	34008	14575	0	192	40	2	0	
6	6-8 & 6-8 Ext.	Assasuni, Satkhira, Tala	15450	14700	11760	2940	0	66.33	28	0	182.00	At field level, there has no data separately
7	7/1	Assasuni,Shamnagar	3887	2700	1866	834	0	34.21	9	0	28.50	
8	7/2	Assasuni.	10486	8390	5870	2520	0	59.59	16	0	45.10	
9	9	Paikgacha.	1255	1247	680	567	0	8	3	0	10.5	
10	12-Oct	Koyara, Paikgacha	16315	12715	6870	5845	0	67	15	0	19	
11	13-14/2	Koyara	17854	14280	12850	1430	0	93	16	0	0	
12	18-19	Paikgacha	3380	3300	2200	2800	0	32	4	0	3	
13	20,20/1	Paikgacha	1600	1500	1470	1250	0	23	10	4	1.5	
14	21	Paikgacha	1417	1215	1215	880	0	17	3	0	6.5	
15	22	Paikgacha	1630	1417	1417	0	0	20	4	48	0	
16	24	Abhaynagar, Dumuria, Keshobpur, Manarampur	28340	22600	22600	0	0	26	11	0	0	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
17	25	Dumuria Fultala	17400	13900	13900	0	0	46	13	0	50	
18	26	Dumuria	2696	2100	2100	0	0	29	4	0	18	
19	27/1, 27/2	Dumuria	4260	3400	3400	0	0	45	9	0	27.2	
20	28/1	Dumuria	5600	4500	4500	0	0	23	9	0	12	
21	28/2	Batiaghata	2590	2000	2000	0	0	20	4	0	5.1	
22	29	Batiaghata, Dumuria	8218	6570	6570	0	0	49	11	81	39	
23	30	Batiaghata	6396	4048	4048	0	0	40	21	3	37.3	
24	31	Dacope	7288	6500	6072	4858	0	47	24	0	6.5	
25	31 Part	Batiaghata	4848	4048	4048	0	0	29.5	9	2	29	
26	34/1	Bagerhat Sadar	2212	1660	1660	-	-	10.46	3	0	30.88	
27	36/1	Bagerhat, Chitalmari, Fakirhat, Mollahat, Rupsa	40343	28290	28290	-	-	95.00	36	16	270.31	Rehabilitation of 36/1 project is goging on
28	39/1A	Pathargatha	11740	9500	9500	0	0	58	11	37	104	Rehabilited under ECRRP Programme
29	39/1B	Matbaria	13100	10480	10480	0	0	74.18	16	12	96	Rehabilited under ECRRP Programme
30	39/2A	Bamna	5080	4060	4060	0	0	30.6	5	44	99	Rehabilited under ECRRP Programme
31	40/1	Pathargatha	2105	1684	1684	0	0	23.45	4	24	35	Rehabilited under ECRRP Programme
32	41/2	BargunaSadar	3644	2550	2550	0	0	39	7	15	98	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
33	41/3	BargunaSadar	1053	850	850	0	0	19.82	3	14	25	
34	41/4	BargunaSadar	1741	1393	1393	0	0	18.6	6	12	60	Rehabilitated under ECRRP Programme
35	41/5	BargunaSadar	3880	3000	3000	0	0	50	11	29	90	Rehabilitated under ECRRP Programme
36	41/6A	BargunaSadar	3850	3000	3000	0	0	33.17	11	6	68	Rehabilitated under ECRRP Programme
37	41/6B	BargunaSadar	7280	5600	5600	0	0	44.4	8	5	47	Rehabilitated under ECRRP Programme
38	41/7	Mirzaganj	6984	4500	4500	0	0	47.48	9	7	85	
39	41/7A	Betagi	6220	5300	5300	0	0	39	5	7	47.7	
40	41/7B	Betagi	5510	5227	5227	0	0	28.66	11	30	100	Rehabilitated under ECRRP Programme
41	Bibichini	Betagi	4600	3680	3680	0	0	26.7	2	5	37.9	
42	42	BargunaSadar	2794	2235	2235	0	0	28.11	7	14	80	Rehabilitated under ECRRP Programme
43	43/1	Amtali	16275	8500	8500	0	0	86	13	24	98	Rehabilitated under ECRRP Programme
44	43/1A	Amtali	3000	2200	2200	0	0	27	6	2	58.5	
45	43/1B	Kalapara	3000	2500	2500	0	0	21	7	6	25	
46	43/2A	Patuakhali	5182	3887	3887	0	0	40	5	38	76	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
47	43/2B	Galachipa, Amtai, Patuakhali	5460	4000	4000	0	0	41.5	6	24	82	
48	43/2D	Patuakhali	6500	4875	4875	0	0	43	17	58	110.4	
49	43/2E	Patuakhali	1650	1300	1300	0	0	20.26	7	40	42	
50	Dumki Laukathi	Patuakhali	8770	7717	7717	0	0	50.5	14	10	49	
51	Itbaria Labukhali	Patuakhali	3613	3500	3500	0	0	35	7	8	32	
52	Mirzagonj, Rampura	Mirzagonj, Patuakhali	5155	4950	4950	0	0	45.6	7	6	50	
53	43/2F	Amtali	4453	3500	3500	0	0	32.1	13	55	53	
54	44	Amtali, Taltoli,Kalapara	17500	12500	12500	0	0	81.56	16	14	108.5	Rehabilited under ECRRP Programme
55	45	Taltoli	4089	3200	3200	0	0	26.56	4	10	102.5	Rehabilited under ECRRP Programme
56	46	Kalapara	4697	3757	3757	0	0	40	12	4	37	Rehabilited under ECRRP Programme
57	47/1	Kalapara	2478	2065	2065	0	0	22	7	5	24.5	Rehabilited under ECRRP Programme
58	47/3	Kalapara	2025	1660	1660	0	0	19.7	5	10	25.3	
59	47/4	Kalapara	6600	5600	5600	0	0	59	26	1	65	Rehabilited under ECRRP Programme
60	47/5	Kalapara	7500	6000	6000	0	0	33	14	0	75.8	Rehabilited under ECRRP Programme
61	50-51	Rangabali	6935	5895	5895	0	0	48.8	7	0	17	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
62	52-53A	Rangabali	3663	2900	2900	0	0	24.65	3	0	22.5	Rehabilited under ECRRP Programme
63	52-53B	Rangabali	4064	3250	3250	0	0	32.2	10	0	33	Rehabilited under ECRRP Programme
64	54	Kalapara, Amtoli, Galachipa	13954	10256	10256	0	0	59.33	10	0	30	Rehabilited under ECRRP Programme
65	55/1	Galachipa	10325	7230	7230	0	0	46.16	10	14	125	Rehabilited under ECRRP Programme
66	55/2A	Patuakhali, Galachipa,	7166	5000	5000	0	0	41	11	13	72	
67	55/2B	Galachipa	2600	2080	2080	0	0	30.2	6	8	45.5	Rehabilited under ECRRP Programme
68	55/2C	Galachipa	6275	5020	5020	0	0	47.54	7	29	74	Rehabilited under ECRRP Programme
69	55/2D	Patuakhali, Dashmina	8540	6600	0	0	0	64.5	9	6	75	Rehabilited under ECRRP Programme
70	55/2E	Patuakhali, Dashmina, Bouphol	10535	8955	8955	0	0	86	22	19	118	
71	55/3	Galachipa, Charfassion	9845	7385	7385	0	0	69.25	9	20	59.7	Rehabilited under ECRRP Programme
72	55/4	Rangabali	5142	4100	4100	0	0	32.53	4	15	25.5	Rehabilited under ECRRP Programme

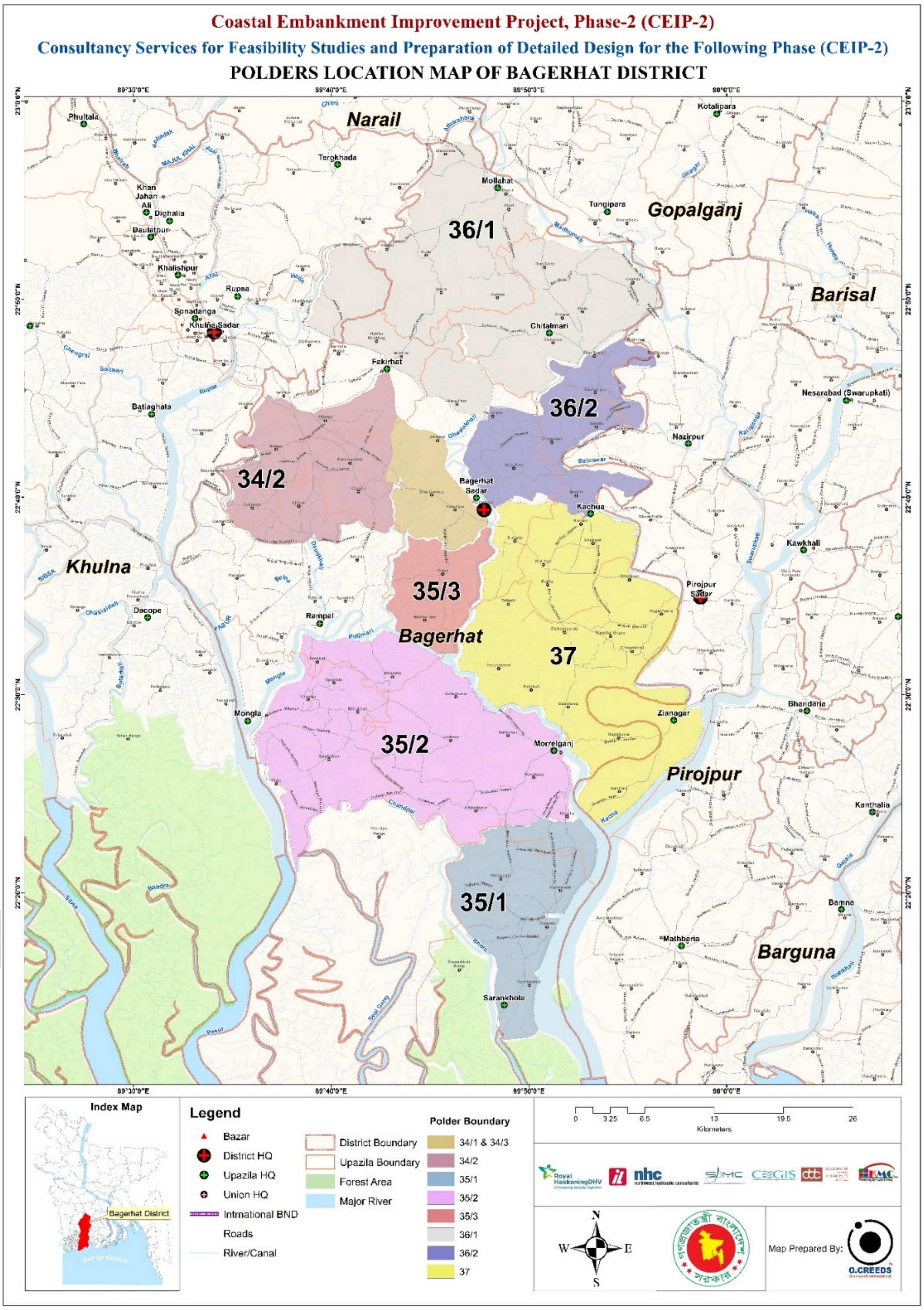
Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
73	Satla Bagda-1	Agailjhara,wazirpur.	3860	3281	3281	0	0	20	8	0	67	
74	Satla Bagda-2	Uzirpur, Agailjhara	12794	8968	8968	3000	0	46.5	5	10	98	
75	Satla Bagda-3	Uzirpur, Agailjhara	1600	1397	1397	500	0	19	3	0	48	
76	56-57	Bhola Sadar, Borhanuddin, Daulatkhan Tajumuddin, Lalmohon, Charfession	123800	97792	97792	0	0	250	23	13	80.5	
77	58/1	Manpura	4200	3800	3800	0	0	34	7	0	0	
78	58/2	Manpura	4312	3924	3924	0	0	27.73	5	0	0	
79	58/3	Manpura	1308	1075	1075	0	0	17	2	0	0	
80	59/1A	Companiganj, Shudharam	15506	12320	12320	0	0	35.9	26	0	125.30	
81	59/1B	Shudharam	18218	7500	7500	0	0	40.25	13	0	251.50	
82	59/2	Ramgati & Kamalnagar, Lakshmipur.	23755	15941	15941	-	-	96.56	15	-	-	6 Functional & 5 Non-Functional
83	59/2 Ext.	Sadar, Lakshmipur & kamalnagar Lakshmipur.	4000	-	-	-	-	21.87	3	-	-	2 Functional & 1 Non-Functional
84	59/3B	Shudharam	31376	23532	23532	0	0	70	9	0	280.58	
85	59/3C	Companigonj	16200	12150	12150	0	0	42.26	7	0	62.60	
86	60	Sonagazi	24306	18230	18230	0	0	26	10	2	39.87	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
87	61/1	Sitakunda	7660	5300	5300	0	0	26.77	23	0	76.82	
88	61/2	Mirsharai	17000	3300	3300	0	0	21.5	11	0	84.25	
89	62	Bandar, Patenga & Pahartali	5600	2554	2554	0	0	21.70	14	0	18.35	
90	63/1A	Anowara	7500	6000	5940	0	0	48.28	27	0	60.70	
91	63/1B	Anowara	7300	4950	4950	0	60	33.20	16	0	48.85	
92	64/1A	Banshkhali	5600	4200	4200	-	-	59.96	24	-	35.61	
93	64/1B	Banshkhali	8000	6000	6000	-	-	55.68	33	-	78.14	
94	64/1C	Banshkhali	1800	1350	1350	-	-	23.43	8	-	14.71	
95	64/2A	Banshkhali, Pekua, Chakoria	3750	2945	2905	0	608	34.45	17	0	40.18	P-64/2A consists of 4 sub-polders
96	64/2B	Pekua, Chakoria	7736	5736	5431	272	33	95.67	37	0	72.55	P-64/2B consists of 5 sub-polders
97	65	Chakoria	6649	5069	4698	100	271	46.7	28	4	66.91	
98	65/A	Chakoria	806	689	540	0	149	8.85	3	0	14.6	
99	65/A1	Chakoria	2280	1824	1824	0	0	15.5	8	12	15	
100	65/A3	Chakoria	604	540	540	0	195	9.62	5	12	11	
101	66/1	Cox's Bazar Sadar	4930	3160	2765	395	0	19.9	9	1	29.2	

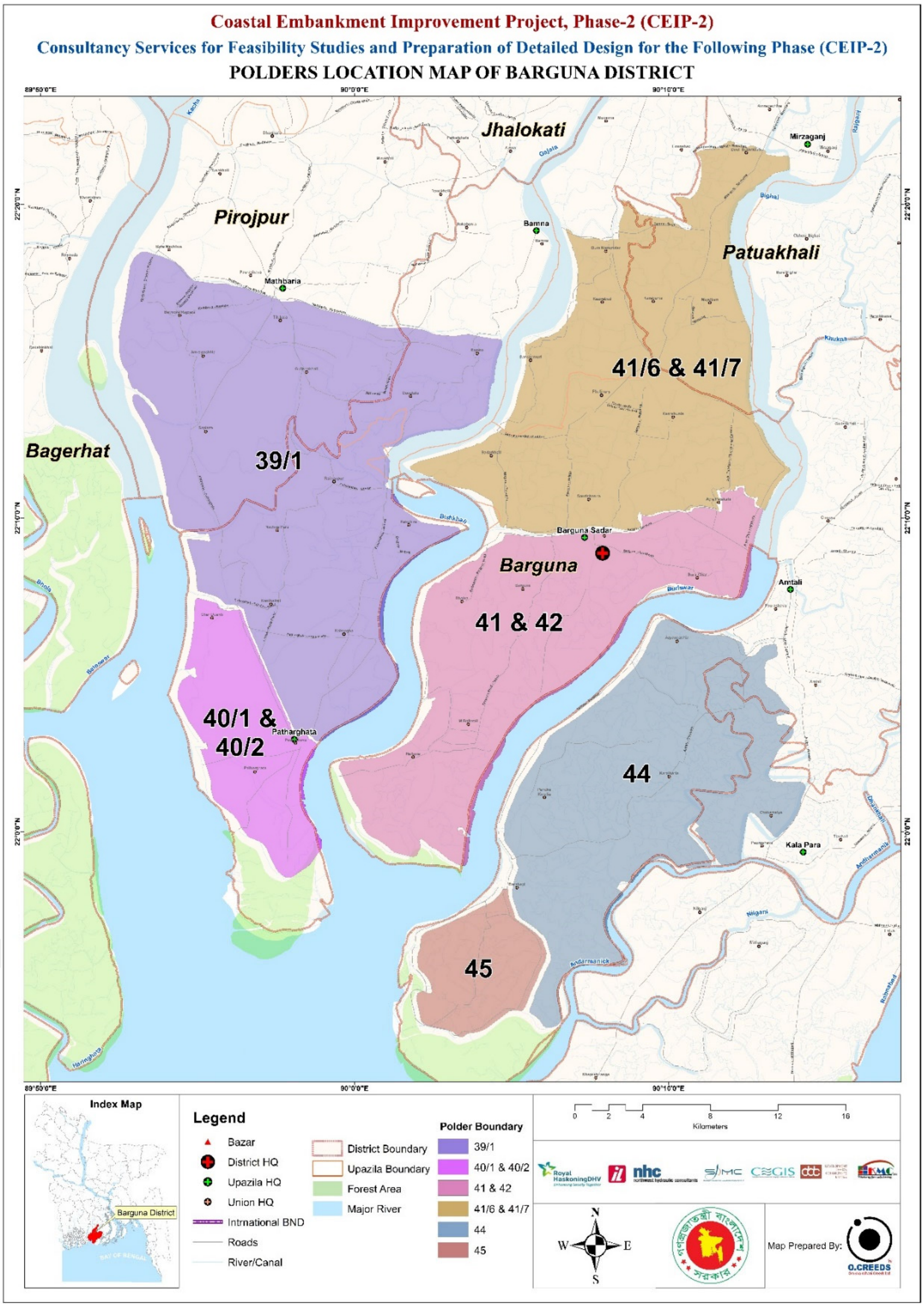
Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
102	66/2	Cox's Bazar sadar & Ramu	2400	1845	1845	70	593	19.5	17	19	27.9	
103	66/3	Cox's Bazar sadar	4727	3449	3309	70	70	52.425	30	51	41.97	
104	66/4	Chakoria	3778	3340	3296	142	340	32.43	15	15	40.1	
105	67	Teknaf	1607	1344	1260	120	143	12.7	14	5	50	
106	67/A	Teknaf&Ukhiya	1500	1375	1215	135	25	12.9	2	0	20	
107	67/B	Teknaf	900	750	740	10	0	8.05	6	3	25	
108	68	Teknaf	3500	3350	3000	300	50	24.95	8	13	41	
109	69/NE	Moheshkhali	2226	1277	1188	0	89	15.5	6	0	20.1	
110	69/P1	Moheshkhali	3360	2689	2500	89	100	28.37	12	3	33.5	P-69/P1 includes new area of P-69/Ext.
111	70	Moheshkhali	3025	1068	370	686	12	31.32	18	0	35.62	
112	71	Kutubdia	5116	4159	3233	817	686	40.12	9	0	36.4	
113	72	Sandwip	22700	17000	16800	0	109	58	27	0	69	In CTG-2 Division
114	73/1(A&B)	Hatiya	15334	12267	12267	0	0	68.305	19	0	135.64	
115	73/2	Hatiya	11134	8296	8296	0	0	54.10	27	0	84.67	
116	Boyerchar	Hatiya	8250	6600	6600	0	0	27.78	3	0	33	
117	Char Bagardona-1	Subornachar	1350	1080	1080	0	0	28.6	1	0	25.57	

Sl. No.	Polder No./ Polder Name	Location Name of Thana	Gross Protected Area (HA)	Cultivable Land				Main Project Feature				Remarks
				Total (HA)	Crop (HA)	Shrimp (HA)	Salt (HA)	Embkt. (Km)	Regulator (No)	Flushing Inlet (No)	Drainage Channel (Km)	
118	Char Bagardona-2	Subornachar	1200	960	960	0	0	20.36	1	0	41.9	
119	Charmojid	Subornachar	850	680	680	0	0	8.5	1	0	69	
120	Kumiriya to Sonaichari Flood Control Project	Sitakunda	1610	1335	1335	0	0	4.5	6	0	30.25	
121	CDSP-II MAA	Sonagazi	1981	1585	1585	0	0	11.5	2	0	13.03	
122	Kukri-Mukri	Charfession, Bhola	1119	920	920	0	0	14.1	6	6	0	Flood Control Embankment was constructed during FY 2014-2015 under CCTF fund. Drainage structure is under construction under an ADP Project, implemented by Bhola O&M Division-2
		A. Sub-Total=	**1077653**	**819547**	**763475**	**66740**	**3533**	**5085.8**	**1447**	**1031**	**6434.78**	

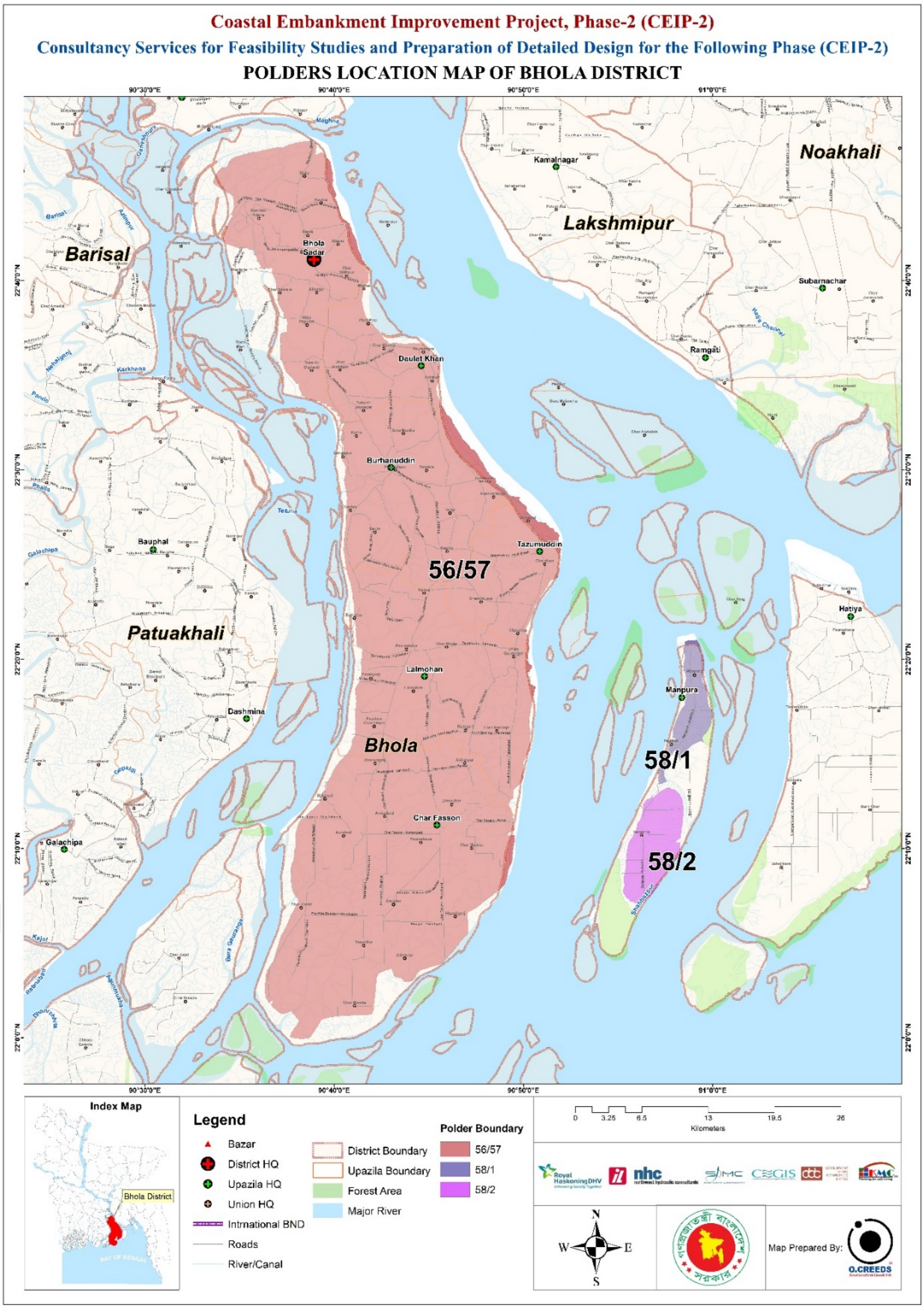
Appendix 5 Polder maps (District wise distribution)



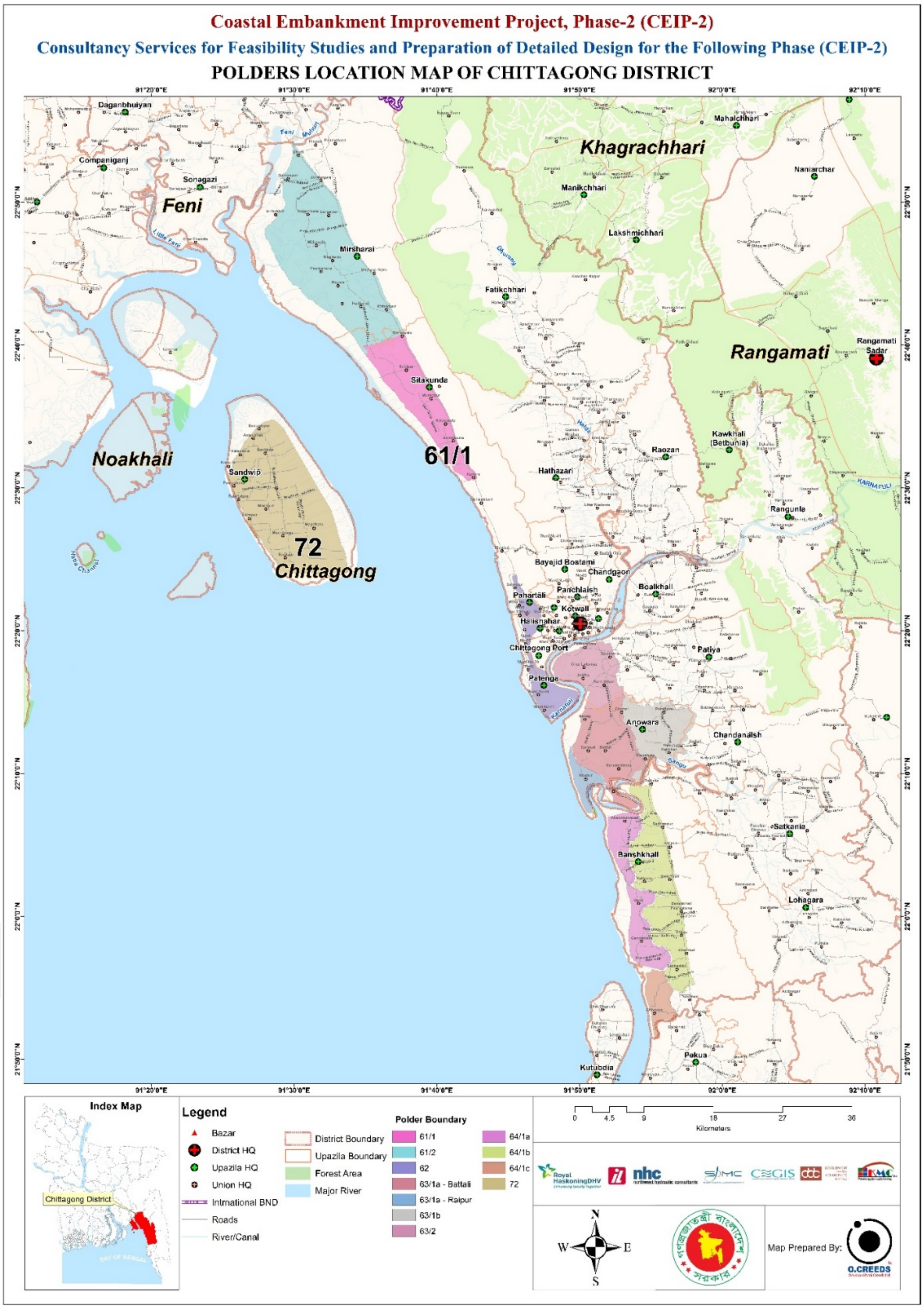
Figure_Apx 2: *Polders in Bagerhat District*



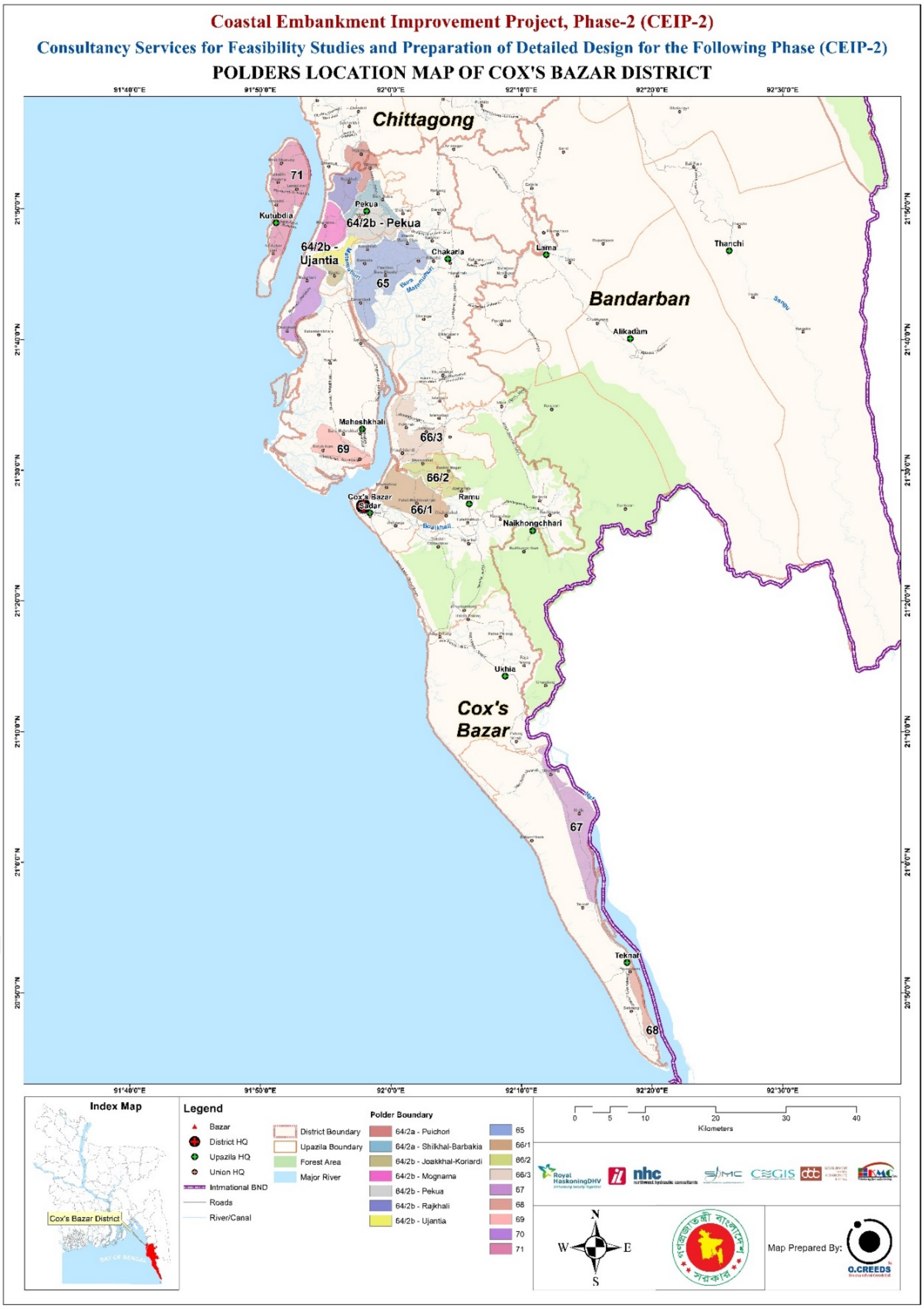
Figure_Apx 3: *Polders in Barguna District*



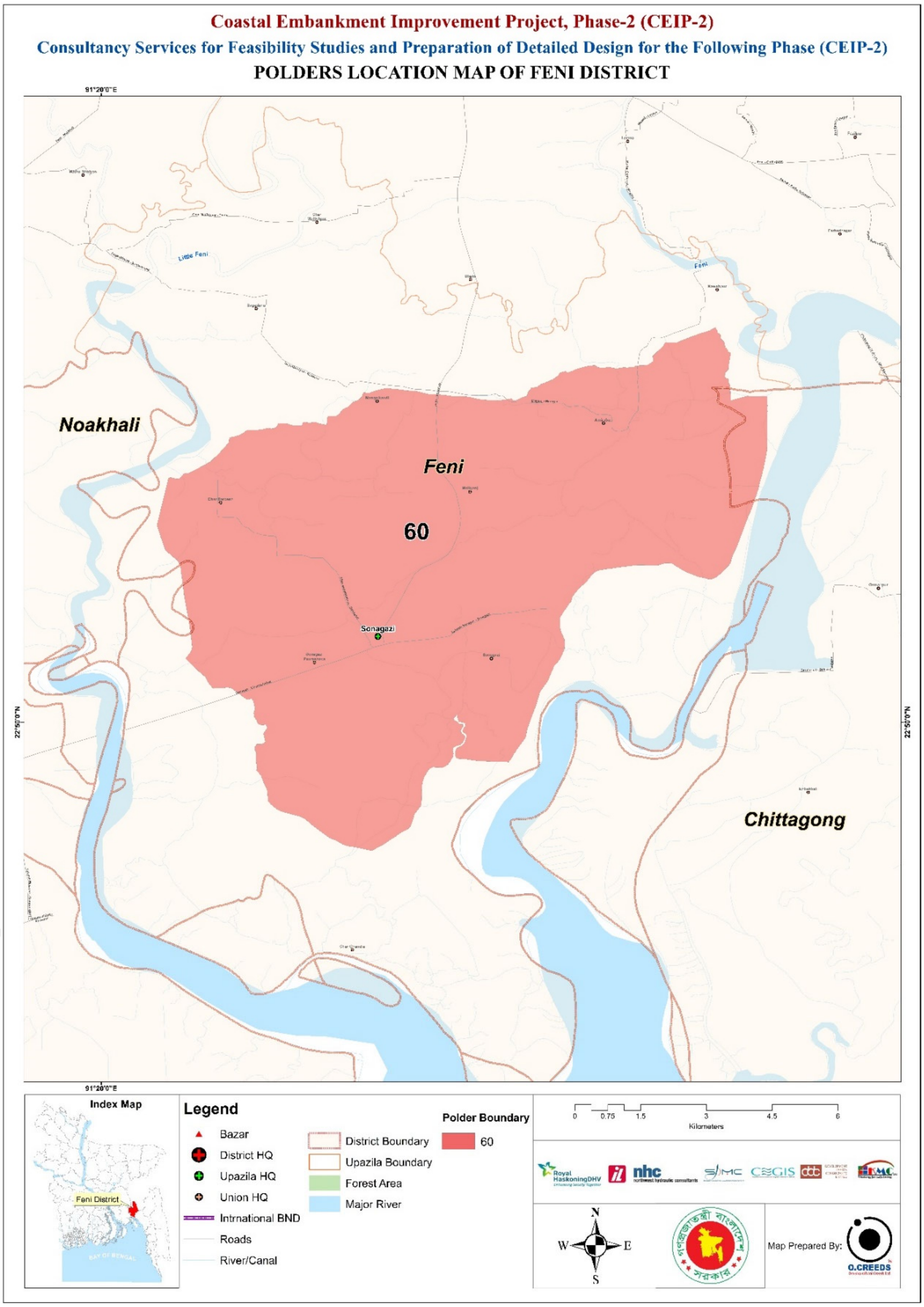
Figure_Apx 4: Polders in Bhola District



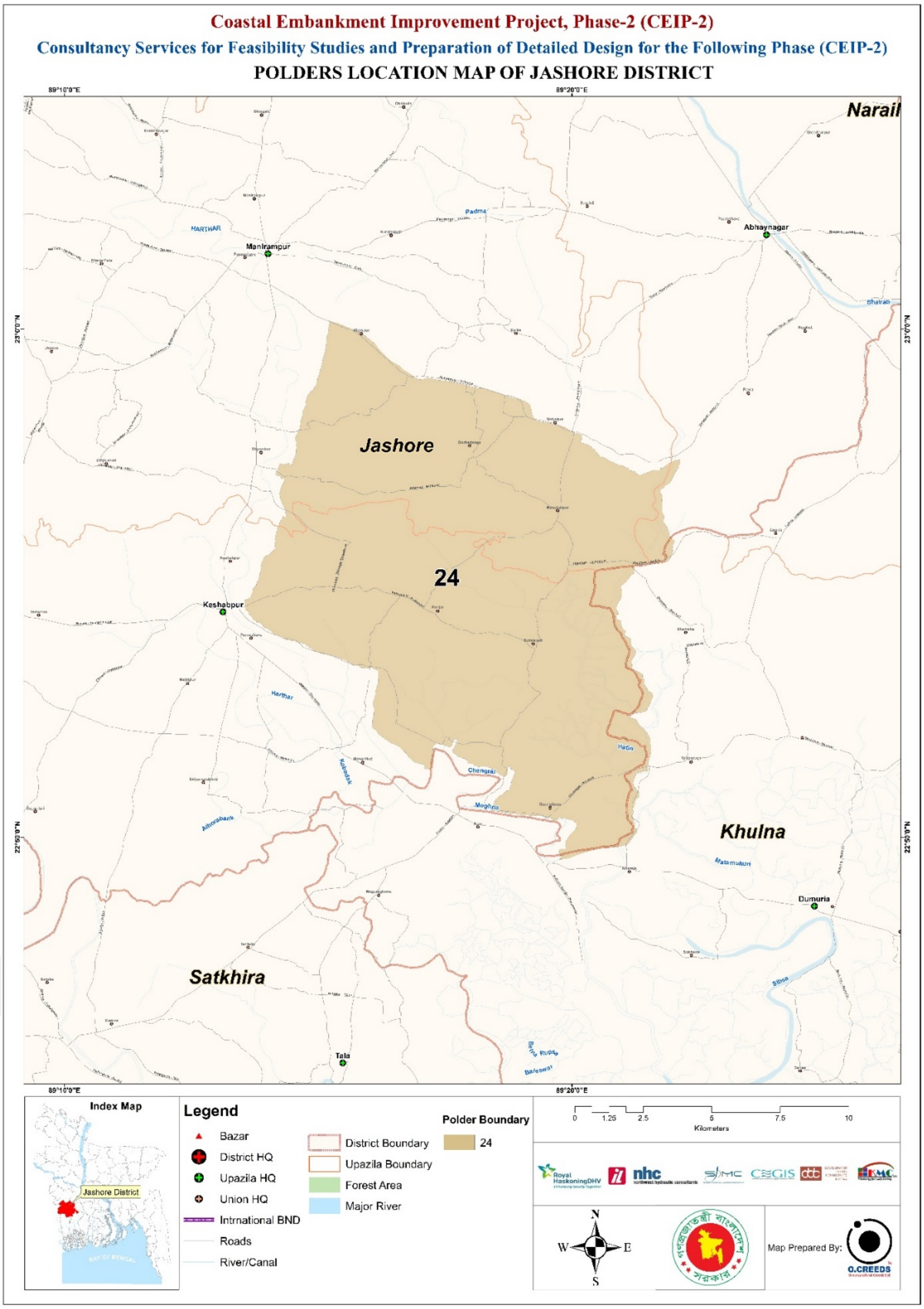
Figure_Apx 5: Polders in Chittagong District



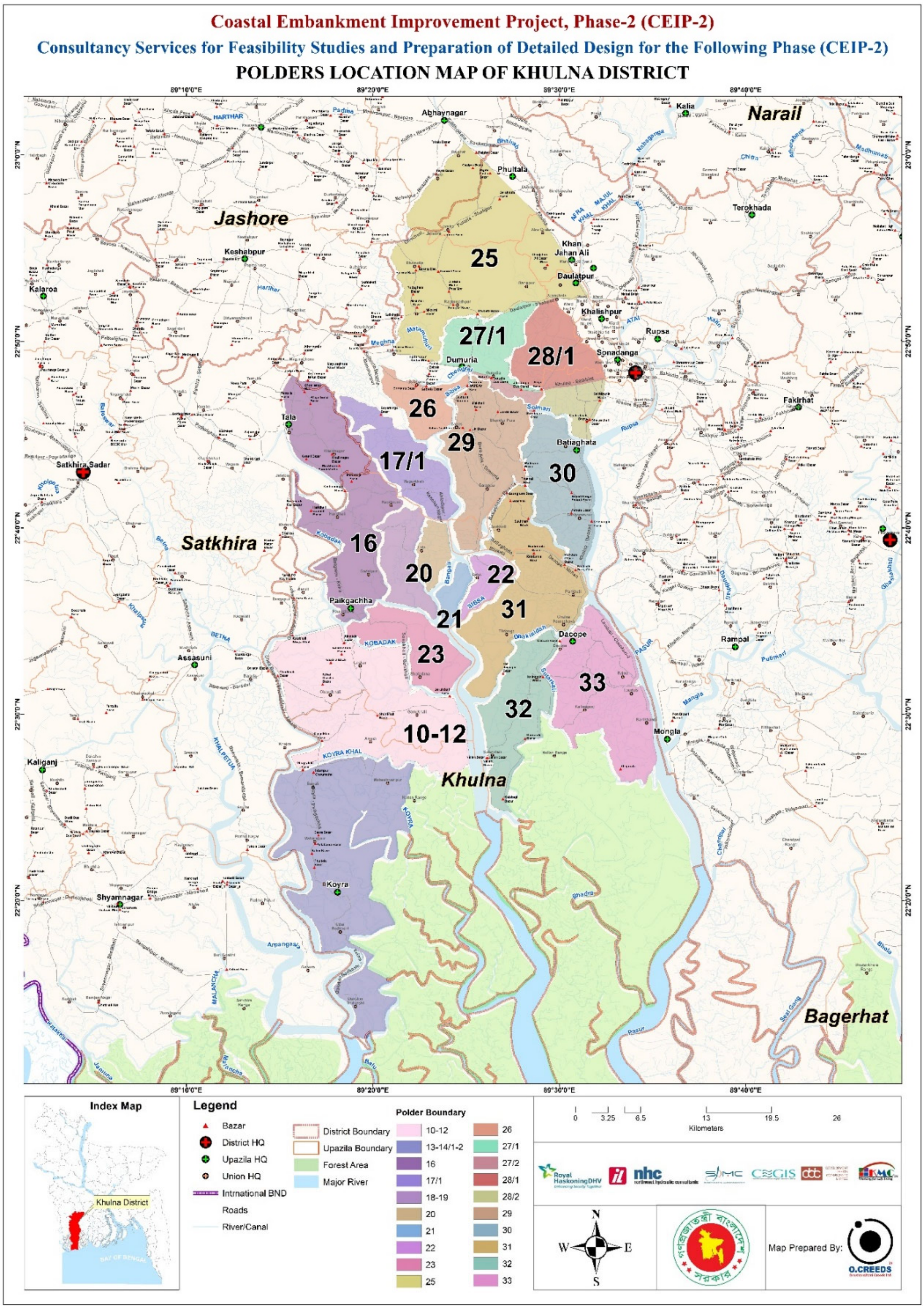
Figure_Apx 6: Polders in Cox's Bazar District



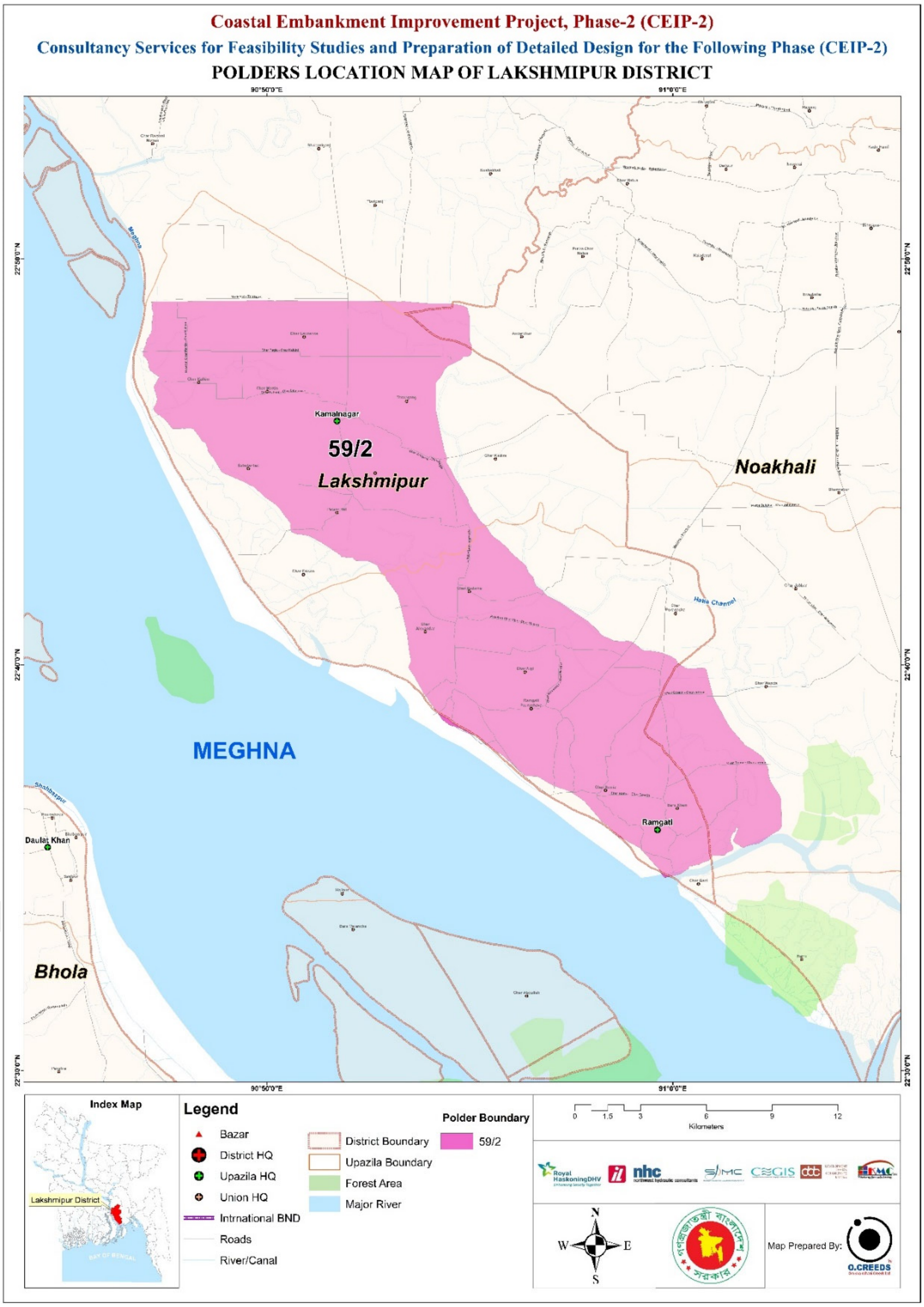
Figure_Apx 7: Polders in Feni District



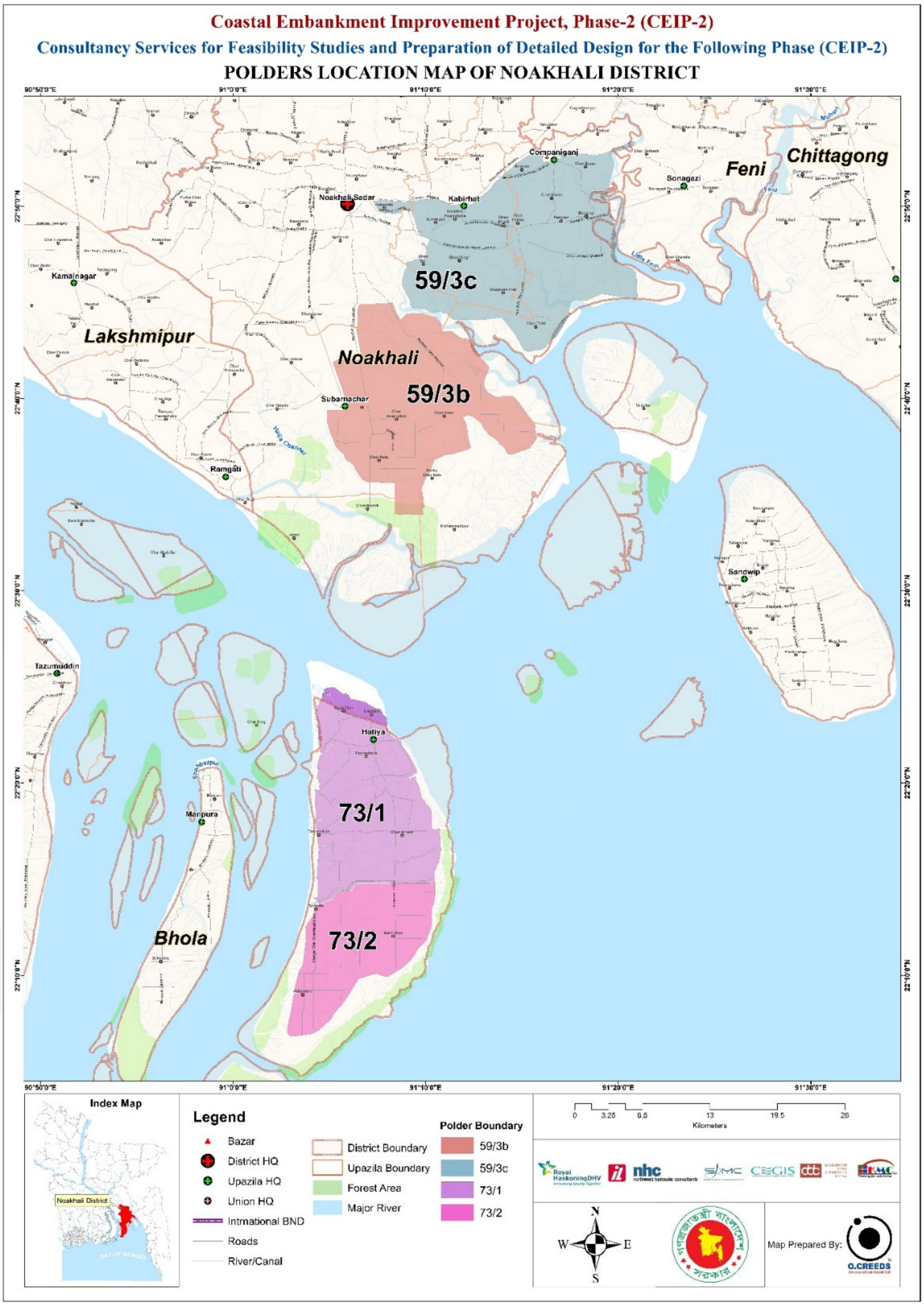
Figure_Apx 8: Polders in Jashore District



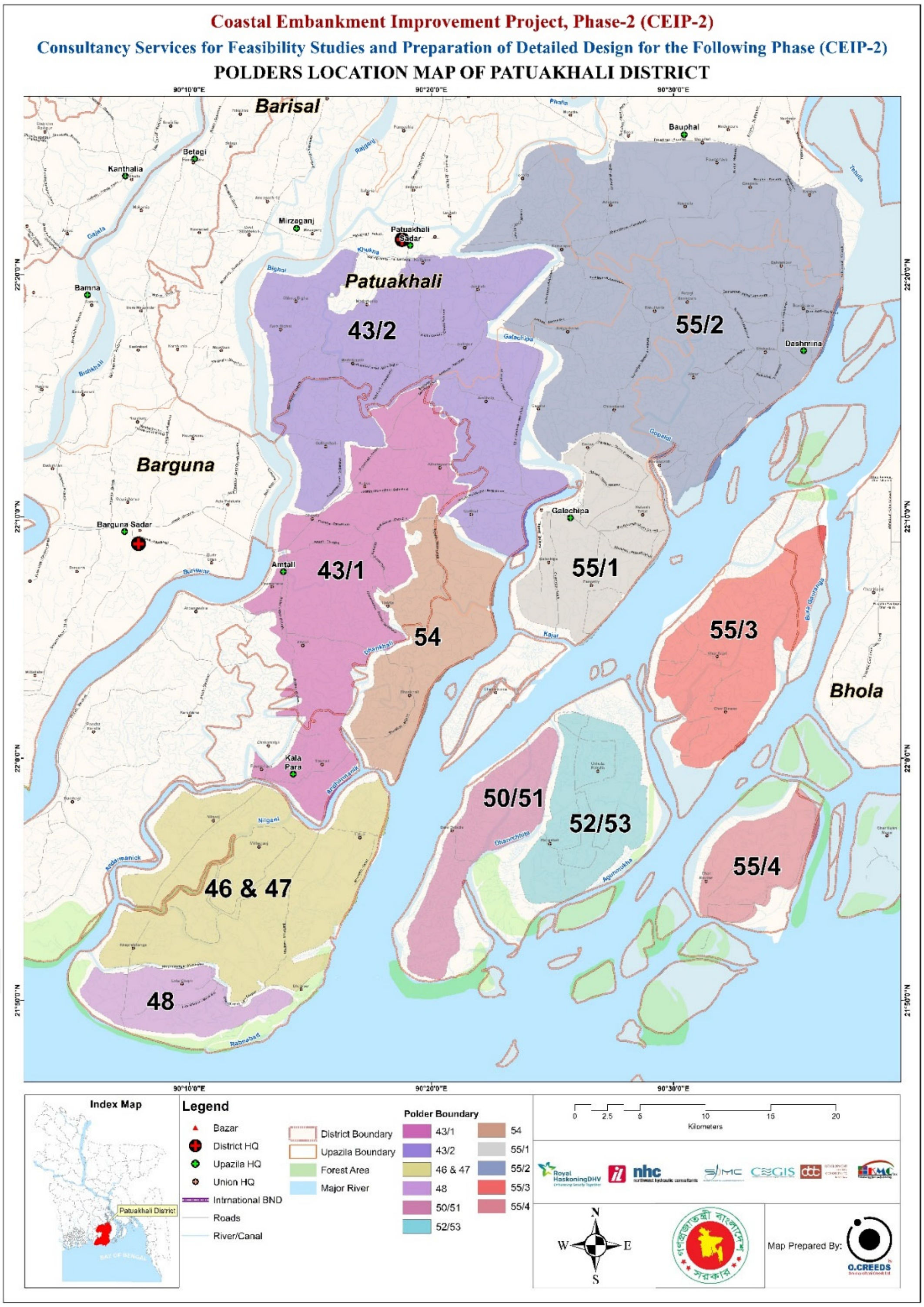
Figure_Apx 9: Polders in Khulna District



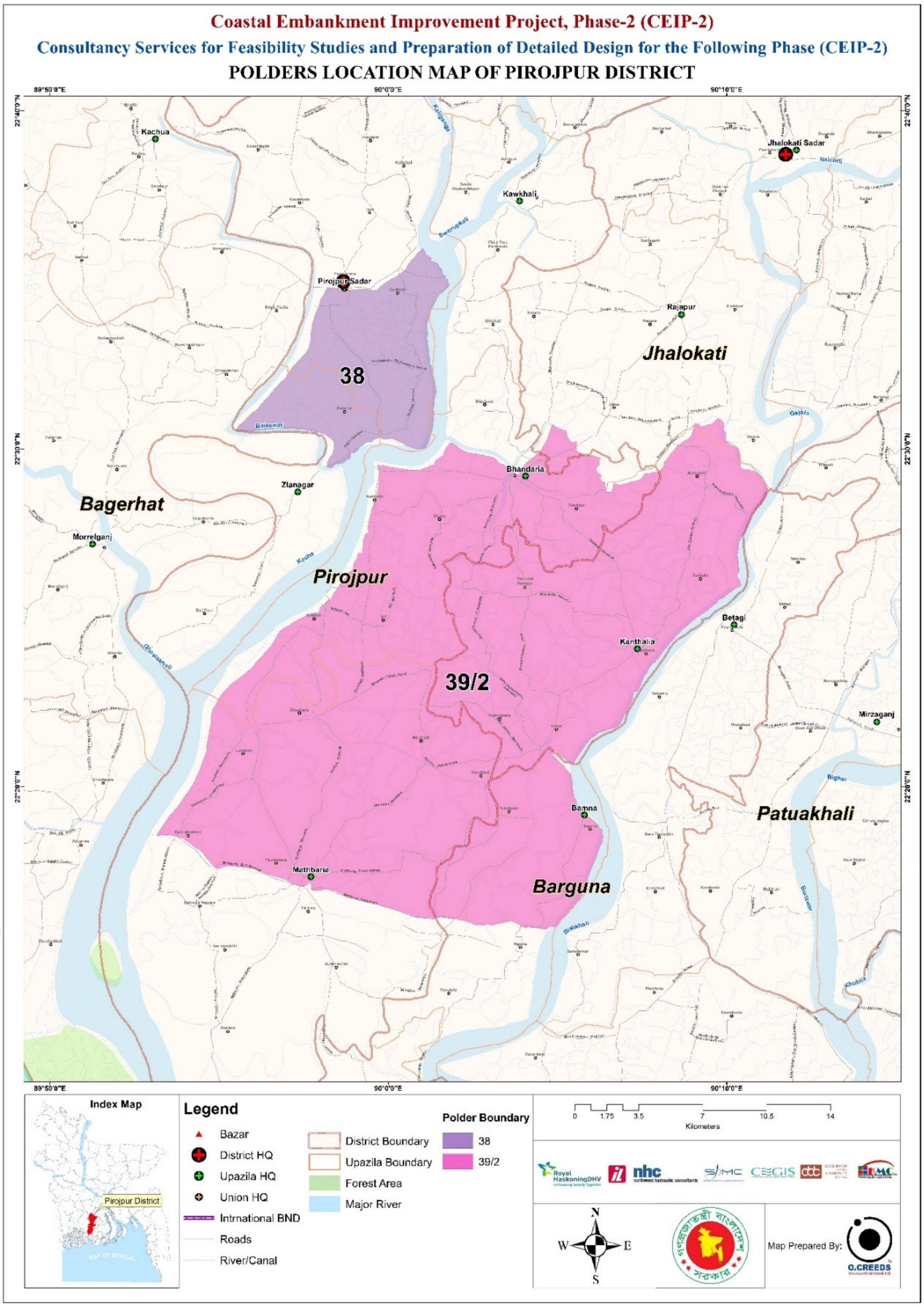
Figure_Apx 10: Polders in Lakshmipur District



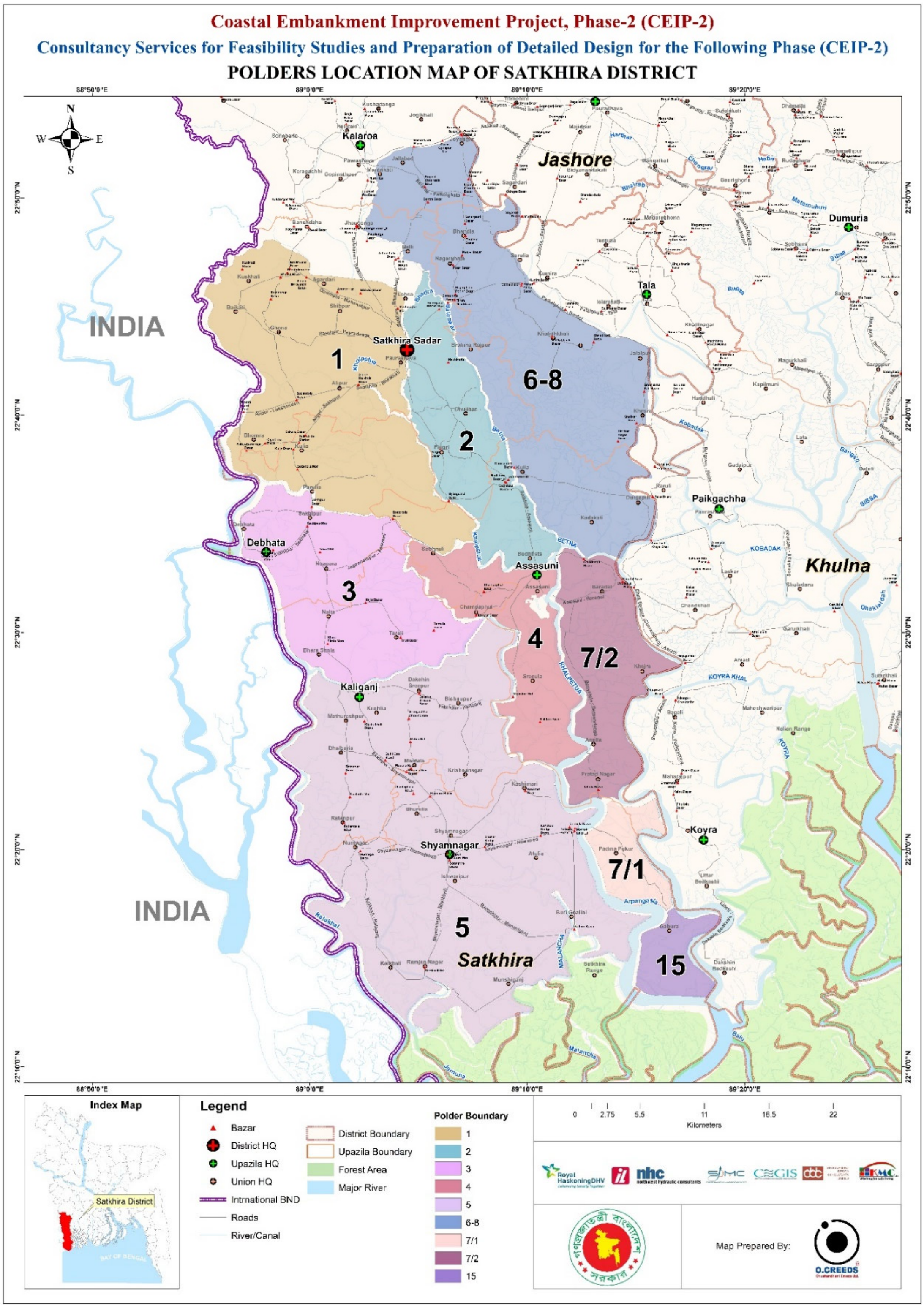
Figure_Apx 11: Polders in Noakhali District



Figure_Apx 12: Polders in Patuakhali District



Figure_Apx 13: Polders in Pirojpur District



Figure_Apx 14: Polders in Satkhira District

Appendix 6 Required data

A6.1 Required primary data for selection of polders and feasibility study

The following data are needed to obtain from previous projects and studies.

Data	Readily available	Partially available	Quality	Required	Source
Wave heights		✓	✓	✓	CEIP-1 DDCS&PMS and CEIP-1 LTM
Storm surge levels		✓	✓	✓	CEIP-1 DDCS&PMS and CEIP-1 LTM
Sedimentation rates				✓	CEIP-1 LTM
Macro-scale morphology of the coastal zone				✓	CEIP-1 LTM
Morphological assessment of rivers and investigation of bank erosion (especially Pussur, Bishkhali, Sibsa and Baleswar)				✓	CEIP-1 LTM
Long term Morphology Modelling of rivers				✓	CEIP-1 LTM
Hydrological assessment of rivers				✓	CEIP-1 LTM
Drainage situation in polders				✓	CEIP-1 LTM
Climate change scenarios and projections		✓	✓		CEIP-1 DDCS&PMS and CEIP-1 LTM
Cost Benefit Assessments for the coastal zone		✓		✓	CEIP-1 LTM
Discharges of rivers (from existing surveys)				✓	CEIP-1 LTM
Soil investigations along the coast and rivers (from existing surveys)				✓	CEIP-1 DDCS&PMS and CEIP-1 LTM
Salinity levels in polders (from existing surveys)				✓	CEIP-1 LTM
Bathymetric survey data along coast		✓		✓	CEIP-1 LTM
Cross sections of drainage canals		✓		✓	CEIP-1 LTM
Historic bathymetries					Literature

Morphologic behaviour or rivers				✓	CEIP-1 LTM
Observed water levels along coast		✓	✓	✓	CEIP-1 DDCS&PMS and CEIP-1 LTM
Condition of drainage and flushing sluices		✓		✓	CEIP-1 LTM Data base
Condition of bank protection works		✓		✓	CEIP-1 LTM Data base
Digital Elevation Model (DEM)	✓				• MERIT • SRTM
More detailed DEM				✓	CEIP-1 LTM
Sediment characteristics		✓	✓	✓	CEIP-1 DDCS&PMS and CEIP-1 LTM
Satellite images					
Models (various)					
Detailed Designs under CEIP-1 Programme including embankments, slope protection works, bank protection works and hydraulic structures	✓		✓		CEIP-1 DDCS&PMS
Economics					KfW
Land use plans		✓		✓	
Unit prices construction work	✓				• CEIP-1 DDCS&PMS (BWDB Schedule of Rates and Contractor Contracts) • CAAB, Cox Bazar Airport Extension Detailed Designs (IWM/CDR), 2019
Background data on the 139 polders along the coast of Bangladesh	✓		✓	✓	CEIP-1 DDCS&PMS and CEIP-1 LTM

A6.2 Literature collected and required

The following literature and reports have been collected and several of them are required to be received (the latter are marked in orange):

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3. Char Development and Settlement Project (CDSP), Bridging Phase, Dutch Government, IFAD, GoB, 2019.
4. Dutch Government, Blue Gold Program, Ministry of Foreign Affairs, 2014.
5. Coastal Embankment Improvement - Project Phase 1, Detailed Design and Supervision Consultancy and Project Management Support, Various reports, Royal HaskoningDHV and partners, 2015 - ongoing.
6. Coastal Embankment Improvement - Project Phase 1, Long Term Monitoring, DHI, Deltares, IWM, 2018 – ongoing.
7. Hagenaars, G., de Vries, S., Luijendijk, A. P., de Boer, W. P., & Reniers, A. J. H. M. (2018). On the accuracy of automated shoreline detection derived from satellite imagery: A case study of the sand motor mega-scale nourishment. Coastal Engineering, 133 (June 2017), 113–125. https://doi.org/10.1016/j.coastaleng.2017.12.011
8. Developing concept design solutions for coastal erosion in Bangladesh, Technical Proposal submitted 12th September 2019 by CDR International, Deltares and IWM, 2019.
9. Bank protection optimization in coastal Bangladesh, Summary of Quick Wins, Kees Dorst and Erik Mosselman, 2019.
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11. Khulna, Water as Leverage, CDR, Royal HaskoningDHV, Defacto, Nelissen & Schuurmans, WUR, 2019.
12. World Bank/NEC/CDR International, Bangladesh, Coastal Resilience and Delta Plan, Knowledge Exchange to the Netherlands, September 27, 2019 to October 6, 2019, Findings Report no. 1 – October 2019.
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15. Trends analysis of river bank erosion at Chandpur, Bangladesh: A remote sensing and GIS approach, Biswajit Nath, Sultana N. Naznin, Paul Alak, International Journal of Geomatics and Geosciences, Volume 3, No 3, 2013.
16. Hydro-Morphology of Meghna Estuary, Md. Misbah Uddin, Dr. Jahir Bin, Alam, Zahirul Haque Khan, Dr. G. M. Jahid Hasan and Rubayat Alam. 2015.
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DHV and Haskoning in association with BETS Consulting Services Ltd. - DevConsultants Ltd. Engineering Planning Consultants Ltd. & Kranti Associates Ltd., 2007.

19. Cost benefit analysis and flood damage mitigation in the Netherlands, M.Brinkhuis-Jak & S.R. Holterman, M. Kok, S.N. Jonkman.
20. Design Manual Procedures for Designs of Polders in Tidal Areas in Bangladesh, Md. Abdul Quassem, P.F. Raijmakers, J. Burger, Delta Development Project Bangladesh Water Development Board, 1983.
21. Designing robust coastal structures, J.K. Vrijling, W. Kanning, M. Kok & S.N. Jonkman.
22. Standard Design Manual, Bangladesh Water Development Board, Volume-I, Standard Design Criteria, Standard Design Manual Committee, 1994.
23. Construction Industry Research, Information Association, Civieltechnisch Centrum Uitvoering Research en Regelgeving (Netherlands) and Centre d'études maritimes et fluviales (France), 2007. The Rock Manual: The use of rock in hydraulic engineering (Vol. 683). Ciria.
24. Coastal Engineering Manual. Washington, D.C.: U.S. Army Corps of Engineers, 2006.
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A6.3 Data required for Economic Analysis

Collection of baseline data at polder level (and second best Upazila level) for the 20 selected polders (and store these on Box folders)

It is expected that the Consultant will gather relevant data for the cost-benefit analysis. Recent data regarding assets, economic sectors (agriculture, aquaculture, tourism, etc.) are of utmost important for the CBA. In below table an overview is provided of data needed.

Table 1. Data needs vulnerability analysis 20 polders (damage model do-nothing baseline) and CBA , non-exhaustive to be reviewed by technical and hydrology experts)

Indicator (at polder level, or second best at Upazila level)	Relevancy	History (Necessary)	Projections based on climate change and socio-economic scenarios (Needed for proper resiliency planning)
Thematic area			
Meteorology and hydrology data			
Flood maps with inundation levels (in cm of different flood events (T=10, T=25, T=50, T=100,	High	Required	Needed
Duration of historic floods (inundations) at different return times (T) & levels in cm (in minutes or hours)	High	Required	Needed
Asset data for the selected 20 polders (GIS from google earth, open street maps etc.)			
No or m2 for different building types (types of housing, roads, commercial, government buildings, education, health, agri crops acres etc.) in the polders.	High	Required	Needed (plans for future buildings, scenarios urbanization)
Km roads (primary, tertiary) in polders (and inundation levels historic events)	High		
Km/M2 Bridges	High		
Maps of critical infrastructure (hospitals, water supply, waste, energy etc.) for the selected 20 polders	High	Required	Plans for new infra needed
Socio-economic data for the selected 20 polders			
Average population growth in the polders (2000-2020)	High	Required	Can be developed based upon trends
Local production or employment growth at sector level (2000-2020)	High	Required	Can be developed based upon trends
Economic activities in polder areas (by sector)	Medium	Needed	Needed
Number of fatalities (for each polder) at historical inundation and cyclone events (polders)	High	Needed	Nice to have

Number of additional diseases at historical inundation events (polders)	Medium	Nice to have	Nice to have
Average income (and growth trend) of people working in affected industries	Medium	Nice to have	Nice to have
Local property values of affected types of buildings (or reconstruction costs per m2 per type of asset , i.e. building or m road)	High	Needed for Cost-Benefit Analysis of measures (CBA)	Nice to have
Historical damage costs of inundation-flooding) for different events/ T)	Medium	Nice to have	Wil be developed based upon historical data
Damage curves (relation cm inundation, % damage of assets)	Required for damage cost estimation	Needed for damage model (input CBA)	Nice to have
Real interest rates government bonds (15Y, 30Y) (recent years)	Required for cost-benefit analysis of measures	Needed for CBA	Nice to have
Inflation rate Bangladesh (2018-2020)	High	Needed for damage model end CBA	Scenarios will be developed

Collection of trend data relevant for the baseline (do-nothing) scenarios

Population growth, economic growth (including agricultural land development) and income growth will result in an increasing volume of assets and a higher quality of assets over time in the future for many of the polders. This implies damage caused by the relevant hazards is expected to grow in the future. Therefore, scenarios will have to be developed based upon historical growth trends of population and the economy in the polders.

Therefore, Consultant will collect data on population growth, economic growth of relevant industries (agriculture, aquaculture, tourism) for the selected 20 polders. Apart from this most recent socio-economic scenarios of the Bangladesh DeltaPlan 2100 (BDP 2100) can be used as input for the socio-economic scenarios for the polders. Important data to be collected:

- Long term average annual population growth rates in Bangladesh from DeltaPlan (BDP2100) scenarios
- Long term average annual GDP growth rates from Bangladesh DeltaPlan (BDP2100) scenarios
- Long term scenarios for average annual agriculture production growth from BDP 2100

Collection of financial and economic indicators relevant for the CBA

Finally the damage model and CBA model will need some indicators such as GDP growth and the inflation rate to adjust for recent developments of prices (2018-2021) and interest rates as inputs for the relevant discount rate.

- Annual GDP volume growth (constant prices) Bangladesh (2000-2018 + most recent years),
- Annual inflation rates Bangladesh (2000-2018-2020)

- Interest rates government bonds (15Y, 30Y) Bangladesh

Collecting relevant reports and studies (and store these on box)

Consultant could collect other relevant studies, such as:

- Studies with relevant data regarding historical inundation events for the selected polders;
- Studies regarding livelihoods of people, agriculture and aquaculture for the selected polders;
- Cost – Benefit Analysis studies of similar flood related projects in Bangladesh (CEIP1, KfW Barisal feasibility and CBA study (Ecorys) etc.);
- Scenarios Bangladesh DeltaPlan 2100;
- …..

Appendix 7 Field visit reports

A7.1 Polder 4

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. Polder 4 has a 80 km long embankment covering Assasuni Upazila under Satkhira District surrounded by mighty flowing rivers like Kobadak and Kholpetua and other small rivers. Due to the cyclonic surges hit of "Ayla" in 2009, "Foni" & "Bulbul" in 2019 and "Amphan" in 2020, polder 4 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 80km of Polder 4, 30 km is situated on the right bank of Kobadak river and others are situated by the side of other rivers. The gross protected area is 10,500 ha of which total cultivable area is 8,400 ha. Crop & shrimps are being cultivated here (crop:3,360 ha & shrimp: 5,040 ha).

Technical

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30m and side slopes were 1:2 in C/S (country side) & 1:3 in R/S (river side). There are many fish culture projects owned by local people (locally called "Gher") inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 80 km embankment need complete rehabilitation out of which 6.80 km is most vulnerable and 11.90 km is vulnerable.

Tidal affect

The high tide waves around the turbulent rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 15 km riverbank protective works and 22 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 20. Moreover, 25 numbers box inlet are to be constructed. 54 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 30 ha area is required to be brought under afforestation. For this, around 150,000 seedlings will be planted.

Figure_Apx 15: Polder 4 at Kakrabunia, Assasuni, Satkhira.

Figure_Apx 16: Polder 4 at Hazratkhali, Assasuni, Satkhira.

Figure_Apx 17: Polder 4 at Daksin Puijala, Assasuni,

A7.2 Polder 5

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. This polder system was started from Satkhira, the then sub-division of Khulna District and now a district situated in the south-western zone of Bangladesh adjacent to Indian border. This is the largest polder with a 194.35 km long embankment covering Shyamnagar & Kaliganj Upazila and surrounded by mighty flowing rivers like Kalindi, Kholpetua, Kakshiali, Goalghesia, Chuna, Chunkuri, Malancha and many others. Due to the cyclonic surges hit of “Ayla” in 2009, “Foni” & “Bulbul” in 2019 and “Amphan” in 2020, polder 5 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure in order by fighting against river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 194.35 km of polder 5, 27 km is situated on the right bank of Kholpetua river, 46 km is situated on the left bank of Kalindi river and others are situated by the side of Mothergang, Mirgang, Kakshiali, Golghesia rivers. The gross protected area is 55,061 ha of which total cultivable area is 48,583 ha. Crop & shrimps are being cultivated here (crop:34,008 ha & shrimp: 14,575 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD & 4.57 mPWD respectively along the river of Kholpetua & Kalindi with crest width of 4.30m and side slopes were 1:2 in C/S & 1:3 in R/S. There are plenty of fish culture projects owned by local people (locally called “Gher”) inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 194.35 km embankment need complete rehabilitation.

Tidal affect

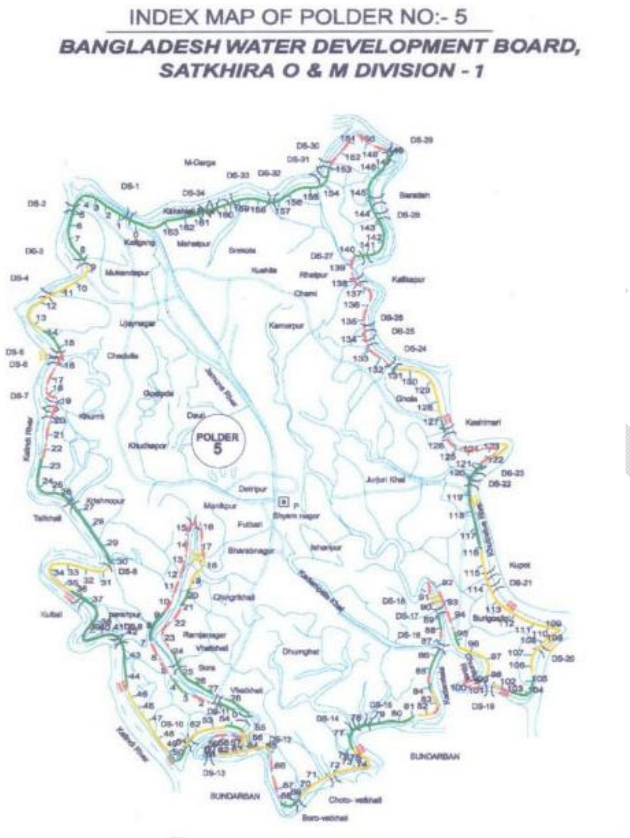
The high tide waves around the turbulent rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 20.083 km riverbank protective works and 23.313 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 43. Moreover, 63 numbers box inlet are to be constructed. 104 km drainage channel and 11 km small river are required to be re-excavated for smooth navigation. In addition to this, 18.8 km river dredging is required.

Afforestation

For environmental safeguarding, a green belt of about 140 ha area is required to be brought under afforestation. For this, around 400,000 seedlings will be planted.



Figure_Apx 18: Index map of Polder 5

Figure_Apx 19: Polder 5 km 89.500 at Chuna, Shyamnagar, Satkhira

Figure_Apx 20: Polder 5 km 110.200 at Dargabati, Shyamnagar, Satkhira

Figure_Apx 21: Polder 5 km 32.500 at Noikati, Shyamnagar, Satkhira

Figure_Apx 22: Polder 5 km 132.500 at Madinar Darga, Kaliganj, Satkhira

Figure_Apx 23: Polder 5 km 123.500 at Biral Laxmi, Shyamnagar, Satkhira

Figure_Apx 24: Polder 5 km 6.100 at Hadda, Kaliganj, Satkhira

A7.3 Polder 7/1

Polder 7/1 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 34.21 km embankment need complete rehabilitation out of which 7 km is most vulnerable and 13.50 km is vulnerable. Therefore, the field division is asking 5 km riverbank protective works and 15 km embankment slope protection work for safeguarding the embankment. In addition, The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 7. Moreover, 12 numbers box inlet are to be constructed. 32 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 5 ha area is required to be brought under afforestation. For this, around 50,000 seedlings will be planted.

Polder description

As per information from field division, out of 34.21 km of Polder 7/1, 10 km is situated on the right bank of Kobadak river and others are situated by the side of other rivers. The gross protected area is 3,110 ha of which total cultivable area is 2,700 ha. Crop & shrimps with overlapping (Crop & Shrimp are producing in same area) are being cultivated here (crop:1,866 ha & shrimp: 2,500 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30m and side slopes were 1:2 in C/S & 1:3 in R/S. There are plenty of fish culture projects owned by local people (locally called "Gher") inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 34.21 km embankment need complete rehabilitation out of which 7 km is most vulnerable and 13.50 km is vulnerable.

Tidal affect

The high tide waves around the turbulent rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 5 km riverbank protective works and 15 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 7. Moreover, 12 numbers box inlet are to be constructed. 32 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 5 ha area is required to be brought under afforestation. For this, around 50,000 seedlings will be planted.

Figure_Apx 25: Polder 7/1:at Jhapa-1, Assasuni, Satkhira.

Figure_Apx 26: Polder 7/1 at Jhapa-1, Assasuni, Satkhira.

Figure_Apx 27: Polder 7/1 at Jhapa-2, Assasuni, Satkhira.

A7.4 Polder 7/2

Polder 7/2 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges. 59.59 km embankment need complete rehabilitation out of which 15.50 km is most vulnerable and 19.20 km is vulnerable. Therefore, the field division is asking 15 km riverbank protective works and 25 km embankment slope protection work for safeguarding the embankment. In addition, the existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 14. Moreover, 32 numbers box inlet are to be constructed. 62 km drainage channel is required to be re-excavated for smooth navigation. For environmental safeguarding, a green belt of about 55 ha area is required to be brought under afforestation. For this, around 150,000 seedlings will be planted.

Polder description

As per information from field division, out of 59.59 km of Polder 7/2, 20 km is situated on the right bank of Kobadak river and others are situated by the side of other rivers. The gross protected area is 10,486 ha of which total cultivable area is 8,390 ha. crop & shrimps with overlapping (Crop & Shrimp are producing in same area) are being cultivated here (crop: 5,870 ha & shrimp: 2,520 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30m and side slopes were 1:2 in C/S & 1:3 in R/S. There are plenty of fish culture projects owned by local people (locally called “Gher”) inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankments become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 59.59 km embankment need complete rehabilitation out of which 15.50 km is most vulnerable and 19.20 km is vulnerable.

Tidal affect

The high tide waves around the turbulent rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 15 km riverbank protective works and 25 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 14. Moreover, 32 numbers box inlet are to be constructed. 62 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 55 ha area is required to be brought under afforestation. For this, around 150,000 seedlings will be planted.

Figure_Apx 28: Polder 7/2 at Tutikhali-1, Assasuni, Satkhira

Figure_Apx 29: Polder 7/2 at Tutikhali-2, Assasuni, Satkhira

Figure_Apx 30: Polder 7/2 at Tutikhali-3, Assasuni, Satkhira.

Figure_Apx 31: Polder 7/2 at Banyatola, Assasuni, Satkhira.

Figure_Apx 32: Polder 7/2 at Bamondanga, Assasuni, Satkhira.

A7.5 Polder 10-12

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. Polder 10-12 has 67 km long embankment covering Koyra and Paikgacha Upazila under Khulna District surrounded by mighty flowing rivers like Shibsha, Kurulia and Koyra. Due to the cyclonic surges hit of "Ayla" in 2009, "Foni" & "Bulbul" in 2019 and "Amphan" in 2020, polder 10-12 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 67 km of Polder 10-12, 10 km is situated on the left bank of Shibsha river and others are situated by the side of Kurulia and Koyra rivers. The gross protected area is 16,315 ha of which total cultivable area is 12,715 ha. crop & shrimps are being cultivated here (crop:6,870 ha & shrimp: 5,845 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30m and side slopes were 1:2 in C/S & 1:3 in R/S. There are many fish culture projects owned by local people (locally called “Gher”) inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 67 km embankment need complete rehabilitation out of which 15 km is most vulnerable and 28 km is vulnerable.

Tidal affect

The high tide waves around the mighty rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 11 km riverbank protective works and 23 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 15. Moreover, 28 numbers box inlet are to be constructed. 52 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 70 ha area is required to be brought under afforestation. For this, around 260,000 seedlings will be planted.

Figure_Apx 33: Polder 10-12 at Kumkhali, Paikgacha, Khulna

Figure_Apx 34: Polder 10-12 at Near Kumkhali, Paikgacha, Khulna

Figure_Apx 35: Polder 10-12 at Baintala Gate, Paikgacha, Khulna

A7.6 Polder 13-14/2

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. Polder 13-14/2 has 91.77 km long embankment covering Koyra Upazila under Khulna District surrounded by mighty flowing rivers like Kobadak, Ungtihara and Koyra. Due to the cyclonic surges hit of “Ayla” in 2009, “Foni” & “Bulbul” in 2019 and “Amphan” in 2020, polder 13-14/2 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 91.77 km of Polder 13-14/2, 45 km is situated on the left bank of Kobadak river and others are situated by the side of Koyra and Ungtihara rivers. The gross protected area is 17,854 ha of which total cultivable area is 14,280 ha. crop & shrimps are being cultivated here (crop:12,850 ha & shrimp: 1,430 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30 m and side slopes were 1:2 in C/S & 1:3 in R/S. There are some fish culture projects owned by local people (locally called “Gher”) inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment.

Some photographs are pasted below this report. Thus, 91.77 km embankment need complete rehabilitation out of which 35.70 km is most vulnerable and 30.68 km is vulnerable.

Tidal affect

The high tide waves around the mighty Kobadak river are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field Division is asking 25 km riverbank protective works and 25 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 16. Moreover, 33 numbers box inlet are to be constructed. 74 km drainage channel is required to be re-excavated for smooth navigation. In addition to this, 15 km river dredging is required. Conditions of all the 12 sluices/water control structures is very bad and 4 of them are fully damaged. Some of the collected pictures of damaged embankment, sluice and protective works are given bellow.

Figure_Apx 36: Embankment failure in polder 13-14/2

Afforestation

For environmental safeguarding, a green belt of about 40 ha area is required to be brought under afforestation. For this, around 250,000 seedlings will be planted.

Figure_Apx 37: Polder 13-14/2 at Hogla-1, Koyra, Khulna.

Figure_Apx 38: Polder 13-14/2 at Hogla-2, Koyra, Khulna.

Figure_Apx 39: Polder 13-14/2 at Dashalia, Koyra, Khulna

A7.7 Polder 29

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. Polder 29 has 49 km long embankment covering Batiaghata and Dumuria Upazila under Khulna District surrounded by mighty flowing Rivers like Gangrail, Bhadra and Upper Shaltha. Due to the cyclonic surges hit of "Ayla" in 2009, "Foni" & "Bulbul" in 2019 and "Amphan" in 2020, polder 29 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 49 km of Polder 29, 10 km is situated on the left bank of Gangrail river and others are situated by the side of Bhadra and Upper Shaltha rivers. The gross protected area is 8218 ha of which total cultivable area is 6,570 ha. Only Crops are produced in all 6,570 leaving no shrimp to cultivate here.

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30 m and side slopes were 1:2 in C/S & 1:3 in R/S. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report.

Thus, 49 km embankment need complete rehabilitation out of which 10 km is most vulnerable and 18 km is vulnerable.

Tidal affect

The high tide waves around the mighty rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 9 km riverbank protective works and 13 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 11. There are also 81 numbers of flushing inlets which need rehabilitation. 72 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 70 ha area is required to be brought under afforestation. For this, around 240,000 seedlings will be planted.

Figure_Apx 40: Polder 29 at Chandgar, Dumuria, Khulna

Figure_Apx 41: Polder 29:at Baroaria, Batiaghata, Khulna

A7.8 Polder 31

The CEP was taken up for construction of embankment and other infrastructure by creating polders for safeguarding the area from salinity & increasing the agricultural lands in 1960. Polder 31 has 47 km long embankment covering Dacope Upazila under Khulna District surrounded by mighty flowing rivers like Possure, Shibsha, Dhaki, Bhadra, Jhapjhapia and Chunkuri. Due to the cyclonic surges hit of "Ayla" in 2009, "Foni" & "Bulbul" in 2019 and "Amphan" in 2020, polder 31 has been damaged tremendously. It has now become a challenge for BWDB to maintain its embankment and other infrastructure from river erosion, high tide, flood & drainage congestion and especially the cyclonic surges.

Polder description

As per information from field division, out of 47 km of Polder 31, 12 Km is situated on the right bank of Possure river and others are situated by the side of Shibsha, Dhaki, Bhadra, Jhapjhapia and Chunkuri rivers. The gross protected area is 7,288 ha of which total cultivable area is 6,500 ha. Crop & shrimps with overlapping (crop & shrimp are producing in same area) are being cultivated here (crop:6,072 ha & shrimp: 4,858 ha).

Technical embankment description

During construction phase, the embankment was constructed keeping its reduced level at 4.27 mPWD with crest width of 4.30 m and side slopes were 1:2 in C/S & 1:3 in R/S. There are plenty of fish culture projects owned by local people (locally called "Gher") inside the polder. The Gher owners usually take saline water from the river through pipes installed beneath the embankment by boring without taking sufficient protective measures and thereby the embankment become weak. Due to lack of proper maintenance and prolonged use, the design level in many places has been lost. The situation becomes critical and overtopping of embankment/ breach in the embankment occurs when cyclonic surge like Amphan/Ayla hits the embankment. Besides this, river erosion is also one of the reasons for damage of embankment. Some photographs are pasted below this report. Thus, 47 km embankment need complete rehabilitation out of which 13 km is most vulnerable and 18 km is vulnerable.

Tidal affect

The high tide waves around the mighty rivers are damaging the embankment twice daily by hitting its slopes. River erosion is also damaging the embankment. For protecting the embankment, requisite measures for protecting the slope of embankment and riverbank are required to be taken up. The field division is asking 15 km riverbank protective works and 22 km embankment slope protection work for safeguarding the embankment.

Drainage

The existing drainage regulators are not functioning due prolonged use and required to be rebuilt and the number is 24. Moreover, 24 numbers box inlet are to be constructed. 72 km drainage channel is required to be re-excavated for smooth navigation.

Afforestation

For environmental safeguarding, a green belt of about 60 ha area is required to be brought under afforestation. For this, around 225,000 seedlings will be planted.

Figure_Apx 42: Polder 31 at Jhalbunia, Dacope, Khulna.

Figure_Apx 43: Polder 31:at Kaminibashi, Dacope, Khulna.

Figure_Apx 44: Polder 31 at Khona, Dacope, Khulna

Figure_Apx 45: Polder 31 at Botbunia, Dacope, Khulna

A7.9 Polder 30

Polder description

Polder No- 30 is located at Batiyagata Upazilla of Khulna District. Total length of the embankment is about 40 km out of which about 22 km is paved road. The polder is situated in three unions covering a total of 8,048 ha land inside the polder, 27 water management structures (drainage sluice and flashing sluice) and 39 km of drainage canal inside the polder.

In many placed the local people took shelter on the embankment for their residential purposes. A lot of shops are also found on the embankment in particularly settlement areas. Some community properties including mosques, clubs, etc. are also constructed on the embankment. Main occupation of local people are business and fish cultivation.

Water Management Organization (WMO)

WMO is quite active in this polder. Local people are involved in the committee. Conflict among the committee members is not reported during the reconnaissance visit. The water management committee supervises the entry and exit of river water into the polder.

Potential impact on land acquisition and resettlement

Two locations have major impact due to the erosion of river and therefore, need to construct retired embankment. Re-sectioning of the embankment is also required in most areas of the embankment. Approximately 5 ha land will need to be acquired for rehabilitation of the embankment. It is estimated that about 800 residential household, more than 300 commercial enterprises and 6 Community Properties (CPRs) will potentially be affected due to rehabilitation of the polder.

Tidal affect

Aila and Sidr damaged the embankment though the Yeas, Mohasen, Bulbul and Nargis had very little impact on the Polder 30. Still the local people remains scared as the river water could damage the embankment and cause severe impact on their livelihood. Also water can over flow the embankment during the cyclone as the embankment height is very low.

Public opinion

Local people think that in some places embankment situation is very critical. The risk is higher as the Poshur River is very close. Moreover, river erosion can damage the embankment at any time and therefore they will be in trouble to manage the crop production and fish culture. Rehabilitation of the polder is an urgent need of the people.

Photographs below have been taken on 5th august 2021.

Figure_Apx 46: Foron Para, Botiiaghata, Khulna.

Figure_Apx 47: Gopalkhali, Botiaghata, Khulna.

Figure_Apx 48: Kismot Fultola, Botiaghata, Khulna.

A7.10 Polder 39

Polder description

Polder No- 31 is located at Dacope Upazilla of Khulna District. Total length of embankment is about 47 km out of which 15 km is paved road. The remaining area is very vulnerable to river erosion threat. The polder is situated in two union and one municipality covering total 14,998 ha land inside the polder, 27 water management structures (DS and FS) and 7.5 km of drainage canal. The polder is always under river erosion and tidal surge threat. Main occupation of local people are business and fish cultivation

WMO

There is no WMOs in this polder. But people are interested to be the part of water management by forming WMOs**.**

Potential impact on land acquisition and resettlements

Five locations along the embankment are very vulnerable and need to be reconstructed. Most of the areas of the embankment are under threat of erosion and for rehabilitation of this polder about 10 hector land will need to be acquired. Around 900 residential households, about 800 commercial enterprises and 9 CPRs (mosque, club, etc.) will be affected due to the project.

Tidal affect

Aila and Sidr created damage to the embankment. In many places the embankment breached. Moreover, the people faced severe loss during the YEAS and Amphan due to damage of the embankment. Water over-topping during large high tide is a common phenomenon since the embankment height is very low. This creates a massive crop loss almost every year.

Public opinion

Local people opined that in some places the embankment condition is very bad and they can be affected by tidal affect at any time. The risk of natural disaster is higher as the Shibsha River is very close. Moreover river erosion will create great loss unless the embankments are strengthened.

Photograph have been taken on 5th August 2021

Figure_Apx 49: Gorkathi, Dacope, Khulna.

Figure_Apx 50: Khona, Dacope, Khulna.


Figure_Apx 51: Kamini basia, Dacope, Khulna.


Figure_Apx 52: Botbunia Bazar, Dacope, Khulna


Figure_Apx 53: Pankhali, Dacope, Khulna

A7.11 Polder 40/1

Polder description

Polder No- 40/1 is located at Patharghata Upzilla of Barguna District. The polder 40/1 situated in one union covering a total of 3,567 ha land and 22,326 population in 5,535 families inside the polder. The polder contains 12 primary schools, 2 high schools, 1 college, 3 madrashas, 4 community clinics and 3 cyclone shelters. Total length of embankment is about 27 km out of which about 3 km is paved road. Remaining area is mostly exposed to the river and quite vulnerable.

WMO

There is no WMO in polder 40/1. Due to non-existence of WMO people cannot take any decision collectively. People are very much interested to be the part of WMO for agriculture and fishery activities.

Potential impact on land acquisition and resettlement

About 6 km of the area has river erosion threat. 1.5 km of embankment has to be replaced and 4.5 km has to be strengthened. Also protective work for 4.5 km embankment is urgently required. Rehabilitation of the embankment including reconstruction of fashing sluice & drainage sluice will require about 17 ha land acquisition. There are more than 200 shops and more than 400 families have taken shelter on the embankment due to displacement by river erosion and other reasons.

Tidal affect

As it is close to the sea, normal waves hit the embankment. Due to cyclone Yeas & Aila the embankment has suffered a lot of damage. High tide usually affects the polder and local people suffers every year.

Public opinion

The opinion of the people of the area is to build sustainable and high-quality embankment without repairing the dams every year. The DWDB has to work every year to protect the embankment. WMO is required to keep the people in unity and get benefit from the project.

Figure_Apx 54: Polder-40/1, Location- Chorlathimara, Uapzilla: Patharghata , District: Barguna

Figure_Apx 55: Polder-40/1, Location- Haringhata Bazar, Uapzilla: Patharghata , District: Barguna

Figure_Apx 56: Polder-40/1, Location- Padma, Uapzilla: Patharghata , District: Barguna

Figure_Apx 57: Polder-40/1, Location- Ruhita Bazar, Uapzilla: Patharghata , District: Barguna

A7.12 Polder 41/6A

Polder description

Polder No- 41/6A is located at Barguna Sadar Upzilla, Barguna District. Total length of embankment is about 34 km out of which 13 km paved road. Remaining areas are in bad condition and about 3 km area is under river erosion threat. The polder situated in 2 union covering total 5,200 ha land with 26,500 population in 6,500 families inside the polder. Total 25 primary schools, 6 high schools, 1 college and 5 Madrasahas are inside the polder.

WMO

There is no WMO inside the polder. People are interested to be part of the WMO for maximize benefit of the polder.

Potential impact on land acquisition and resettlement

About 3 km of area have river erosion threat. About 2.5 km of retired embankment is to be constructed and 1.5 km to be strengthened to protect from river erosion threat. Also protective work for 2.5 km embankment has to be done. Rehabilitation of the polder including retired embankment, protective work, re-sectioning and construction of flashing sluice & drainage sluice require about 13 ha of land acquisition and displacement of more than 400 shops in various small markets and more than 600 houses from the embankment.

Tidal affect

Due to cyclone Yeas & Aila the embankment got a lot of damage. It gets tidal affect in almost every year and people faces trouble.

Public opinion

People strongly opined to build sustainable and high-quality embankment so that it doesn't need to repair every year. The DWDB have to work every year to maintain the embankment.

Photograph have been taken on 5th august 2021

Figure_Apx 58: Polder-41/6A, Location- Jangalia, Uapzilla: Barguna Sadar , District: Barguna

Figure_Apx 59: Polder-41/6A, Location- Khadempur, Uapzilla: Barguna Sadar , District: Barguna

Figure_Apx 60: Polder-41/6A, Location- Adam Bazar, Uapzilla: Barguna Sadar , District: Barguna

Figure_Apx 61: Polder-41/6A, Location- Khadempur, Uapzilla: Barguna Sadar , District: Barguna

A7.13 Polder 47/1

Polder description

Polder No- 47/1 is located at Kalapara Upzilla, Mohipur thana under Patuakhali District. Total length of embankment is about 22 km out of which only 5 km paved road. Remaining area is mostly vulnerable and about 3.5 km embankment has river erosion. The polder situated at three Mouza in one union covering total 2,834 ha or 16 square km with 20,086 population in 6,155 families. The polder contains 13 primary schools, 1 high schools, 1 college, 2 Madrashas, 4 community clinics, 3 cyclone centres, 1 coast guard station and 1 police station inside the polder.

There are 400 vulnerable people (fishermen community) are found on the embankment and no commercial fish culture field (Gher) though there are many ponds near the embankment. The amount of agricultural land is high. Main occupation of the people is fishing in the river and sea.

WMO

There is no WMO in polder 47/1. General people know nothing about it.

Potential impact on land acquisition and resettlement

About 3.5 km retired embankment is required and another 4 km protective work has to be done. All flashing sluice & drainage sluices need to repair. Rehabilitation of the embankment and construction /repairing of the sluices require about 18 ha of land will have to be acquired. About 250 shops and about 800 houses are to be displaced.

Tidal affect

Due to the proximity of the sea and the shallowness of the river, tidal surge hit the embankment. Due to cyclone Yeas & Aila the embankment suffered a lot of damage.

Public opinion

The people strongly opined to build a sustainable and high-quality embankment. They also expressed their views to keep provision of fishermen community beside the embankment since they depend on the fishing in the river and sea. Maintenance of the embankment is very much necessary in every year to protect the people and crops inside the polder.

Figure_Apx 62: Polder-47.1, Location- Komolpur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

Figure_Apx 63: Polder-47.1, Location- Nazibpur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

Figure_Apx 64: Polder-47.1, Location- Nizampur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

Figure_Apx 65: Polder-47.1, Location- Sudhirpur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

Figure_Apx 66: Polder-47.1, Location- Sudhirpur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

Figure_Apx 67: Polder-47.1, Location- Puran Mohipur, thana- Mohipur, Upzilla: Kalapara, Dist-Patuakhali

A7.14 Polder 55/1

Polder Description

Polder No. 55/1 is located at Galachipa Upzilla under Patuakhali District. Total length of embankment is about 47 km out of which about 22 km paved. Remaining area is in bad condition and about 12 km is under river erosion threat. The polder situated at four Union and one Municipality covering a total of 5,200 ha land and around 60,000 population in about 15,000 families inside the polder. The embankment has almost disappeared into the river along 5 km of the Lohalia River and 7 km of the Kajaldi River. There is most of the land is agriculture land and few is Fish Gher.

WMO

There is no WMO. The committee was there 15 to 20 years ago when OMIP worked.

Potential impact on land acquisition and resettlement

About 2.5 km retired embankment is required and 10 to 12 km protective work is to be done. All flashing sluice & drainage sluices are to be repaired. About 13 ha of land will have to be acquired to develop the embankment. About 1000 shops and 800 houses will be displaced from the embankment. Apart from them there are about 1500 vulnerable people (fishermen community) on the embankment who lead their livelihood by fishing from the river/sea.

Tidal affect

The polder 55/1 is exposed to the river and vulnerable to river erosion threat. Due to cyclone YEAS & AILA the embankment has been damaged a lot.

Public opinion

The people living on and inside the polder expressed their views to strengthen the embankment with a sustainable solution so that repairing will not be required every year.

Figure_Apx 68: Polder-55/1, Location- Barnatali, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 69: Polder-55/1, Location- Bibirhaola, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 70: Polder-55/1, Location- Dakua, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 71: Polder-55/1, Location- Panpatti Lunch Ghat, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 72: Polder-55/1, Location- Panpatti Lunch Ghat, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 73: Polder-55/1, Location- Ratandi Taltali, Uapzilla: Galachipa , District: Patuakhali

Figure_Apx 74: Polder-55/1, Location- Ratandi Taltali, Uapzilla: Galachipa , District: Patuakhali

A7.15 Polder 59/3B

The representative of DDC visited 2 spots of the polder-59/3B in Noakhali District on 18-08-2021. During their field visits, they have been collected some pictures which are given below;

Figure_Apx 75: Polder 59/3B, Akhter Miar Hat, Union: Mohammadpur, Upazilla: Subarnachar, District: Noakhali

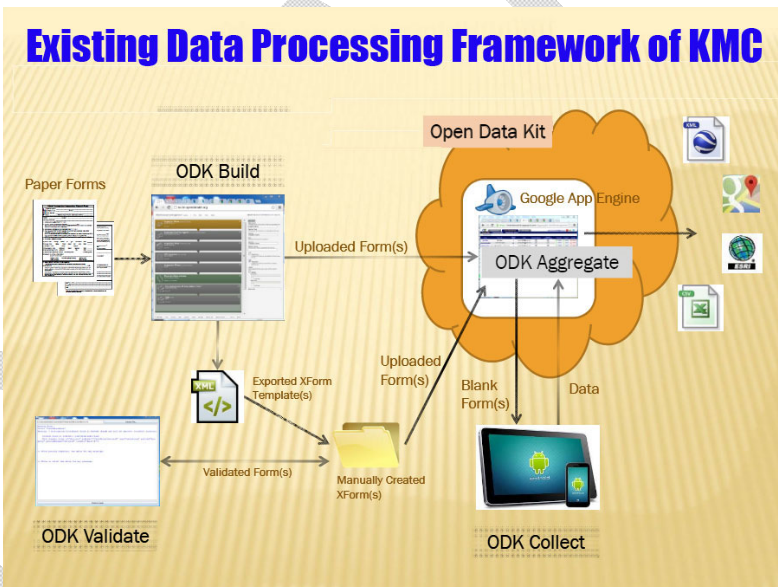
The segment of embankment in the first picture is in the home state area and is used as the road. For frequent movement of people and domestic animals, the grass turf has been damaged and has become into this shape. The sluice in the second picture is good and only requires some minor maintenance.

Appendix 8 Preparation RAP, LAP and EIA

A8.1 RAP

Using electronic devices for data collection

Electronic device will be used to conduct census & inventory of losses survey and socioeconomic survey to reduce time, maintain accuracy of data, on-spot checking, and validation, and keep the client informed about the daily progress of activities. The use of electronic devices (tablets) give significant benefits over traditional paper-based surveys. Using Tablets-based questionnaire greatly reduces survey error, especially data entry error and time required for data collection and processing. Once data is collected with a Tablet, there is no need for a subsequent data entry process since the data is entered directly into a data file. It allows day to day checking of data quality from central office and incorporate feedback, if any. Tables have full GPS functionality, which makes it possible for GIS to be incorporated in the study design. Each and every affected structure will have GPS location and photograph during conducting survey which will prevent fraudulent claims in the future and reduce grievances. In addition, it reduces printing of huge papers and burden of carrying many questionnaires in the field and storing them in the office that eventually reduce environmental hazard.



Figure_Apx 76:: Existing data processing framework of KMC

Video capturing of the alignment

A video will be captured for all affected properties including vacant land, crops, structures, trees, pond etc. after household numbering but before starting the census and IOL survey. This video capturing is generally called a 'running video' which will be carried out to prevent fraudulent claims in the future and to fulfil the requirement of the ARIPA 2017. This video film will be edited and converted into DVD and submitted to the client as a supporting document of LAP that will be submitted by the BWDB to DC offices for the land acquisition process. Another video filming will also be conducted after census and IOL survey is done which will also be retained with the client.

The ground control station and the Unmanned Aerial Vehicle (UAV) work together, with the assistance of the flight planning software installed on the smartphone. Once the flight starts its operation, the UAV can follow the flight path automatically. Having completed the desired number of images acquisition, the UAV returns home by itself.

Figure_Apx 77: UAV team

Spot level/land level data will be taken at 5m to 10m distance or closer depending on the existing condition of the field up to a 100m width and at a 100m interval along the proposed alignment for different districts. Using Total Station, the land level/spot level will be recorded from coordinates and height data for the proposed alignment. This data can be used to create spot height maps, contour maps, or more complex terrain models of the surveyed area.

Total Station is an electronic device that is a complicated but accurate instrument to calculate and collect both position (X, Y) and reduced level (Z) of different features on the earth surface simultaneously.

Total Station should take the following points into account regarding topography survey:

- Accuracy check of machine: calibration;
- Correct 2 reference point (X, Y, Z) input;
- Back point check;
- Good condition of prism;

- Fair weather;
- Logistic support;
- Clear visibility through machine;

The Total station can accurately take the spot level of points and coordinates of different features. This may be used to produce site layout, topographic maps, contours etc. However, for surveys like road alignment and homestead delineating where level is not essential a GPS using ProXR can do faster surveying. All the existing structures on the land such as homestead, bazar, sluice gate, culvert, bridge, school, college, road etc., or important locations will be recorded around 20 m buffer along the proposed roads. For the present study, all the waterbodies and soil types along the alignment will also be collected.

Ground control points (GCPs) are points on the ground with known coordinates. In an aerial mapping survey/drone survey, GCPs are points to which the surveyor can precisely pinpoint. With only a handful of known coordinates, it is possible to accurately map large areas. In the present study GCPs point will be taken for capturing topographic mapping using drone flying along the proposed study area.

At the initial stage, a desktop study relating to existing topographic maps and public information will be carried out at the Onushandhani Creeds Ltd. office. Vertical control points and on site boundary positions will be established. These stations should form a reference system that will be used during the survey as well as while setting out control points for construction purposes. Such control points are essentially 12mm iron pegs, embedded in concrete. A descriptive plate will be put on each station indicative of the X and Y coordinate as well the height. The coordinate system for the survey will be based on the Global Coordinate System (Universal Transverse Mercator- UTM WGS 84). All surveys will be carried out based on a local survey system which will be clearly defined. A conversion process will also be outlined.

The survey will be verified with beacons located in the area. The survey should be carried out with pre-calculated 15m grid intervals, in the event of irregularities/topographical features (watercourses, hills, manmade structures, underground services, etc.) the grid interval will be reduced in order to ensure accuracy. The site perimeter is recommended to be extended by 50m outside the boundary of the detailed survey for Digital Terrain Model (DTM). The entire project area including access roads and other services (transmission lines, pipelines, etc.,) is considered as part of the study.

The developed tools and techniques will be grounded in the study area for pre-testing. The study team will be conducted mock surveys for a proper quality check of the tools and techniques. An UAV system can quickly and inexpensively collect highly detailed data of smaller areas. A surveying drone offers an enormous potential for surveyors and GIS professionals. With a drone, it is possible to carry out topographic surveys of the same quality as the highly accurate measurements collected by traditional topographic surveys, but in a fraction of the time. This substantially reduces the cost of a survey and the workload of specialists in the field.

The scope for the UAV team is:

- Carry out a UAV survey in the study area;
- Collect highly precise GCPs for image georectification;
- Generate orthophotos, DSM, DTM, contour and land levels;
- Extract all possible physical features in the project area;
- Capture a 4K video of selected areas using drones.

Deliverables of Topographic survey

- Orthophotos as GeoTIFF of the study area with at least 5 cm GSD or lower;
- Digital Surface Model (DSM) of the study area;
- DTM of the study area;
- Land levels & contour map at every 5m interval;
- Extracted physical features in shapefile format;
- Selected sets of data will be provided in CAD Format;
- 3D points clouds for better visualization;
- 4K video for one small selected area.

Video filming of the affected properties

After conducting the census and IOL survey, a video will be captured of the affected properties along with the household head or his/her senior proxy. The household number and affected structures/trees/business, etc. will be captured during this video and the owner/proxy will declare his/her identity and ownership status. This video will be retained by the client as evidence. GPS locations of all structures will be included within the video file to cross check with the field and to present as an evidence during grievance mechanism.

PVS /market survey

A PVS/market survey will be conducted to estimate the fair land market value and replacement cost (i.e. market value and transaction costs) of affected land of the substations. The survey will be conducted by collecting the government records (transacted deeds) from the sub-registrar's office, Mouza rates (declared by the GOB) for 2020 and current market price from the knowledgeable people (other than affected people) from various cross sections. Potential respondents for land price survey will include five categories of people such as; potential sellers, potential buyers, deed writers, religious leaders and teachers. At least 10 questionnaires will be filled up for each of the affected substations. Mouza rates (established by GOB) for the year 2020 will also be collected from concern tahsil office (union land office) to assess recorded price. Collected information from various sources will be summarized and replacement cost will be determined for preparation of the estimated budget for land acquisition and resettlement.

Identify the legacy of incomplete land acquisition

The legacy of incomplete land acquisition or no acquisition of land used will be identified consulting with BWDB for existing embankments and devised approach the acquisition of land for the first works package in consultation with the affected landowners and the BWDB.

Data analysis and management

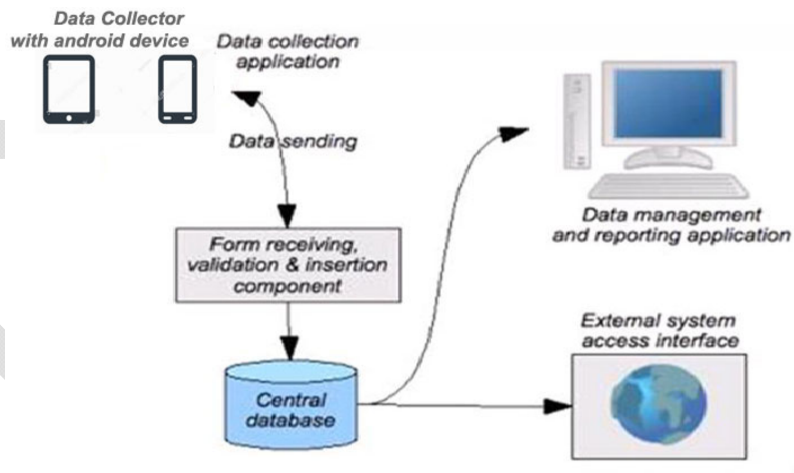
SPSS/access software will be used for analysis and management of census, socio-economic and Asset Inventory Survey data. Field level survey will be conducted through Tablets, so data checking and validation will be simultaneously going on. Online data collection procedure with daily updates will be shared with the client during the period of survey so that they can also check and give observation on the survey results and any bottlenecks they find. Necessary tables will be generated by the Data Analyst. List of affected landowners with quantity of land to be acquired, list of structure owners, list of sharecroppers, list of squatters, tenants, agricultural and commercial wage laborers will be generated and enclosed with the RAP.

Data Compilation and Report Preparation

Resettlement Specialist will review the data construct tables as per the reporting requirement. The MIS Specialist and data expert will generate tables as per requirement of Resettlement Specialist.

Guideline for RAP management

A web based MIS system will be developed from the beginning of the project preparation activities. The data of IOL survey will be collected by android device (mobile/tab). This IOL survey data will be transferred to the developed application. The importing procedure will be available in the developed application. The purpose of the web based MIS application is to provide up-to-date information to the authorized users on the status of progress in the preparation stage. The application will have the option to use with all the information at the implementation stage by adding more modules.



Figure_Apx 78: RAP management

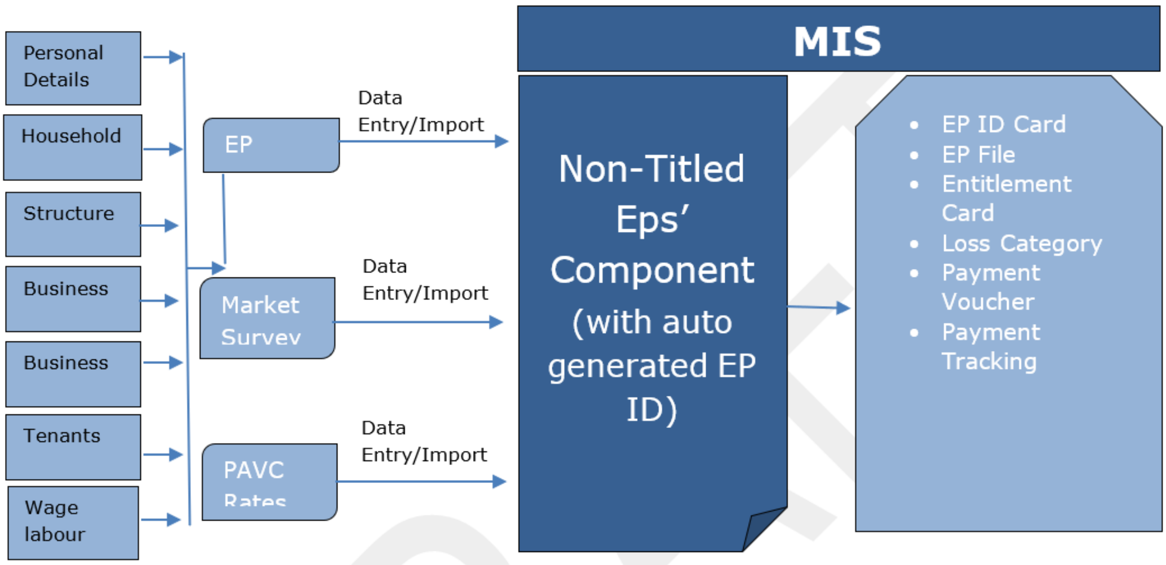
In the preparation stage the MIS system will develop the following modules to process the data/information with repots.

- IOL Survey Module
- Disability and Other Vulnerable Module
- Gender Based Violence (GBV) (from contractor part) Module

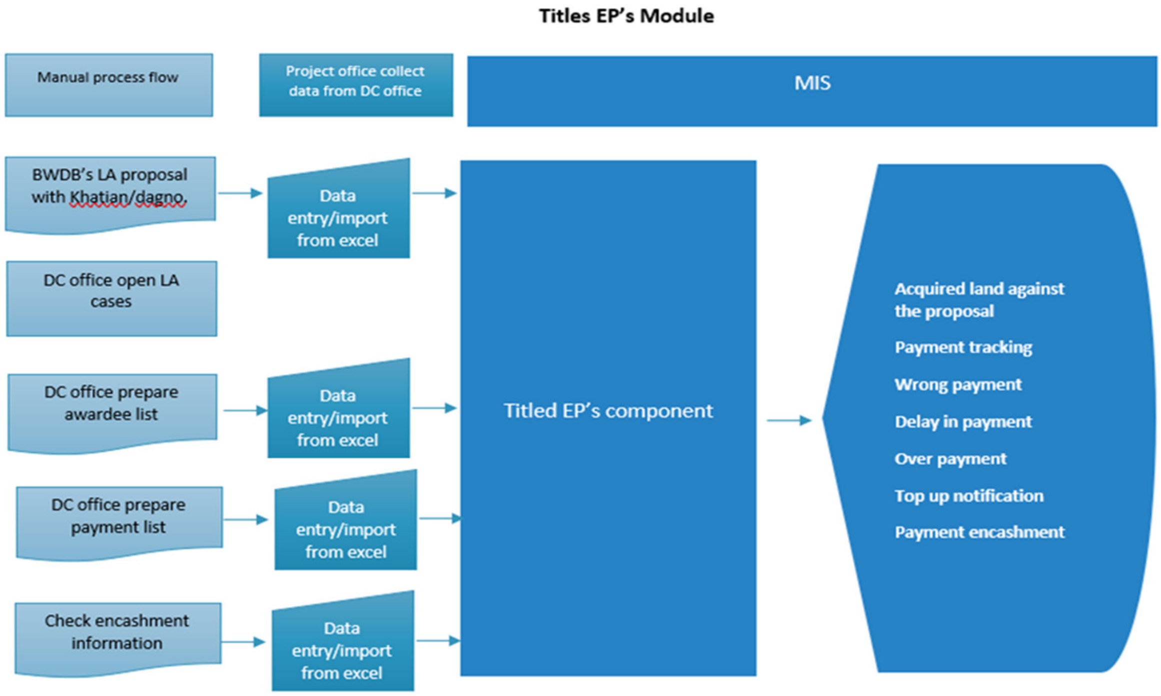
In the IOL Survey all the detail information of affected persons will be collected. It will include the household information, category of losses, structure, wage labour, tenant etc. This section will be designed to include sub-sub section for Titled Affected Persons and Non-Titled Affected Persons, payment processing (determining entitlement, payment of entitlements) and payment tracking systems (comparing with entitlement as per finalized baseline data and actual payments) should be included. A data filter option will be added with location, date range, payment range, District, Upazila, Date, Category of Loss etc.

IOL survey module, in assistance of its sub-chambers collect and portray the data for various aspects of an entitled person including information on businesses, tenants, employees, not to mention in depth data collection on the entitled person himself.

IOL survey module



Figure_Apx 79: IOL survey module



Figure_Apx 80: Titles EP's module

A8.2 LAP

Baseline survey and base map Preparation

Identification of the project area and RoW by field survey and following the right of way to be provided by the client. The safeguard Consultant will identify alignment for any retired embankments and agree-with the communities and affected land owners and finalize with assistance from the BWDB local offices and community leaders.

Considering any existing alignment map, KMC will conduct a primary baseline survey to identify the mouza names and sheet numbers fallen within the project right of way under the administrative boundary. This process will include primary and secondary data-base survey to ascertain the mouza names , JL Number, and the sheet numbers as well.

Collection of Mouza Maps of previous land acquisition

It is known that land acquisition was done during construction of the existing embankment. Such acquisition documents (Maps, etc.) will be collected from the concern BWDB offices and or DC offices to check with the ground reality whether the embankment is still on the acquired land or shifted due to river erosion. LAP team will check each and every Mouza with the ground reality.

Collection of latest published Mouza maps

KMC survey team will collect latest published Mouza Maps on which revenues are being collected. These will be collected from Directorate of land Records or from concern DC offices. LA Proposal will be submitted only on the latest published Mouza maps.

Digitization of the Mouza maps

After collection of genuine Mouza maps, Auto cad Engineer will digitize all Mouza Maps before geo referencing. This will help to calculate land quantity in each plots and correctly set the alignment and adjust where required.

Collection of Layout Plan/Alignment

KMC will require the correct layout plan/alignment for preparation of the land acquisition plan. Upon receipt the layout plan/alignment the LAP team will draw the alignment on the Mouza Maps with Pencil. This will be treated as draft alignment drawing which will require ground truthing before finalization.

Collection of Geodetic Control Point (GCP)

Assistant GIS Expert will collect GCPs for each Mouza Sheet (minimum 6 GCPs in each Mouza) using the latest technology. A team of experts under the LA Team will be deployed for GCP collection. This will be used for georeferencing at ground.

Georeferencing of the Plots

KMC will conduct Georeferncing with maximum care to ensure highest accuracy and minimize the offset The Land Acquisition Expert and Jr. GIS Expert will ensure correct the georeferencing during ground truthing before finalization of the LAP.

Edge Matching

After georeferencing edge matching will be done with utmost care under the leadership of the Land Acquisition Expert and Jr. GIS Expert

Ground Truthing of the alignment

LAP team will conduct ground truthing of the alignment to match the alignment and plot numbers with the real world.

Collection of Land Ownership Details and Fill up CHA Form

LAP team will collect the land ownership details, khatian etc. from DC offices or Upazila AC (Assistant Commissioner) land office. The list of recorded owners will be written the CHA form with other information as required in Column 1-4.

Preparation of Plot Index

Plot index will be prepared considering category of land (as per record), total quantity of land in the respective plots, proposed acquisition area. Khatian numbers and name of recorded owners. Mouza wise plot index will be prepared. Plot Index will be prepared based on the prescribed "Umo" and "Cha" form of the LA Act 2017.

Preparation and submission of Polder wise Land Acquisition Plan (LAP)

After maintaining standard practice and following all steps above, KMC will prepare land acquisition plan as draft and submit one set to the Client for their initial comments and suggestion. LAP will contain Mouza maps duly printed on Tracing Cloths (as per requirement of the ARIPA 2017) and plot index as mentioned in Para ix. One LAP will be prepared for each polder. Khatians (duplicate copy) will also be submitted along with the LAP.

Video filming/Still picture

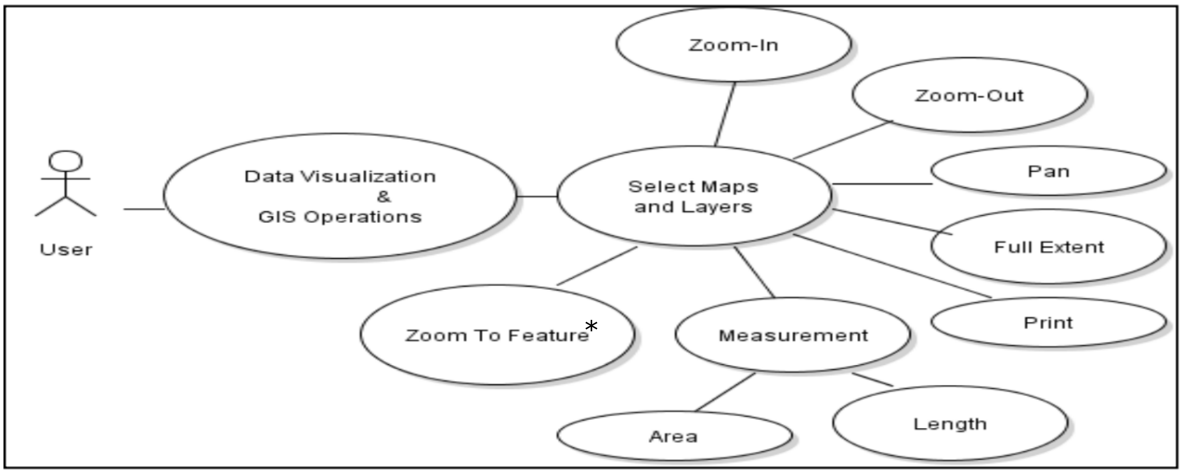
As per Land Acquisition Law (LA Act 2017), video filming of the total alignment/project site would be submitted to the DC office. The Senior officials of DC offices (ADC revenue, LAO) will conduct reconnaissance visit to validate the LA proposals before the DLAC meeting is held. Video filming will also be captured during the field visit of the DC officials. Following the instruction/requirement of the DC officials, video filming will be captured and submitted to the concern DC office before the DLAC meeting is held. Video film will be edited and converted in to DVD.

Data Processing for preparation of Land Acquisition Plan

KMC will develop a MIS for preparing Land Acquisition Plan(LAP). All the required information for LAP preparation (and implementation) will be available here including Package, Ploder, District, Upazila, Union, Village/ward, Mouza, Plot, Khatian numbers, Ownership Status. The list of recorded owner of the acquired lands will also be prepared through this system. All the plot schedules, land areas, recorded owner list will be created automatically by polder/district/mouza/plot etc. All the necessary reports will be possible to create with this application in the LAP preparation stage.

From the previous experience in Land Acquisition Plan preparation it is found if there is a geo referenced map included in this part it will help in many ways. The ongoing project status and progress can be calculated easily with the help of this sort of maps.

After completion of land survey and geo referencing the map will be developed with the geo referenced data. The maps will be incorporated in the developed application. Authorized users will have the following facilities. The plot schedule, recorded owner table and Entitled Persons information will be linked with this map so that all features will be viewed with specific detail by accessing this map. The following diagram express the way of data visibility from the map. According to the requirement of the project the map will be navigable with the set data. Some of the advantages of this sort of map is shown in the following diagram.



The feature will include: Location (Division, District, Mouza, Plot), Land detail: Category, type, ownership, there will be provision to add more features like EP, category of losses and so on.

Advantage of Geo-Referenced Navigable Map.

This Geo referenced (navigable) map will also serve many purposes in preparation of Resettlement Action Plan and implementing stage. There will be provision to link this map with the IOL survey data and Title holder data table so that each and every details of Entitled Persons' will be determined with one click on the map. The maps will be developed in the required level (plot/mouza/polder/package) in consultation with the BWDB and other project concerned.

A8.3 EIA

Ambient air quality

Vehicles transporting men and materials to and from survey sites, and movement of survey equipment will cause gaseous emissions, which include PM_{10}, $PM_{2.5}$, CO, HC, NO_x, and lead/ benzene. To mitigate the foreseen impacts, KMC will ensure through survey contractors, as well as sub-contractors, the execution of survey activities following the EMP.

Figure_Apx 81: Ambient Air quality EIA team

Furthermore, such impacts will only be perceived during the survey period, which is temporary. Having implemented the EMP during the project survey and being supervised by KMC/contractor personnel will minimize the emissions. These impacts can be minimized by proper planning and by adopting simple steps. The fugitive dust emission can be minimized by spraying water. KMC should insist that the survey contractor uses standard equipment, which meets the exhaust and noise standards (Schedule 5 and 6 of The Environment Conservation Rules 1997, amended 2002, 2010); generator (DG set) exhaust and noise standards; and other survey equipment standards such as US Federal Highway Administration Standards or any relevant standards. For trucks and other vehicles, KMC should insist truck operators who are operating on access roads and entering TP to carry out regular maintenance and engine tuning. In addition, KMC should insist the drivers to show truck-servicing records at the entry gate and take appropriate action if the vehicle is not maintained reasonably for a long time.

Noise quality

The potential for survey noise impact varies by location and land use. Rural and residential areas surround the present survey sites. Overall, survey noise impact is largest during the night. Therefore, noise-generating operations should only be planned during the daytime. To deal with noise exposure by survey workers in the survey site, a pocket guide by OHSAS is helpful.

Figure_Apx 82: Photograph demonstrating field level noise EIA technique.

The following noise reduction measures are suggested in the pocket guide:

- **Reduce it**: Reduce the noise by using the quietest equipment available. For example, choose a smaller, quieter generator;
- **Move it:** Move the equipment farther away with the use of extension cords, additional welding leads, and air hoses. Noise levels go down as we increase our distance from a

noisy object. Move the generator (for example) farther away or face it in a direction that is away from where most people are working. If you are not required to be in a high noise area, move to a quieter area;

- **Block it:** Block the noise by building temporary barriers to plywood or other on-site materials to keep the noise from reaching workers. Place a five-sided, oversized wooden box over the generator. Add fire-resistant acoustical absorbing material (foam) inside the box. If the generator sits on soil or sand, that will help absorb some of the noise.

Soil quality

After the development of the area with industries, disposal of process waste may contaminate land and soil quality of the area. The impact can be significant and long-term in case of uncontrolled discharges. Improper disposal of waste (hazardous and non-hazardous waste) may degrade the soil, water, noise, air quality, and ecology of the area.

The following steps are to be considered for further inspection and testing:

- Topsoil, if excavated from the project site should be stored in covered condition and shall be used later for landscaping purposes;
- Storage of raw materials, debris, and fuel on paved surfaces;
- Training the workers to handle the material to minimize leakage of material on the soil;
- Provision of cross-drainage structures to prevent waterlogging and soil erosion;
- Stone pitching with grass tiring should be done for the high embankment close to the water body;
- Disposal of survey debris, municipal waste from labour camps, and hazardous waste from the site should be disposed of at the identified site;
- Keeping provision of land for development of solid waste management facility within the TP site;
- No open area should be left, apart from vegetation to protect the soil;
- Mulching of soil must be done regularly to prevent direct exposure of soil to wind and water.

Water quality

The major water quality concern will be the wastewater discharge or site run-off at worksites during the survey, particularly the sites located within project areas or water gathering ground (WGG) areas.

Figure_Apx 83: Demonstrating field level surface water sample sollection techniques for water quality tests.

Figure_Apx 84: Demonstrating field level groundwater sample collection techniques for future laboratory testing.

To minimize the water quality impact during the survey, various key measures are:

- Minimizing the run-off from the site by the survey of sediment basins;
- Maintaining the flow of water sprinklers to avoid wastage of water;
- No debris should be thrown or disposed of in any water body like a river, pond, canal, etc., or groundwater source like functional or abandoned well;
- Excavation should not be carried out during the monsoon;
- Provision of a temporary storm water drainage system during the survey phase to drain the storm water.;
- Excavated pits should be provided with garland drains to prevent the entrance of water inside the pit;
- Provision of oil & grease traps with the storm water drains draining the parking and fuel storage area;
- Provision of septic tanks and soak pits at the site & labour camps for disposal of sewage generated by survey labour;
- Waste generated by survey camps should be disposed of regularly at the identified site for debris disposal.

Appendix 9 COVID regulations during surveys

Consultant will take measures on the COVID-19 related health and safety measures as follows:

- Review the Site-Specific Health and Safety Management Plan (SSHSMP) for the project that is prepared and submitted by the contractor;
- Make recommendations to the employer about the approval of the SSHSMP;
- Communicate the approved SSHSMP to all consultants and contractors throughout all project stages;
- Should any unforeseen events occur, review the updated SSHSMP and make a recommendation to the employer concerning the approval of the SSHSMP;
- In addition to the obligation to maintain safety on site, undertake formal monthly safety audits throughout all stages of the Project;
- Prepare the project execution plan, which, includes how the management of SSHSMP is to be addressed throughout all stages of the project.

Figure_Apx 85: COVID – 19 precaution plan

Plan the work, so that the employees can work while keeping a distance from one another. For example:

- Divide workstations between employees or companies at the start of the day;
- Avoid having many employees working in the same room, so that they can keep a distance from one another.

Make hand wash or hand sanitizer available for employees in all relevant areas. For example:

- At the entrance to the survey site;
- At break areas;
- In dressing rooms and toilet facilities;
- Encourage employees to wash their hands upon arrival to the survey site, as well as before and after breaks.

Minimize contact with others. For example:

- Stagger break times;

- Organize clock-in and office hours at staggered times, so that employees can keep a distance from one another, concerning e.g., getting dressed and eating;
- Have breaks outdoors when the weather permits, or in the company car;
- Use your tools wherever possible;
- Cancel meetings that are not urgent, or hold them via telephone, zoom, or outside of the building;
- Work from home whenever the task allows via zoom meetings.

Prioritize regular cleaning and sanitizing. For example:

- Clean or sanitize more regularly than usual;
- Clean handles, surfaces, and toilets several times per day;
- Ensure that there is frequent ventilation in site offices, etc.;
- Wipe tables between dining times;
- Washables chairs in all meeting rooms;
- Do not forget the coffee machine or microwave.

Figure_Apx 86: Mandatory office practice.

Appendix 10 Analytics of coastal zone

A10.1 Socio-economic conditions

Demographics and poverty

The coastal zone has 19 districts with 153 upazilas in which 41 million currently make their livelihoods. The coastal zone accounts for 32% of the land area and 25.7% of the population of Bangladesh[48]. The average density in the coastal zone is some 1000 persons per square kilometer[49]. The population density generally increases away from the coast: the interior coast (1180 / sq km2) has roughly a 50% higher population density than the exposed coast (770 / sq. km2). Despite this difference, the population is quite evenly spread throughout the coastal zone. About 70% of the upazilas in the coastal zone have a population density between 500 and 1500 per sq. km2. There are 10 upazilas with a high population density (> 10,000 / sq.km2 or more). West of the Meghna estuary, these are Jessore, Khulna, Khalispur, Sonadanga and Palong which are all located at the interior coast. East of the Meghna estuary, however, the Chittagong district has 5 upazilas with a high population density (Chittagong port, Doble mooring, Pahartali, Panchlaish and Chandgaon) located in the exterior coast.

The various areas in Bangladesh show significant spatial differences in the pace as well as quality of development, having regional differences in livelihood opportunities and living standards. The income disparity between urban and rural areas is still prevalent with headcount poverty levels of 35.2% in rural and 21.3% in urban areas in 2010. The coastal belt of Bangladesh is considered as being among the poorest regions of the country (in 15 out of the 19 coastal districts) with a below national average GDP per capita, with Chattogram and Khulna being the two relatively advanced coastal districts of Bangladesh[50]. In relation to gender equality and occupation opportunities, Bangladesh as a whole, ranks 116 out of 137 countries in the Gender Inequality Index (GII), which reflects the huge differences in the daily lives of men and women in the country, particularly in rural areas[51]. On the other hand, woman labour force participation is slightly increasing in the coastal zone.

Economic activities

The socioeconomic conditions of Bangladesh's Coastal Region are not uniform, mainly due to physiographic influences. The Central area in the figure has many char lands and is not easily accessible from other sections of the country by road or train. The Central region's major sources of income are fishing and agriculture, while people migrate to Middle Eastern countries to work as laborers. Some parts of the Central region are inaccessible, and there is no natural barrier to natural disasters, leaving the people who live there extremely vulnerable. Tourism, shrimp farming, fishing, and agriculture are the main economic activities of the Western region.

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[48] BBS (Bangladesh Bureau of Statistics). 2011. Bangladesh Population and Housing Census. Accessed February 2014. http://www.bbs.gov.bd/PageReportLists.aspx?PARENTKEY=41.
[49] Based on WB data set
[50] Dr Muhammad Abdul Mazid (2020), Containing intra-regional imbalance in coastal districts, Article in The Financial Express
[51] UN Women, Bangladesh Centre for Advanced Studies (BCAS), (2014). Baseline Study on the Socio-Economic Conditions of Women in Three Eco-Zones of Bangladesh. Available online at: http://www.uncclearn.org/sites/default/files/inventory/unwoman30112015.pdf

In the districts of Jessore and Khulna, there are industrial zones that ensure the participation of many people from the western region in tertiary and secondary economic activity. Because Chittagong Metropolitan (CMP), Chittagong Port, and Cox's Bazar Sea beach are in this region, it has excellent road and rail network connectivity with the rest of the country. People travel from other regions of the country to work in businesses like shipbreaking in CMP, which has a large secondary and tertiary economy[52].

The majority of coastal population are highly dependent on agriculture as a source of income and for food security. This is especially true for the polder areas which are dominant in the Ganges Tidal floodplain West and East and the Meghna estuary. Due to the construction of the embankments in the 1960s-1980s, the scale of the agricultural production in Bangladesh has seen an increase of up to 200 to 300 percent in certain areas. In 2013, 1.2 million hectares of land were being utilized for agricultural purposes within the embankment system, which represents almost 15% of Bangladesh's total arable land.

Fisheries are increasingly important activities in the coastal zone. Marine captured fish was around 650,000 ton (2018)[53] of which Hilsa shad (Tenualosa ilisha) is the dominant species. This generates income and employment for 2.5 million people. Aquaculture has grown rapidly in the past decades in the past decades in the polders of the coastal zone around Cox's Bazar-Chittagong in the southeast and in particular near Jessore and Khulna in the southwest. This activity is predominantly carried out in ponds in the coastal zone. Both brackish water shrimp (bagda) and freshwater shrimp (galda) are produced in small-sized farms which use more than 200 000 ha. Bangladesh has now a 2% contribution to the global shrimp market[54].

Other important activities in the coastal zone are industrial/commercial areas, salt production, ship-breaking and recycling, and tourism[55]. The three main city centers Barisal, Chittagong and Khulna are hubs for commercial and industrial activities. Salt production has a long tradition in Bangladesh and is concentrated in the southeast near Chittagong and Cox's Bazar. This activity is economically important for about 1 to 1.5 million people in the coastal zone. The ship-breaking and recycling industry is another important economic activity mainly concentrated in Chittagong. This activity converts end-of-life ships into steel and other recyclable parts. It provides direct employment to about 30,000 people but also indirect jobs are created. Tourism is at its infancy in Bangladesh but growing. Cox's Bazar is a well-developed tourism destination with natural and cultural attractions. The Sundarbans, Kuakata Beach and St Martin's Island also attract local but also foreign visitors.

The 153 administrative regions (coastal Upazila), even though the coastal Upazilas hold the same coastal character with predominant dependency on agricultural activities and ancillary reliance on industries and other services, the extent of their development varies significantly

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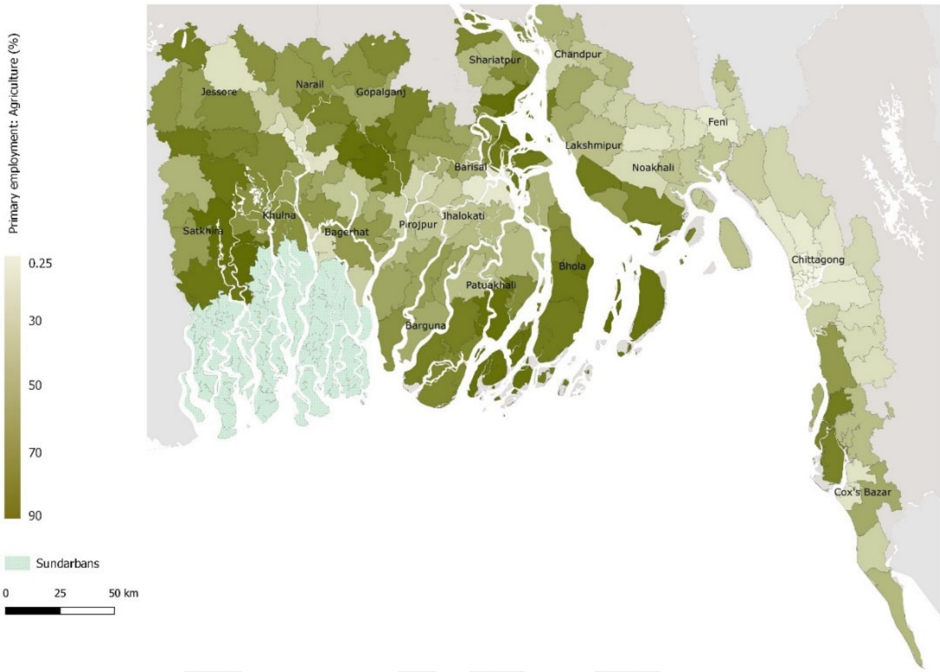
[52] Rabby, Y. W., Hossain, M. B., & Hasan, M. U. (2019). Social vulnerability in the coastal region of Bangladesh: An investigation of social vulnerability index and scalar change effects. International Journal of Disaster Risk Reduction, 41, 101329. https://doi.org/10.1016/j.ijdrr.2019.101329
[53] Department of Fisheries. 2005. Fishery statistical yearbook of Bangladesh 2003–2004. Dhaka, Fisheries.
Resources Survey System, Department of Fisheries.
[54] See: https://tbsnews.net/economy/trade/bangladesh-loses-export-market-whiteleg-shrimp-35693
[55] Bangladesh Delta Plan, 2100. Coastal zone.

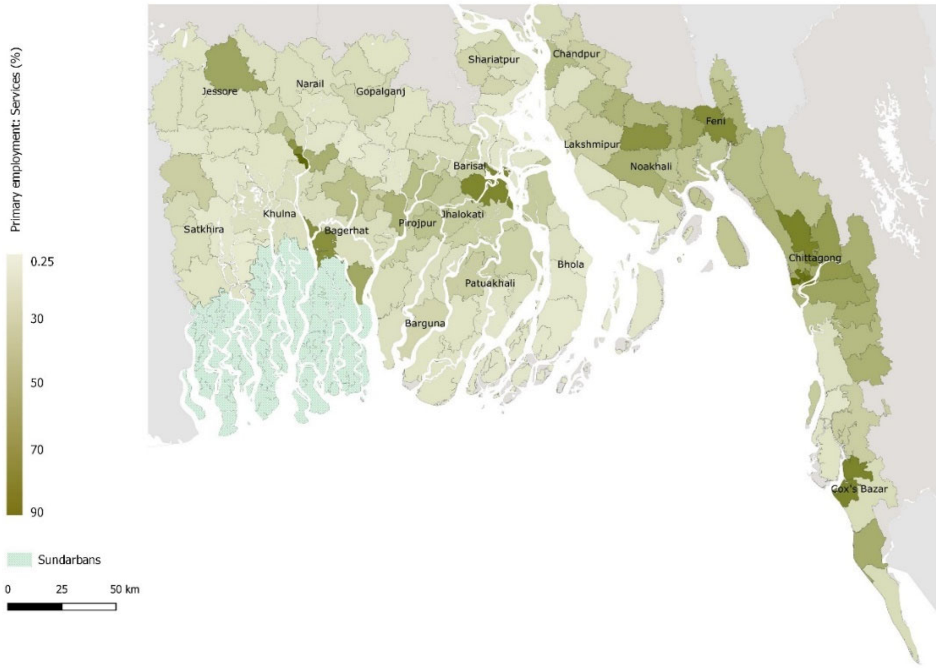
along the coast (Figure_Apx 114, Figure_Apx 115 and Figure_Apx 116). With Upazilas having more resources available and experiencing wider opportunities than others, the poverty level is also expected to differentiate along the coast.



Figure_Apx 87: Primary employment: Agriculture (% of upazila population)[56]

Figure_Apx 88: Primary employment: Industry (% of upazila population)[56]

[56] World Bank (2016). Bangladesh Interactive Poverty Maps



Figure_Apx 89: Primary employment: Services (% of upazila population)[56]

Housing and public services

Residential housing quality shows a strong variation throughout the coastal zone. This ranges from permanent housing to temporary or shanty types of housing. Housing has been classified into four categories based on quality[57]: Pucca (permanent quality), semi-Pucca, Kutcha, and Shanty. These classifications depend the on roof and wall materials used in construction. Typically, the urbanized centers show a better housing quality compared to the more rural areas. In the coastal zone, houses of better quality, with roofs and walls made of brick/cement have shown an increase the last years, while roofs made of stray/bamboo have decreased significantly.

Furthermore, due to weak infrastructure, communication systems, and natural hazards such as arsenic and salinity, a huge portion of the population lacks access to safe drinking water, sanitation, and public health facilities. The development of communication and infrastructure for supporting public utility services may be facilitated by improving the coastal polders. Sanitation and drinking water are two essential public services for coastal communities. The coverage of sanitation was about 55% - 58%[58] in 2012 and does not differ very much between urbanized and rural areas in Bangladesh. The access to clean drinking water is much higher (85%) and predominantly achieved by piped water and tube wells, with the latter being the less sanitary. The number of households utilizing piped water has increased in the coastal zone, yet

[57] Household Income and Expenditure Survey (2005)
[58] Joint Monitoring Program (JMP) 2012 Report, see also BDP 2100

the main source of water remains to be tube wells[59]. Arsenic is a major thread of water supply in both rural and urban areas and this issue is particularly relevant for the divisions Khulna and Chittagong in the coastal zone.

Education and healthcare access and quality also provide insight into the state of the living conditions in the coastal zone. At this moment, the school life expectancy from primary to tertiary education in Bangladesh is 12 years[60]. The current literacy rate in Bangladesh is above 71% (2015)[61]. A literacy survey from 2008[62] shows that the rural literacy rate was found to be 12% lower than that of urban areas, whereas differences across the country and also between men and women were small. The access of necessary healthcare remains challenging for the people living in the coastal areas, particularly the marginalized and disabled[63]. These areas suffer from a lack of appropriate health facilities and skilled healthcare providers.

Land use

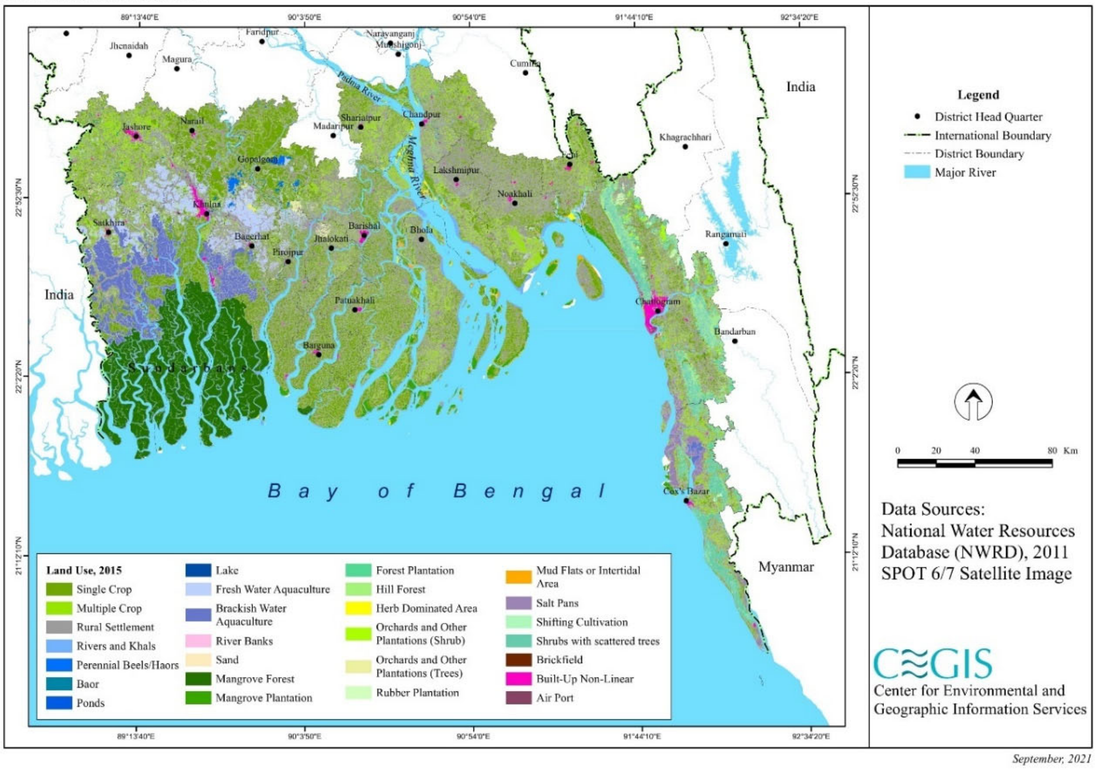
Bangladesh's coastline area includes a variety of land uses, including agriculture/fallow lands (63 percent), towns (19 percent), aquatic bodies/rivers, and forest (Figure_Apx 90). Mangroves and other woods cover the majority of the Ganges Tidal West Plain and Chittagong Coastal Plain zones. The Sundarbans, the world's biggest mangrove forest, is in the southern section of the Ganges Tidal West Plain zone, and it is extremely significant for biodiversity and ecosystem services both locally and globally. Char lands, rivers, and agriculture/fallow lands cover the centre zones Ganges Tidal East Plain and Meghna Deltaic Plain.

Agriculture/fallow lands, communities, roads, and river channels are all prominent land uses within the coastal polders. Agriculture/fallow lands and settlements account for 64 percent and 30 percent of the total area of 139 polders, respectively. In this estimate, shrimp farms and salt farms are included in the agriculture/fallow land use pattern. Shrimp farms are primarily found in brackish water locations along the coast, while salt farms are primarily found in the Chittagong Coastal Plain zone.

One of the most visible forces of change in the southwest coastal area has been the conversion of agricultural and mangrove forest to brackish water aquaculture[64]. Shrimp culture was traditionally limited to the area between the levees and the river channels. However, because of foreign demand, such practices have grown in spatial coverage inside polder systems over the last three decades (post-1980s).

[59] BDP 2100
[60] https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html
[61] See: https://en.wikipedia.org/wiki/Education_in_Bangladesh#Literacy_rate
[62] Literacy Assessment Survey 2008, UNESCO, BBS, 2008.
[63] Fauzia Akhter Huda, Hassan Rushekh Mahmood, Aniqa Tasnim Hossain, Jasmin Khan, Omar Faruk, Zahed Shafiqur Razzak, Kazi Tamara Binta Kamal, Shams El Arifeen (2020) Health Needs and Health System Response in the Coastal Districts of Bangladesh. International Centre for Diarrhoeal Disease Research, Bangladesh
[64] Datta et al. 2010. Shrimp Culture: Trend, Consequences and Sustainability in the South-western Coastal Region of Bangladesh

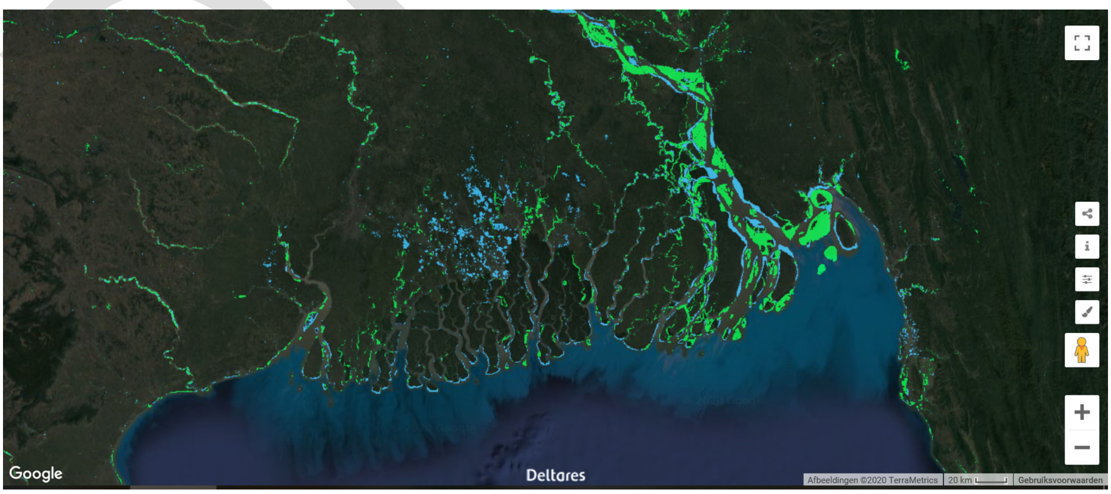
Landuse of Coastal Zone



Figure_Apx 90: Land use Map of Coastal Area

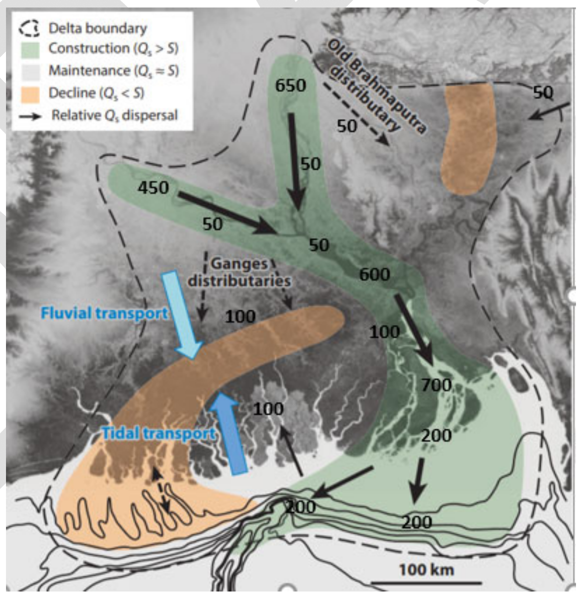
A10.2 Morphological condition

Due to the large population, there is a large pressure on land and newly formed land is quickly inhabited and/or empoldered. However, due to the enormous natural morpho-dynamics in the system (i.e. rivers meander and braid, chars are formed, migrating and disappearing, coastlines are eroding, land is accreting), these inhabited/empoldered areas also suffer from erosion.



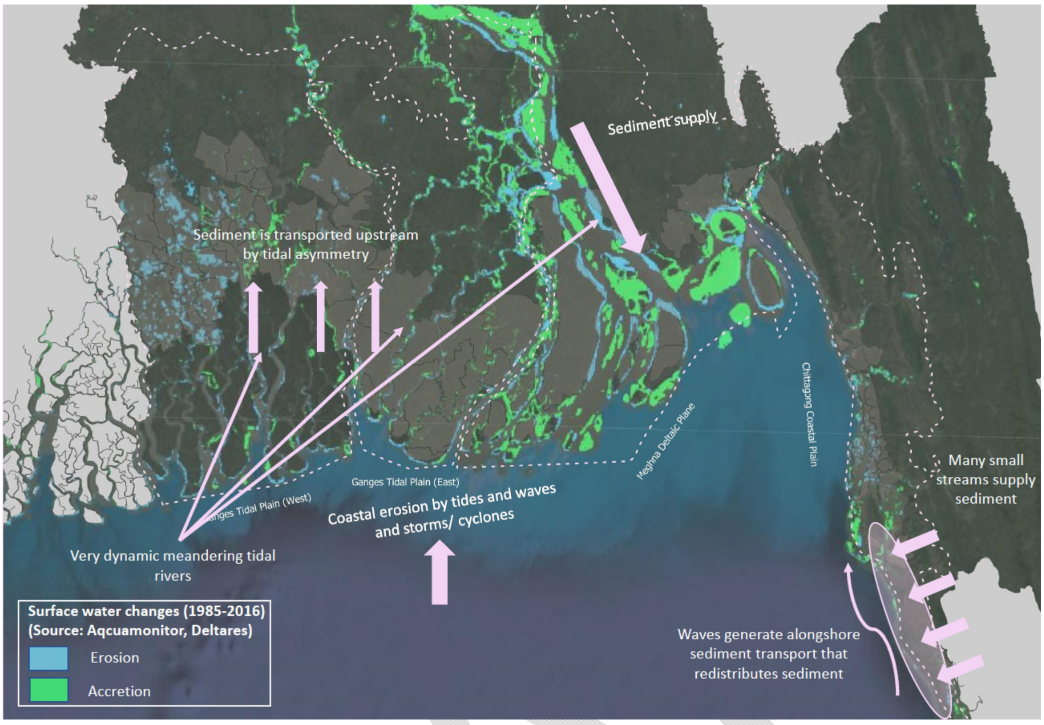
Figure_Apx 91: Erosion and accretion (2000-2017) in Bangladesh from Deltares Aquamonitor

Figure_Apx 91 shows the erosion (blue) and accretion (green) at the Bangladesh coastline between 2000 and 2017 as taken from the Aquamonitor (http://aqua-monitor.appspot.com/), in which the position of the Satellite Derived Shoreline (SDS) is given with subpixel accuracy (10 – 30 m), using a method that combines multiple satellite images into a single image[65]. Blue areas north of the Sundarbans may be attributed to water logging and/or aquaculture. The Meghna estuary delivers large amounts of sediment that results in accretion. Part of the fine sediment is transported towards the west (see Figure_Apx 92) where it is partly transported landward into the many estuaries of the Sundarbans. Large scale changes and processes that take place over long time scales contribute to changes in hydrodynamics and sediment transport in the coastal system. For example, the construction of dams in upstream rivers, such as the Farakka barrage in the Ganges (upstream of the border with Bangladesh) and man-made shortcuts, but also natural morpho-dynamics affect hydrographs and reduce the amount of water and sediment distribution to the downstream branches. Also, the 1950's Assam earthquake is hypothesized to have delivered large amounts of sediment into the rivers that have been eroded slowly over time, first increasing and later on decreasing the amount of sediment delivered towards the coast. North and east of the Sundarbans, a system of polders exists surrounded by estuaries/rivers and peripheral rivers. Polder construction started in the 1960's and reduced the intertidal area of this coastal system. All these developments affected the hydrodynamics and sediment transport, resulting in up-estuary sediment transport, siltation in the upstream branches and a sediment deficit at the coast. The large-scale sediment transport patterns, in combination with high tidal currents, wave attack, episodic erosion events during cyclones and relative sea level rise, all contribute to large scale erosion and accretion at the Bangladesh coastline at the Sundarbans and east of it.



Figure_Apx 92: Left: Large scale sediment transport pattern (from Wilson and Goodbred, 2016)

[65] Hagenaars, G., de Vries, S., Luijendijk, A. P., de Boer, W. P., & Reniers, A. J. H. M. (2018). On the accuracy of automated shoreline detection derived from satellite imagery: A case study of the sand motor mega-scale nourishment. Coastal Engineering, 133 (June 2017), 113–125. https://doi.org/10.1016/j.coastaleng.2017.12.011



Figure_Apx 93: Coastal and riverine characteristics Bangladesh coastal zones

Large parts of the coast of Bangladesh suffer from erosion as a result of a combination of factors. Natural morpho-dynamics that are very variable, driven by tides, waves, salinity- and sediment-driven density flows, river discharges and variation herein due to monsoon seasons. Cyclones have an indirect impact by influencing the natural morpho-dynamics by episodic erosion and sedimentation events and directly threaten inhabited parts and polders. (Relative) Sea level (RSL) rise affects the system on longer time scales.

Whether coastal or bank erosion is predominantly caused by tides, waves, high river discharge during the summer monsoon, cyclones or sea level rise, is dependent on site-specific conditions. For bank erosion in rivers, tides are more prominent than waves, while cyclonic storm surges may still have a considerable effect. Also, during the summer monsoon, the rivers and estuaries might be flushed by high river discharges causing erosion. The polders just north and east of the Sundarbans suffer mostly of erosion due to a combination of high river discharge during the monsoon period and residual sediment transport as a result of estuarine circulation and tidal asymmetry. At the open coast along the Bay of Bengal, the coast is affected by waves and cyclones. Especially at estuary mouths, the tidal velocities might be substantial, and the erosion might be a combination of tide driven current and wave resuspension. Along the entire Ganges tidal plain, erosion along the coastline of the Bay of Bengal is occurring (Figure_Apx 92 Figure_Apx 93), suggesting a large-scale process is cause. This might be a combination of long-term changes in river flow and sediment supply and division of water and sediment over the various rivers in the delta with both human and natural causes, increased tidal asymmetry due to empoldering and siltation in upstream rivers, and sea level rise. Of course, waves and cyclones cause coastal erosion, but the hydrodynamic energy from waves and cyclone has probably not changed as much as the beforementioned factors.

A10.3 Hydraulic dynamics

The coastal zone of Bangladesh is mostly prone to tidal surge and to a lesser extent affected by riverine/ monsoon flooding (Figure_Apx 54), although the maximum significant wave height in monsoon (July-August) can vary between 0.60 m to 1.60m.

Figure_Apx 94: Flood affected area of Bangladesh
(Source: Banglapedia)

Cyclones and Storm surge

Tropical cyclones is the prime natural disaster faced by Bangladesh almost every year causing huge damage to people's life and property. UNDP (2004)[66] identified Bangladesh as most exposed country to tropical cyclone with and with an average of four cyclone striking every year. About 5% of the global tropical cyclones form over the Bay of Bengal[67]. Cyclones affect the region with strong winds accompanied by powerful storm surges and widespread inundation over a vast area. These cyclones generally occur in early summer (April-May) and late rainy season (October-November) and generally follow a track in northeastern direction. These cyclones are accompanied with strong winds, storm surge waves, and rainfall. Numerous devastating cyclone events have recurred in the past, following different tracks and intensities

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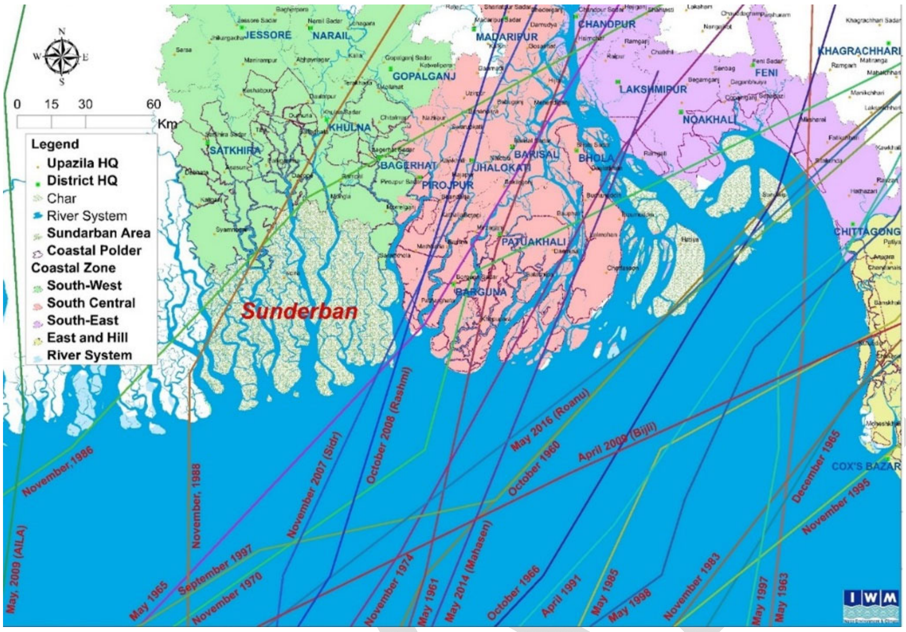
[66] UNDP, 2004. 'A Global Report: Reducing Disaster Risk: A Challenge for Development', United Nations Development Programme, http://ipcc-wg2.gov/njlite_download.php?id=5953, retrieved on 10 May 2014.
[67] Joint WMO-IOC technical Commission for Oceanography (2014). Coastal Inundation Forecasting Demonstration Project

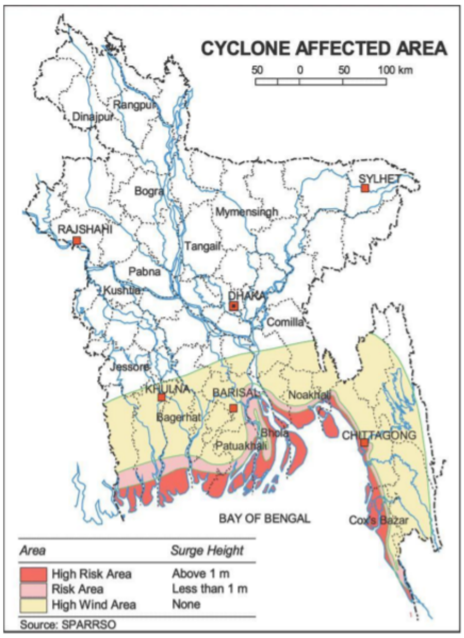
(Figure_Apx 95). Analysis of historical records shows that the major centers in the coastal zone (Khulna, Barisal, Chittagong) have been struck with an comparable number of 40 – 50 cyclones[68].



Figure_Apx 95: Cyclone tracks Bay of Bengal
(source: Institute of Water Modelling)

The coastal zone of Bangladesh is particularly exposed to cyclones, with the southern strip being a high risk area, transforming to a medium risk area as moving more landwards (Figure_Apx 96).

[68] Alam, E., Momtaz, S., Calgaro, E., 2012. A History of Tropical Cyclone Events, their Spatial-temporal Distributions and Effects in Bangladesh, AGU conference, San Francisco.



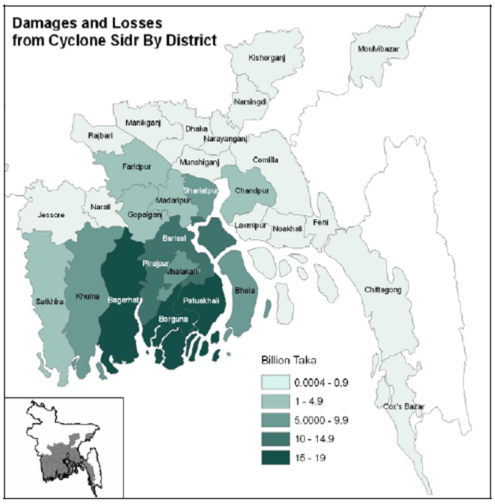
Figure_Apx 96: Cyclone affected areas in Bangladesh[69]

Storm surge generated by the tropical cyclones are subject to being further intensified in Bangladesh, which is attributed to the phenomenon of re-curvature of tropical cyclones in the Bay of Bengal and the shallow continental shelf, especially in the eastern part of Bangladesh. The triangular shape at the head of the Bay of Bengal also attribute to surge amplification. Also, the tidal phase and amplitude are important factors that determine the storm surge levels. Due to these factors, the Meghna Estuarine region is therefore the area where the highest storm surge has been observed. Typical storm surge water levels range from 3 – 5 meters for severe cyclones to more than 10 meters for Cyclone Bhola which was the most devastating in recent history. The storm surge travels far inland along the river branches and thus cause very high water levels around the polders at a far distance from the coast.

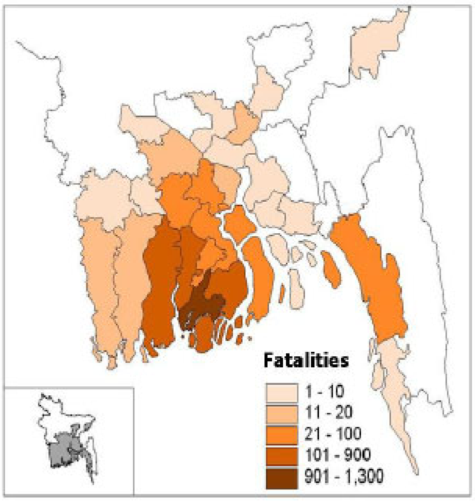
Cyclone winds also generate waves which are mainly affecting the exposed locations along the coast. These waves are generated due the strong winds and propagate towards the shoreline. The shallow bathymetry near the coast partly results in breaking of these waves and limits the wave height. The coastal areas that are most exposed to these waves are the polder areas along the coastline west of the Meghna estuary, the polders in the mouth of the Meghna estuary and the Chittagong-Teknaf coastal strip. Typical wave heights nearshore during cyclones in these areas are 2 - 4 meters. At the tidal rivers and the Meghna estuary in the coastal zone, the wind also generates waves but these are often smaller (1 – 2 meters) due to the limited width of the rivers and also the reduced wind speed more inland.

[69] Bangladesh Disaster Knowledge Network, 2013

A very devastating event was Cyclone SIDR which hit thirty (30) Southern Districts of Bangladesh on Nov 15, 2007 inflicting colossal damages to infrastructures of Coastal Embankment Polders (CEP) and to the lives and properties of Polder residents. The Districts of Patuakhali, Barguna, Pirojpur and Bagerhat were the worst affected ones. Joint Damage Loss and Need Assessments (JDLNA) were done by Government of Bangladesh (GoB) with the support from the international Communities and the estimated loss was assessed at around US$ 1.7 bBillion (BDT 136 bBillion). More than two third of these covered physical damages and the rests were economic losses.

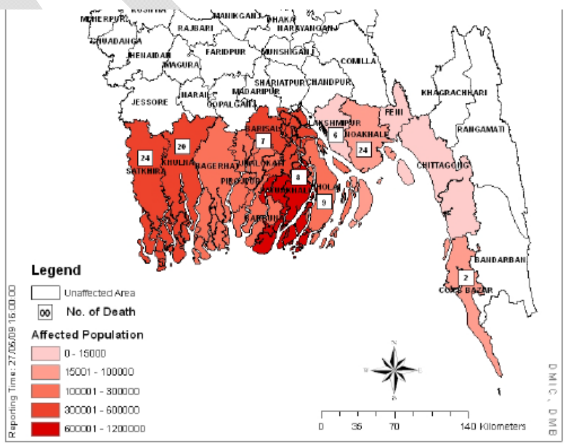


Figure_Apx 97: Most affected districts in damages and losses by Sidr (2007)
Source: Source: Estimates of JDNLA Team



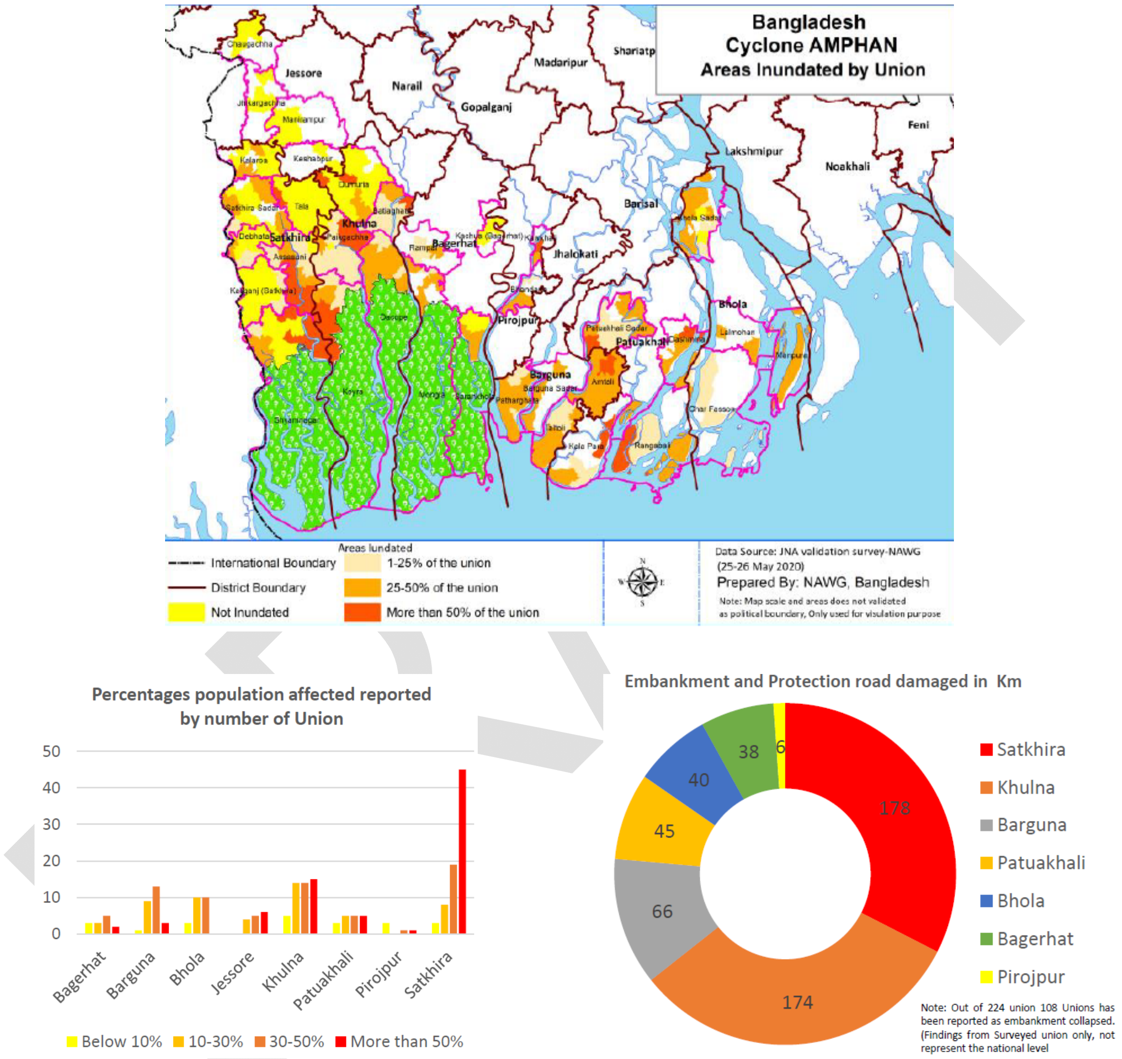
Figure_Apx 98: Number of fatalities per district from Sidr
Source: MoFDM, 2008

Two years later, in 2009, Severe Cyclonic Storm Aila hit Bangladesh, and affected about 40 million people; washed away several thousand homes, took 190 lives, wounded more than 7103 people, flattened huge standing crops, hampered communications system and destroyed infrastructure, livestock, fisheries, social and economic activities.



Figure_Apx 99:Most affected districts in terms of population from cyclone AILA (2009)
Source: ReliefWeb

Cyclone Amphan is the most recent example of a severe cyclone attacking the coastal districts of Bangladesh under Great Danger Signal #10 on Wednesday evening, the 20th May 2020. While the cyclone made landfall in West-Bengal, India, significant impacts were reported in Bangladesh, among which, collapsed embankments, inundation of several villages, damaged houses due to high winds and generally a large extent of economic damages.



Figure_Apx 100: Impacted population and infrastructure due to Amphan (source: Joint Needs Assessment (JNA)

Rivers and flooding

Dynamic river and estuary processes are, of course, mostly to be seen in the Meghna Deltaic Plain (MDP), rather than in the other three areas. The Brahmaputra and Ganges rivers, via the Jamuna and Padma rivers, bring roughly two billion tons of sediment per year into the system, of which some 70% is fine material, very fine sand and silt. In comparison to this, the sediment from the Meghna River's own catchment is negligible (CERP-II, 2000). Most of the sediment is initially carried through the estuary and deposited in the Bay of Bengal. The shifting and sorting of the sediments is done by coastal and marine processes, like tides, waves and surges, as well as by fluvial ones.

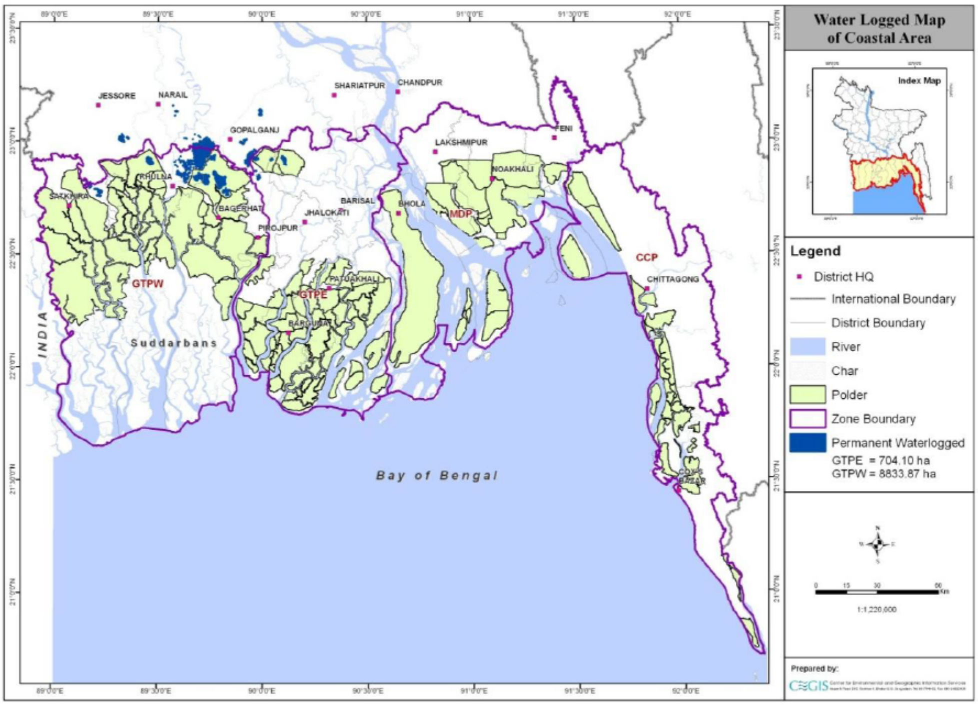
Near the head of the Meghna estuary, around Chandpur and upstream, the dominant processes are fluvial, resulting in braiding and the migration of the thalweg (deepest or main channel). Further downstream, tidal and salinity effects begin to have an influence also, but as far south as Ramgati the migration of the thalweg is the most important process. Dramatic thalweg migration in the much smaller estuary of the Feni River is also eroding a polder embankment. When a thalweg approaches a river bank it tends to erode the bank mainly below water level, so that an embankment built close to the bank will be undermined or outflanked by removal of soil below the level of its toe.

In the seaward parts of the estuary, tidal processes tend to dominate over fluvial ones. In many parts the tidal flow is bi-directional, but the ebb and flood velocities are unequal (tidal asymmetry, leading to 'tidal pumping' of sediment). In other places, notably north and west of Sandwip Island, ebb and flood currents follow different routes (mutually evasive currents). In both cases, tidal action moves sediment often in an inland direction. Under some circumstances sediment can be trapped.

A10.4 Water-logging and salinity intrusion

Drainage of excess water from the polder systems has become increasingly challenging in the past decades due to changing conditions inside and outside the polders. This is especially true for the southwestern region (Khulna, Satkhira, Jessore districts) and Noakhali region, resulting to a total 30% of all polders are now experiencing water logging in the coastal area. This water logging is partly a result of siltation in the drainage canals within the polders resulting from soil erosion which blocks the water flow through the drainage network and towards the drainage structures. Another factor inside the polders is land subsidence due to lack of sediment supply in the polders but also the lowering the ground water table.

Changes outside the polders also impede drainage but these have a different origin in the Ganges Tidal Plain West and the Noakhali region. The Ganges Tidal Plain West has seen a reduction of freshwater inflow during the dry season from the Ganges but also a reduction in tidal prism due the construction of the polder system. These interventions have accelerated river siltation in the past decades in this region. This siltation process in the tidal rivers has resulted in steady increase of tidal water levels in this part of the system. Increasing water levels has reduced the time window of low water periods for draining excess water. In the Noakhali region, a major factor has been the construction of several cross-dams for land reclamation purposes. As a result, the pathways for drainage have become much longer worsening the drainage capacity of these areas.



Figure_Apx 101: Water logging affected areas in coastal zone
(Source: CEGIS, 2011)

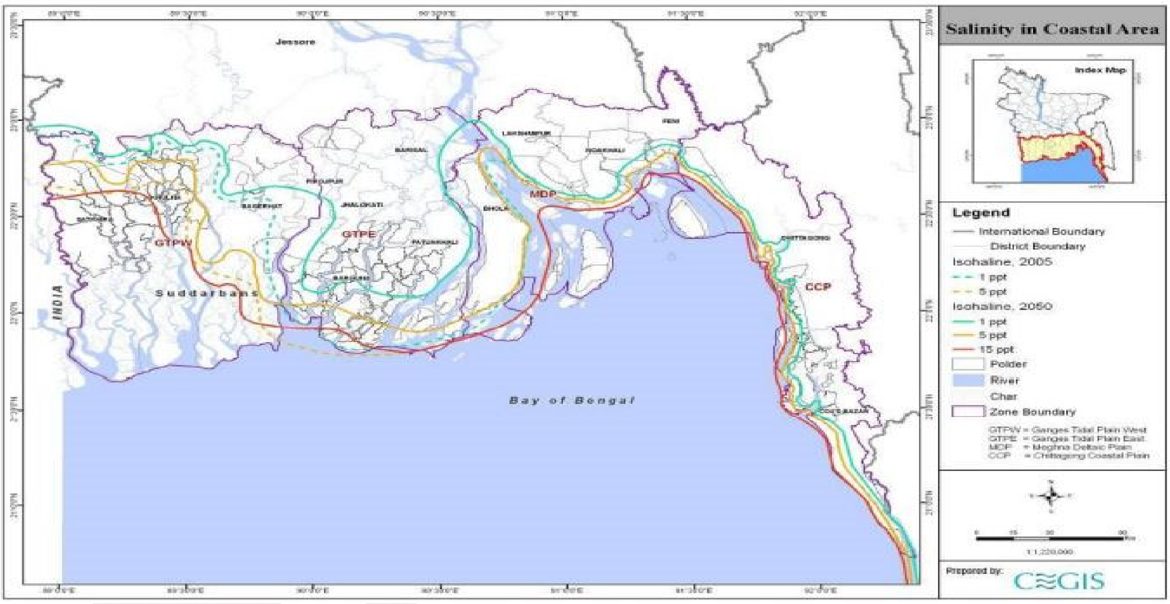
In general, sedimentation processes can be considered beneficial if they occur along the coastline as they cause accretion of land. However, sedimentation proves very detrimental to the efficient functioning of some parts of the river system, especially in upstream stretches of the tidal rivers which are currently experiencing considerable siltation. Siltation of rivers and drainage channels are culpable for causing water logging; saturation of soil with water. In addition, the subsequent loss of tidal range has made it impossible for some polders to be drained through drainage regulators. Siltation had several effects, such as to the navigation route from Hiron Point originally to the Port of Chalna and later to Mongla Port, which began experiencing navigation depth problems in the 1980's[70].

Saline water intrusion is closely linked to sea level rise caused by climate change. Salinity has an impact on the coastal ecology, fisheries, agriculture, and public health depending on temporal and spatial fluctuations. According to IWM and CEGIS (2007), future sea level rise will cause more coastal areas to be afflicted by excessive salinity than current saline affected areas. During monsoon, the 1 ppt salinity line may move upstream by 10 to 20 km, particularly in the central section (through the Baleswar and Buriswar rivers) due to 27 cm and 62 cm sea level rises, respectively. In the year 2000, SRDI conducted a soil survey in Bangladesh's coastal areas. Over the last three decades, the salinity of 187300 hectares has grown. The majority of the Satkhira soil is influenced by salinity, which ranges from moderate to severe. Salinity problems stemming from seawater intrusion are especially intense during the dry months of

[70] DHI, 1994

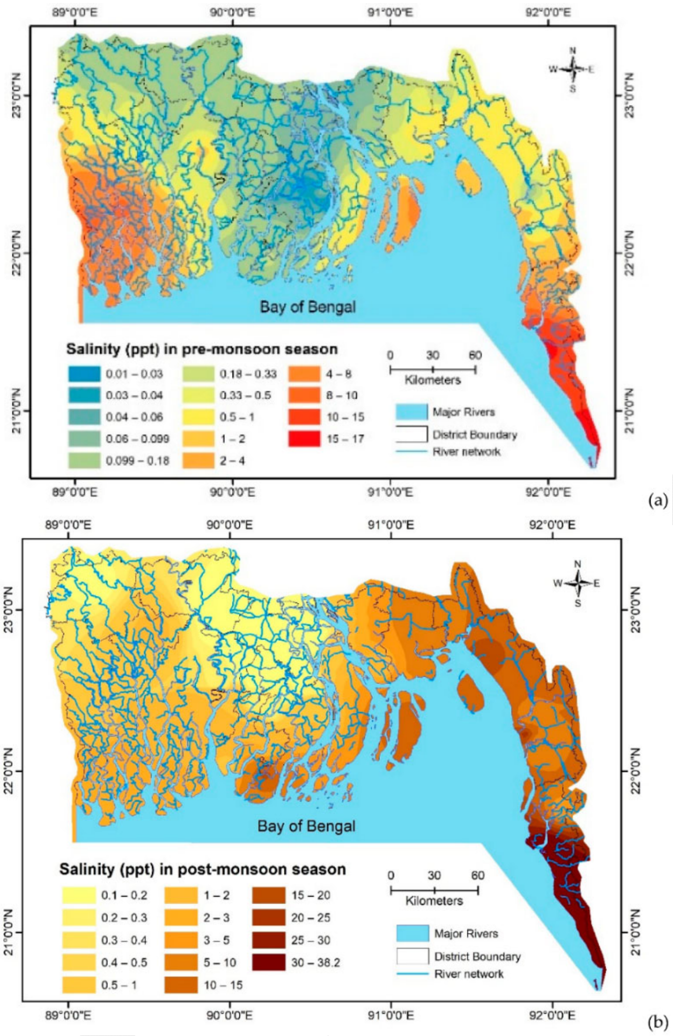
March and April, and fields are frequently left uncultivated because agricultural productivity is limited by salts[71].

Maximum salinity levels in the Meghna Estuary's Hatya and Manpura islands might climb to 3-5ppt for a 27cm (in 2050) and 62cm (in 2080) sea level rise, respectively (IWM and CEGIS, 2007). The salinity problem in the project area will be alleviated due to an enhanced drainage system or protection from saline water intrusion by embankment and water control structures through CEIP. Saline intrusion in khals, ponds, and other surface water sources will be prevented with the projected implementation work of embankment retirement and replacement, as well as new building of water control structures. Flushing during the wet season will also reduce salinity (IWM and CEGIS, 2007).



Figure_Apx 102: Salinity Condition in Coastal Area (for 2005 and 2050)

[71] Rimi, R. H., Rahman, S. H., Karmakar, S., & Hussain, S. G. (2009). Trend Analysis of Climate Change and Investigation on Its Probable Impacts on Rice Production at Satkhira, Bangladesh. Pakistan Journal of Meteorology, 6(11), 37–50



Figure_Apx 103: Seasonal variation in salinity Condition in Coastal Area

A10.5 Climate change

Based on Becker et al. (2020)[72], an overview of estimated Relative Sea Level Rise (RSLR) for the different coastal regions is reported in Table 6-6, and derived based on 101 water level gauges available for the period 1968-2012. The values estimated indicate that RSLR over the analysed 45 years is ≈ 3 mm/year (i.e. therefore larger than global median values reported for the same period ≈ 2mm/year) and with relatively minor differences across the first three regions (i.e. Western Ganges Tidal Plain, Eastern Ganges Tidal Plain, Meghna Deltaic Plain), which are within the uncertainty band. The region with the lowest RSLR is the Chittagong Coastal Plain, however statistical trends are not significant for this region. It should be considered. ASLR rates were also estimated[72] based on satellite altimeter datasets over 1993 to 2012 (Table 6-6).

[72] Becker, M., Papa, F., Karpytchev, M., Delebecque, C., Krien, Y., Uddin Khan, J., Ballu, V., Durand, F., Le Cozannet, G., Saiful Islam, A.K.M., Calmant, S., and Shum, C.K., 2020. Water level changes, subsidence, and sea level rise in the Ganges-Brahmaputra-Meghna delta. Proceedings of the National Academy of Sciences Jan 2020, 117 (4) 1867-1876; DOI: 10.1073/pnas.1912921117

Surprisingly, reported estimated values of ASLR are on the same range as reported RSLR. However, the two datasets have been derived based on completely different datasets and periods. Maximum subsidence rates within the region, estimated as local differences between RSLR and ASLR over 1993 to 2012, can be considerable and up to 7 mm/y. No value was reported for Chittagong Coastal Plain area in view of the large differences with the rest of the delta and enhanced tectonic activity in this region[72]. As also discussed[72], local subsidence is expected to largely enhance the effect of ASLR locally.

Table 6-6: Relative sea level rise[73]

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)	-

Conclusions:

- 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;
- 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
- Differences in absolute sea level rise scenarios across the delta are minimal 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;
- 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;

- 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

[73] *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 (adapted from Becker et al., 2020[72])*

m by 2100. It is advisable to take these high-end values into account in the longterm planning of the polders across the GBM delta.

Cyclone frequency and intensity

Information on TC events derived from the IBTrACS database[74,75] and specifically from the subset by the Joint Typhoon Warning Center (JTWC) were used as a basis to assess possible historical changes in TC frequency and intensity.

Figure_Apx 104 suggests that the number of cyclone events and most extreme cyclone events has been slowly increasing through time during the last 5 decades in the North Indian Ocean. Very remarkable has been the year 2019, which was characterized by 6 TCs, all of them in the “severe” category. This finding is consistent for example with Singh et al. (2000)[76] and Deo et al. (2011)[77] that have shown an intensification of the most extreme TCs. When we focus on the Bay of Bengal only (Figure_Apx 104), one can see that the number of TCs has been decreasing, however the number of most extreme TCs has been increasing through time. The estimated changes have been equal to -0.4% per year and +1.7% respectively for all the TC events and the most extreme ones only. Similar conclusions were reported for example by Webster et al. (2005)[78] and in the BDP2100, indicating that the number of TC is decreasing but the intensity is increasing. Finally, Figure_Apx 104 focuses on the Bangladesh coastal zone only. The figure suggests that, if we focus on the Bangladesh coastal area only, it is difficult to draw firm conclusions on whether the number of events and intensity has decreased/increased over time.

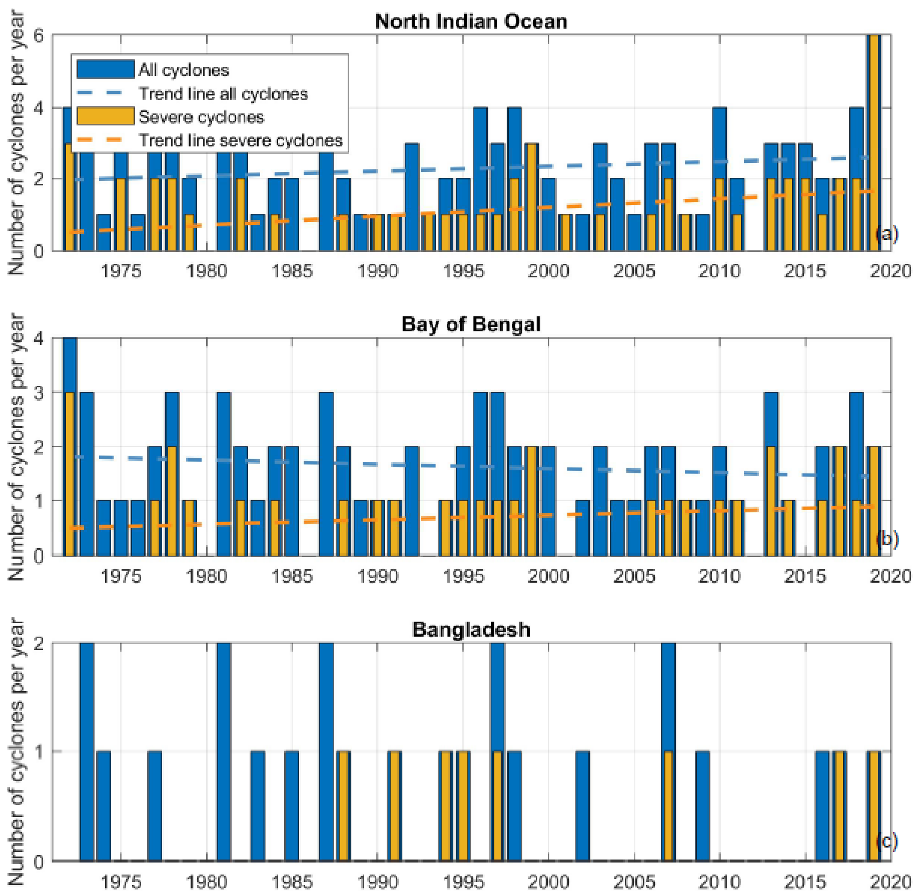
[74] Knapp, K.R., Kruk, M.C., Levinson, D.H., Diamond, H.J., and Neuman, C.J., 2010. The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying Tropical Cyclone Data. American Meteorological Society. https://doi.org/10.1175/2009BAMS2755.1

[75] Knapp, K.R., Diamond, H.J., Kossin, J.P., Kruk, M.C., Schreck, C.J., 2018. International Best Track Archive for Climate Stewardship (IBTrACS) Project, Version 4. NOAA National Centers for Environmental Information. https://doi.org/10.25921/82ty-9e16.

[76] Singh, O. P., Khan, T.M.A., Rahman, S, 2000. Changes in the frequency of tropical cyclones over the North Indian Ocean. Journal of Meteorology and Atmospheric Physics. 75, 11-20. https://doi.org/10.1007/s007030070011

[77] Deo, A.A., Ganer, D.W., and Nair, G., 2011. Tropical cyclone activity in global warming scenario. Journal of Natural Hazards. 59(2), 771-786. 10.1007/s11069-011-9794-8.

[78] Webster, P.J., Holland, G.J., Curry, J.A., and Chang, H.-R., 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science, 309, 1844- 1846, 1575.



Figure_Apx 104: Number of cyclones per year since 1972[79]

<u>Conclusions</u>

- 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.[80] 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

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[79] as retrieved from the JTWC database for: (a) the North Indian Ocean, (b) the Bay of Bengal and (c) the Bangladesh coastal zone. Plots are made for all cyclones (in blue) and only the severe cyclones (maximum wind speed larger than 40 m/s) (in orange). Linear trend lines have been added to show estimated changes in cyclone frequency over the time period.
[80] Knutson, T., Camargo, S.J., Chan, J.C.L., Emanuel, K., Ho, C.-H., Kossin, J., Mohapatra, M., Satoh, M., Sugi, M., Walsh, K., and Wu, L., 2020. Tropical cyclones and climate change assessment. Part II: Projected Response to Anthropogenic Warming, Vol. 101, Issue 3, https://doi.org/10.1175/BAMS-D-18-0194.1

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. [80], 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%.
- 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%[80].
- TCs induced precipitations are projected to increase due to enhanced atmospheric moisture associated with anthropogenic global warming.
- According to global CMIP5 climate models[80] 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.

A10.6 Climate and quality environment

Climate

Bangladesh's climate is dominated by subtropical monsoons, which are marked by large seasonal changes in rainfall, relatively mild temperatures, and high humidity. The entire country of Bangladesh is classified into seven climate zones, with three climatic zones in the coastal areas: (A) South-eastern zone, (F) South-western zone, and (G) South Central zone. Pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and winter are the four major seasons in a year (December-February).

Maximum and minimum temperatures in Bangladesh's coastal zone range from 30°C to 36°C and 11°C to 23°C, respectively[81]. April and May have higher temperatures, whereas January is the coldest month of the year.

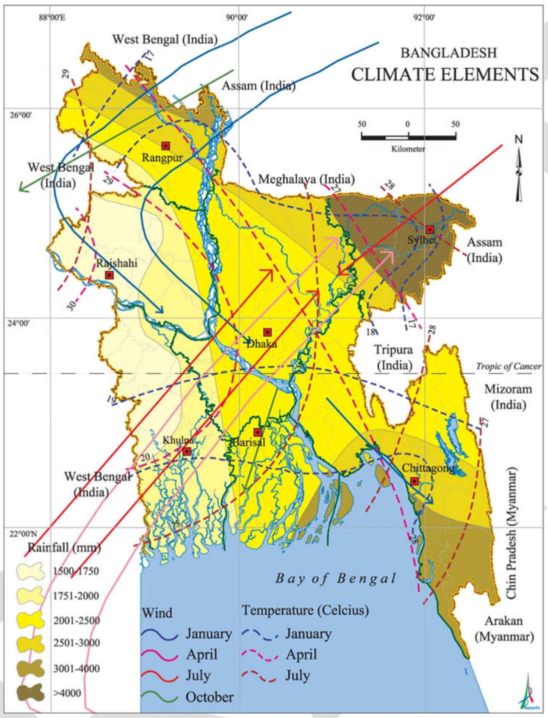
Annual rainfall in Bangladesh's coastal region ranges from little over 1,700 mm in the west to more than 3,200 mm in Cox's Bazar in the east. From Feni to Cox's Bazar, the east coast receives the most rainfall. Aside from the southwest air mass's connection instability, the sea breeze adds to the orographic lifting induced by the Chittagong and Chittagong Hill districts' north-south oriented hills. Most of the rain falls in the foothills.

Humidity levels in the coastal zone are lowest in January and April, and highest in June and October. Only in the months of December and January does evaporation exceed rainfall.

[81] WARPO, 2006.State of the Coast 2006, Integrated Coastal Zone Management Program, Bangladesh

Evaporation outweighs rainfall in all other months. The highest excess occurs from May to October, with the lowest excess occurring from February to April and November.

The wind blows primarily from two directions in the coastal zone: NE and SE. During the winter, the NE winds dominate, while the SE winds dominate during the summer. The greatest average wind speed is 80 km/ hr.



Figure_Apx 105: Climate Scenario of Bangladesh

Air quality

In Bangladesh's coastal region, air pollution is not a major perturbation. Road and river transportation, as well as businesses (such as cement mills, petroleum refineries, and power plants), account for most emissions. Air quality (mostly three metrics - SPM, SOx, and NOx) was measured in eight places throughout the coastal area (4 urban and 4 rural). The current air quality indicators are noted to be within standard norms in most regions, except for high SPM in Khulna city, Chittagong, Cox's bazar, and Noakhali town, which is primarily owing to high traffic loads.

Table 6-7: Air Quality Parameters

Sample Location	Type of Location	Date	Air Quality Parameters		
			SPM ($\mu g/m^3$)	SOx ($\mu g/m^3$)	NOx ($\mu g/m^3$)
Shibbari moor, Khulna City, Khulna	Urban	01/05/12	410	27	46
In front of upzila Polli Unnyon board office, Thana moor, Sharankhola, Bagerhat	Rural	03/05/12	140	11	20

Sample Location	Type of Location	Date	Air Quality Parameters		
			SPM ($\mu g/m^3$)	SOx ($\mu g/m^3$)	NOx ($\mu g/m^3$)
Bus stand moor, Pirojpur town, Pirojpur	Urban	02/05/12	180	10	18
In front of Upazila office, Mathbaria, Pirojpur	Rural	02/05/12	148	5.2	15
Foy's Lake Moore, Khulshi, Chittagong	Urban	20/05/12	314	5.4	14.2
Chokoria Bus Stand, Cox's Bazar	Rural	23/05/12	290	ND	10.2
Court road, Maijdi, Noakhali	Urban	21/05/12	280	4	12.5
In front of Haji Bari, Laksmi Narayanpur village, Noakhali	Rural	21/05/12	45	ND	ND
ECR standard for Residential and Rural area			200	80	80

Water quality

The principal sources of water pollution in the coastal area are domestic sewerage, industrial effluent, and oil spills from water transports. The water quality of various important rivers and ponds in the coastal region was examined and the results showed that most of the water quality indicators were within acceptable limits. Both river and pond water had salty pH and electrical conductivity (EC) values, indicating that they were both saline. In addition, pond waters had a high coliform content. In addition, the quality of groundwater was assessed by collecting tube-well water samples from eight distinct coastal locations. Most water quality measures are within threshold limits, with a few exceptions (for example, high chloride in Khulna city, high iron content in Noakhali town, and high arsenic concentration in Noakhali area). In general, all tube-wells had increased chloride content, i.e. salinity.

Figure_Apx 106: Surface Water Quality Parameters

Sample Location Date	Date	Surface Water Quality Parameters									
		Temp. (ºC)	pH	EC (µS/cm)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	TDS (mg/L)	SS (mg/L)	Coli colonies(No/100m	N-nitrate (mg/l)
Baleshore river (up), Chalna Namajpur, Pirojpur	01/05/12	29.2	6.86	0.49	7.8	0.4	25	1463	45	350	2
Baleshore river (down), Mathbaria, Pirojpur	01/05/12	29.1	6.86	1.12	7.2	0.4	20	1163	45	375	2
Gunakhali river near Raenda bazar, Sharankhola, Bagerhat	02/05/12	31.5	6.86	2.33	7.8	0.4	20	353	60	250	2
Rupsha river ghat Side point, Khulna	03/05/12	29.2	7.71	3.34	7.2	0.8	28	817	70	520	2

Surface water sample of Karnafully river water 15 No ghat, Potenga, Chittagong	20/05/12	32	7.84	2.81	7.3	2.4	351	1268	1079	190	1.3
Surface water sample ofMaijdi DC office Dighi, Noakhali	21/05/12	31.6	7.4	2.36	7.9	2.6	8	950	67	1150	0.5
Surface water sample ofHaji Bari Pond, Lakki Narayonpur, Sadar Noakhali	21/05/12	30	7.21	2.72	8.6	8.4	12	1400	234	1420	0.8
Surface water sample of Matamuhuri river Chokoria Cox's Bazar, Cox's Bazar	23/05/12	31	6.94	2.44	8.2	1.1	3	1540	75	210	0.2
Standard for inland surface water for fisheries as per ECR'97		NA	6.5 – 8.5	NA	≥5	≤6	NA	NA	NA	NA	NA

Note: ND = Not Detected; NA= Not Available
(Source: Lab test by DoE, Khulna and Chittagong, May 2012)

Figure_Apx 107: Ground Water Quality in Different Rivers in Coastal Area

Sample Location	**Date**	**Ground Water Quality Parameters**					
		Temp	**pH**	**Chloride (mg/l)**	**Iron (Fe) (mg/l)**	**SS (mg/l)**	**As (mg/l)**
Tube well water of Danishafa UP office, Mothbaria, Pirojpur	01/05/12	25.4	7.56	355	0.78	5	0
Tube well water of Pirojpur upazila health complex, Pirojpur town, Pirojpur	02/05/12	25.3	7.25	421	0.8	4	0
Tube well water of upazila primary school, Sharankhola, Bagerhat	02/05/12	25.2	7.45	532	0.88	4	0
Tube well water of Divisional Commissioner office, Khulna	03/05/12	25.6	7.57	667	0.45	5	0
Deep T/W sample of Akbarsha mosque, Khulshi, Chittagong	20/05/12	28.0	7.2	66	0.14	1	0
Deep T/W sample of Mojaffor Haji Bari, Laksmi Narayanpur, Noakhali Sadar, Noakhali	21/05/12	26.0	8.3	224	0.76	3	0.5
Deep T/W sample of Kiron Hotel, Maijdi Court, Noakhali	21/05/12	28.7	7.7	388	2.86	2	0.6
Deep T/W sample of Mr. Zakir Hossain home, Kakara, Chokoria, Cox,s Bazar	23/05/12	29.0	6.7	182	0.78	3	0.03

Sample Location	Date	Ground Water Quality Parameters					
		Temp	pH	Chloride (mg/l)	Iron (Fe) (mg/l)	SS (mg/l)	As (mg/l)
Drinking water quality standard as per ECR'97			6.5 – 8.5	150 –600	0.3 – 1.0	10	0.05

(Source: Lab test by DoE, Khulna and Chittagong, May 2012)

A10.7 Environmental

In general

The Ganges Tidal Floodplain West: The Sundarbans mangrove forest (including the part in India) is a globally unique ecosystem due to its size, its variety of mangrove species but the abundance and diversity of fauna. This mangrove forest covers 6,017 km2 in Bangladesh and has 12-13 different mangrove types out of the 35 worldwide. The biotic diversity comprises 400 species of fishes, 53 species of reptiles, over 315 species of birds and 50 species of mammals. Large animals include spotted deer, crocodiles and tigers. Fishes include finfish and shellfish including shrimp and prawn, lobster, crabs, snails, mussels and shells, cuttlefish, squids. Marine mammals like sharks, rays, sea horses, whales, dolphins and also marine reptiles such as turtles and sea snakes live in this region too. The Sundarbans is a RAMSAR site declared under "The Convention on Wetlands". In addition, the Government of Bangladesh has declared three wildlife sanctuaries and three dolphin sanctuaries in the north of the Sundarbans along the Pussur, Shela and Bhola Rivers.

The Meghna Deltaic (Estuary) Plain: The Meghna estuary is an extraordinarily rich ecosystem due to mixing of tidal and river waters, the continuous supply of sediments and nutrients and the remote intertidal areas. The islands in the estuary mouth are a strategic location in the migratory East Asian-Australasian Flyway, in particular waders and other waterbirds during winter. More than a hundred thousand birds visit this area amongst which critically endangered birds like Spoonbill Sandpiper, Nordmann's Greenshank, Asian Dowitcher, Great Knot. These birds feed themselves with benthic organisms, mollusks, crustaceans, and marine worms. The intertidal areas in the estuary are also nursery and feeding ground for many fish species such as Hilsa and Pangas.

The Chittagong Coastal Plain: This region has a large variety of different ecosystems with some small pockets of natural mangrove forests, small estuaries, sand dunes and beaches. One mangrove area of ecological importance is present near Cox's Bazar where it occupies the low-lying saline swamp at the mouth of the Matamuhuri River delta. This area known as Chakoria Sundarban provides a habitat for a variety of marine and terrestrial organisms[82]. Another area of ecological interest is the Teknaf Peninsula with one of the longest sandy beach ecosystems (80 kilometres) in the world. This area has a mixture of mangroves, mudflats, beaches and sand dunes, and lagoons. It provides breeding ground for two globally threatened species of marine turtles and, is located along international bird migration flyways. To protect this rich

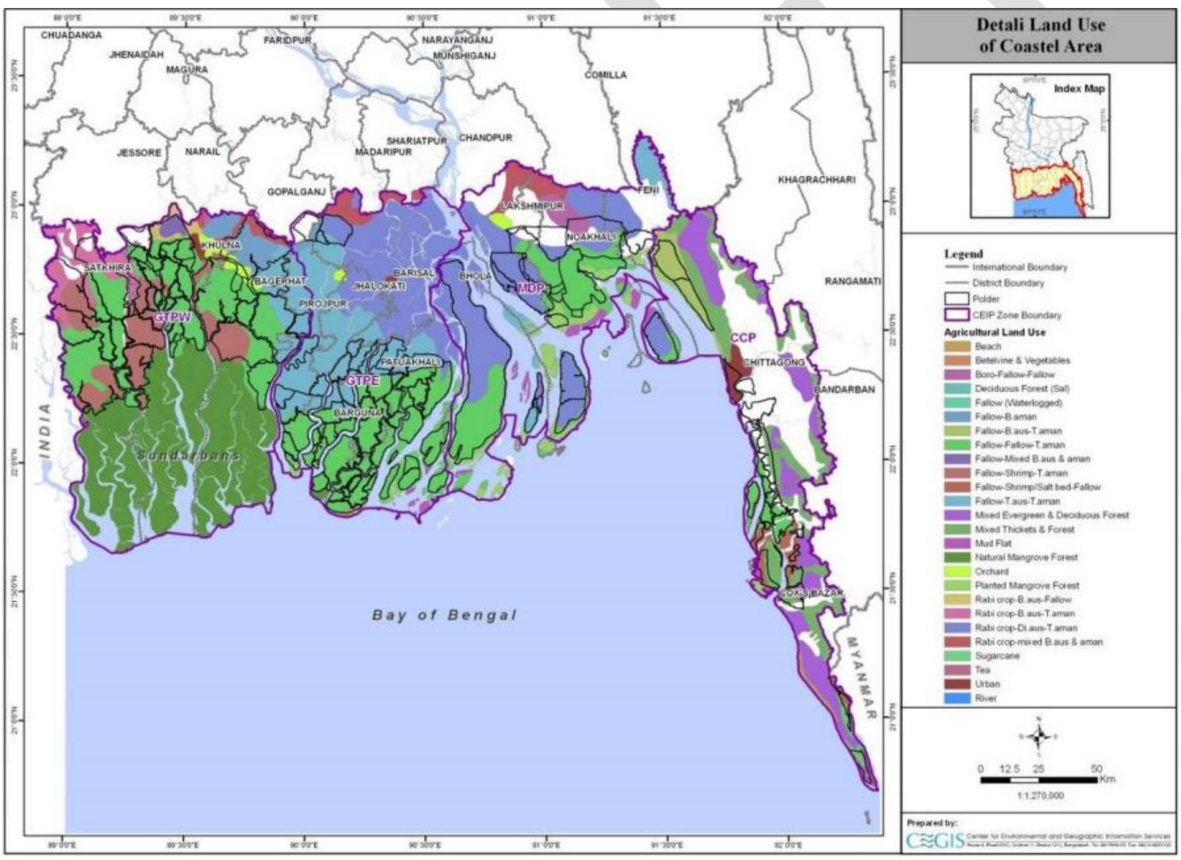
[82] Hossain, M. S., C. Kwei Lin, and M. Z. Hussan. 2001. Goodbye Chakaria Sunderban: The Oldest Mangrove Forest. The Society of Wetland Scientists Bulletin. No. 18 (Sep 2001):19-22.

biodiversity along the coast, the region has three protected areas: Cox's Bazaar - Teknaf Wildlife Sanctuary, Himchhari National Park and Inani National Park.

Soil and agriculture

Several soil types can be found along the coast, ranging in texture from sandy loams to heavy breaking clays. Except for some soils in the Old Ganges and Meghna floodplain basins, most coastal soils are saline and non-calcareous. The majority of coastal zone soils are moderately to severely alkaline.

The coastal region contains approximately 3.6 million acres of Net Cultivated Area (NCA), with an average cropping intensity of 175 percent, and is primarily planted with local and hybrid rice crops. The 139 polders occupy a total area of around 1.12 million acres, of which about 64% is suitable for crop production. Rain-fed cropping and irrigated cropping systems are the most common agricultural strategies in the coastal zone.



Figure_Apx 108: Agricultural Land use Map of Coastal Area

The principal cropping sequences in rain-fed highlands include local/HYV broadcast Aus followed by local/HYV transplanted Aman, and local broadcast Aus followed by a wide range of Rabi crops, depending on the residual soil moisture. In regions with sufficient soil features and access to highways and arterial routes, a broad variety of Kharif vegetables are produced in place of Aus. Jute is the dominant cash crop in the area, with broadcast Aus taking its place in the planting pattern. Kharif vegetables can also be cultivated as a substitute for Aus or jute.

Local / HYV broadcast Aus is followed by local / HYV transplanted Aman as the dominant cropping sequence on medium highland, occasionally flooded up to 90 cm. Rabi crops such as wheat, legumes, oilseeds, vegetables, spices, and minor cereals are also grown as a third or second crop after transplanting Aman. To avoid damage from floods, which begins in June and peaks in mid-August, early broadcast Aus or late transplanted Aman is grown on medium lowland. Jute, wheat, and potato are also farmed on this sort of ground.

Agricultural techniques are determined by factors such as soil and land type, irrigation availability, crop product demand, and so on. Rice is the major crop in the current cropping pattern. Rice takes up a significant amount of the total planted area (approximately 75 percent). In both the Kharif and Rabi seasons, the residual space is used for other crops. Wheat, winter vegetables, bean, cowpea, pulses, oilseeds, potato, sweet potato, chile, cowpea, millet, water melon, ground nut, and other Rabi crops are among them.

The following are the major challenges in the 'agriculture' sector that are related to CEIP:
Soil salinity is the region's most significant limiting factor for agricultural techniques, particularly during the dry season. During the dry season, there is a scarcity of good irrigation water, which inhibits the cultivation of boro rice and rabi (winter) crops, as well as aus cultivation during the kharif-1 (March-July) season. Rainfall variability, unknown dates for the commencement and receding of seasonal floods, and the risk of drought limit the production of aus and aman rice. Waterlogging in the polder areas is a constant problem due to poor drainage and improper sluice gate operation.

Fisheries

In the fresh to brackish water environment, the coastal fishery primarily comprises of two types of fisheries: capture and cultural fisheries. Capture fisheries are divided into three types: river and canal fisheries, marine artisanal fisheries, and post larvae (PL) fisheries. Similarly, the habitat type of cultural fishery includes ponds and shrimp ghers.

River/ canals *Ponds/Ditches* *Gher*

Figure_Apx 109: Coastal fish habitats

In the coastal zone, two types of aquaculture are practiced: fish culture (mostly freshwater species) and shrimp culture. Pond fish farming is more common in the polders of the Ganges Tidal Plain West and East, as well as the Meghna Deltaic Plain (MDP). The ponds/ditches are primarily stocked with white fish, while the Ghers are stocked with either monoculture shrimp or shrimp mixed with white fish/prawn.

The overall cultivable land area in the CEIP area is approximately 931,300 ha, with the shrimp farm covering 89,200 ha. The polder areas of Khulna, Bagerhat, Satkhira, and Cox's Bazar districts are home to the majority of shrimp farms. Bagda (Penaeus monodon, P. indicus), Golda (Macrobrachium rosenbergii), Baila (Glossogobius giuris), Golshatengra (Mystus sp), and other species are part of the Gher cultural fisheries.

Shrimp's importance in the coastal zone has increased dramatically during the previous 30 years. Shrimp farms are important sources of employment and foreign cash in Bangladesh. In 2008-2009, shrimp output in the coastal zone accounted for 99.89 percent of the country's total, according to DoF statistics[83]. It is the country's second-largest foreign exchange earner.

Despite the fact that the coastal area is rich in capture fisheries, particularly brackish water fisheries, culture fisheries such as shrimp culture practices are rapidly expanding in the southwestern and south eastern zones. As a result, mono fish farming will be expanded, influencing the growth of certain fish species. Salinity intrusion due to sea level rise, on the other hand, could restrict freshwater fish habitat in the coastal area. As a result, freshwater fisheries productivity may be impeded, as freshwater carp, catfish, perch, and other species are especially susceptible to moderate salinity.

The following are the significant concerns and issues in the coastal fisheries sector:
Changes in river morphology, poor fisheries management, and aquatic biological conditions; Due to siltation and surface water salinity increase, fish habitat and depth are decreasing. Due to excessive shrimp farming practices, floodplain fisheries are being lost. Inadequate migratory paths between rivers and diverse interior water sources obstruct feeding and spawning migration. Due to a lack of communication and infrastructure, the fish marketing system and post-harvest facilities are inadequate.

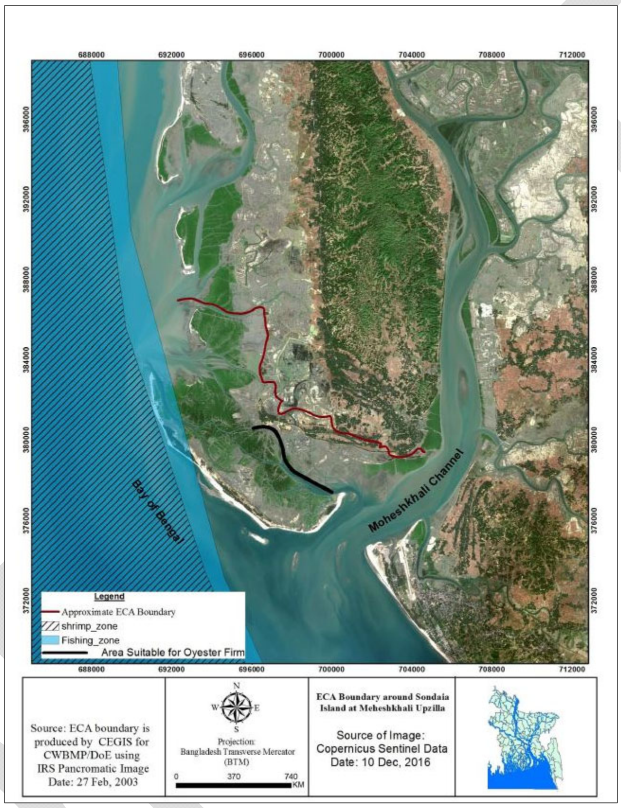
Ecosystems and biodiversity

The Ganges floodplain and major rivers, Coastal marine water, Meghna floodplain, Sundarbans, Chakaria Sundarban, Coastal plains, Offshore islands, and Meghna estuarine floodplain are the ten bio-ecological zones that make up Bangladesh's coastal zone. Due to its ecological and physical conditions, the coastline area is enhanced with a variety of fresh and brackish water environments. Marine, brackish water, freshwater, mangrove, Sundarbans, floodplain, island,

[83] DoF, 2010. Fishery Statistical Year Book of Bangladesh, 2008-2009. Fisheries Resources Survey System, Department of Fisheries (DoF), Dhaka

peninsula, and terrestrial ecosystems are some of the habitat types found in the region (roadside and homestead). This area also contains a shrimp farming pond (Gher) habitat.

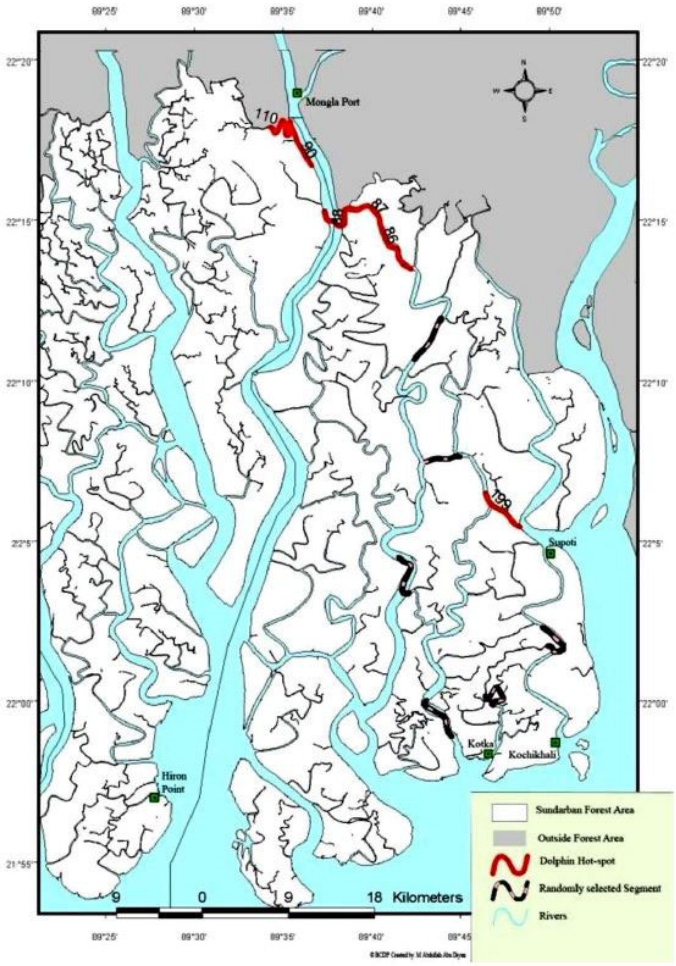
Ecologically Critical Areas (ECAs), Ramsar sites, National Parks, Wildlife Sanctuaries, Eco-parks, Game Reserves, World Heritage Sites, Marine Reserves, and Fish Sanctuaries are some of the ecosystem management approaches used to safeguard sensitive ecosystems in Bangladesh's coastal region.



Figure_Apx 110: Ecological Critical Areas in Sonadia Island
(Source: CWBMP/UNDP/DoE)

Some coastal polders are located within these protected regions, primarily within the Sundarbans Reserve Forest's 10 km perimeter, which has been designated as an ECA (in Satkhira, Khulna and Bagerhat district).

The coastal zone has a healthy terrestrial and aquatic environment, which supports a diverse range of flora and wildlife. The native prominent flora includes Hargoza (Acanthus illicifolius), Narikel (Cocos nucifera), Khejur (Phoenix sylvestris), and Bhadi (Lennea coromandelica).



Figure_Apx 111: Dolphin Sanctuary outlined by red lines[84]

The prominent local animals in the area where shrimp aquaculture is limited are the jackal (Canis aureus), grey mask shrew (Suncus murinus), and little Indian civet (Viverricula indica). The Saurs crane (Grus antigone), the Black-winged stilt (Himantopus himantopus), the Little grebe (Tachybaptus ruficollis), and the Redwattled lapwing (Vanellus indicus) were previously plentiful in this area, but they are now uncommon. In this location, ring lizards (Varanus salva), banded sea snakes (Hydrophic fasciatus), estuarine sea snakes (Hydrophic obscura), and other reptiles are plentiful, but they are rarely seen in areas where heavy shrimp farming is practiced.

Mangroves

The Sundarban, the world's biggest mangrove forest, is in the southwestern part of the coastal region. Mangrove forests are transitional zones between fresh and salt water, with a diverse range of marine and terrestrial vegetation and fauna. Mangrove forests also provide as a natural barrier against cyclonic storms and tidal surges, as well as stabilizing coasts, enhancing land

[84] SMITH, B. D., DIYAN, M. A. A., MANSUR, R. M., MANSUR, E. F. and AHMED, B. 2010. Identification and channel characteristics of cetacean hotspots in waterways of the eastern Sundarbans mangrove forest, Bangladesh. Oryx 44(2): 241-247.

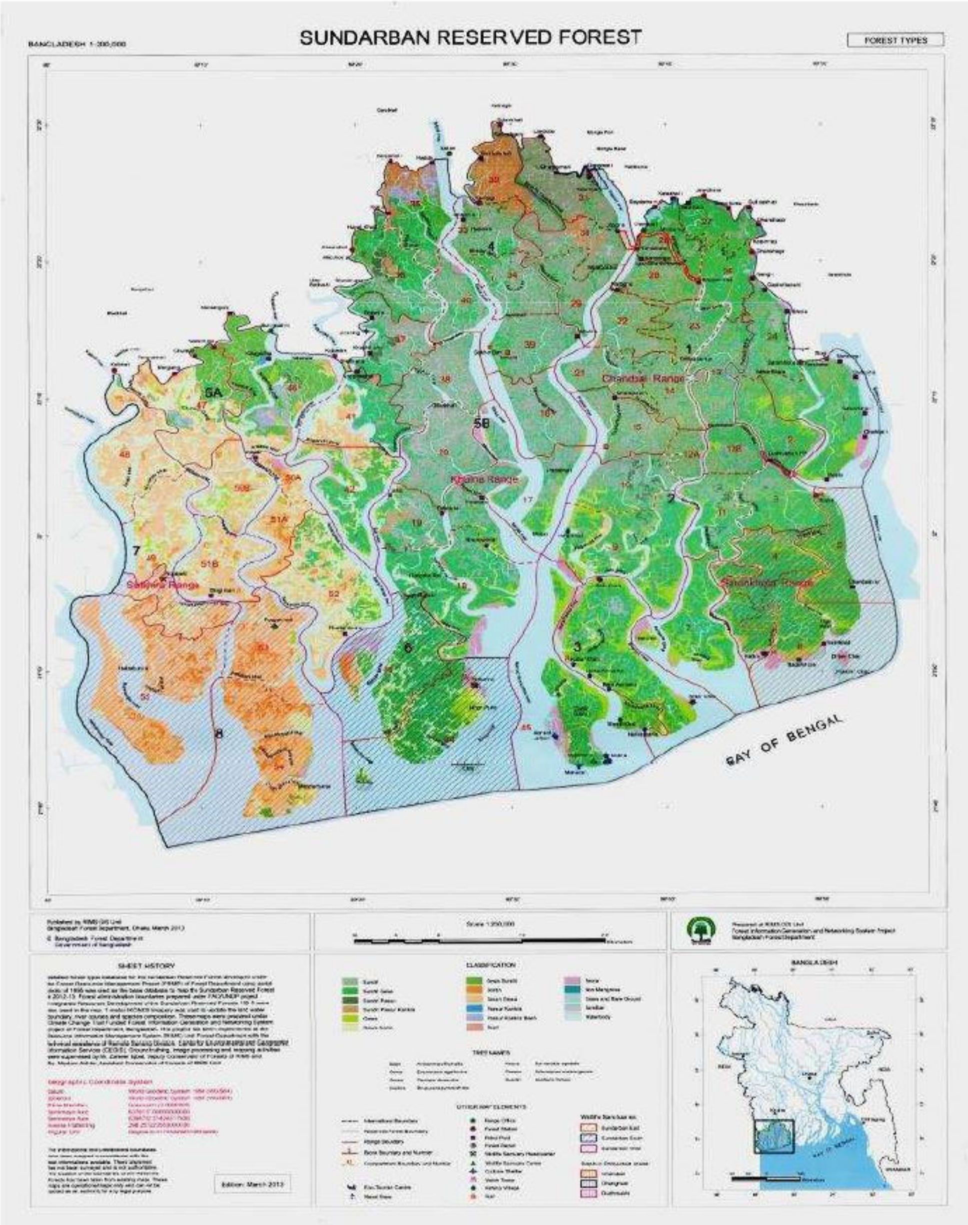
accretion, and enriching soil near the water. The Sundarbans Reserve Forest covers 601,700 hectares, with 406,900 hectares of forest, 187,400 hectares of water (rivers, rivulets, ponds, and canals), 30,100 hectares of wildlife sanctuaries, and 4200 hectares of sand bars.

The mangrove forest is extremely diverse, supporting 334 plant species, 77 insect species of various orders, 7 crabs, 1 lobster, 23 shrimp/prawns, 400 fish, 8 amphibians, 35 reptiles, 270 birds, and 42 mammal species. In the Sundarbans, there are roughly 13 orchid species and 23 medicinal plant species, respectively.

The Sundari (Heritiera fomes) and Gewa (Heritiera sp.) are the two most important commercially important plant species in the Sundarbans (Excoecariaag allocha). Gewa and Goran (Ceriops roxburghiana) are among the trees that are utilized in newsprint mills for paper manufacturing as well as for fuel. The timber woods Sundari and Keora (Sonneratia apetala) are employed. Golpata is the most major non-wood forest product (Nypa fruiticans). This plant's leaves are commonly utilized for thatching roofs of buildings and boats, as well as fencing the homes of millions of people living along the coast. According to the Forest Department, between 2001-02 and 2009-10, the annual output rate of timber, fuel wood, and thatching materials (Golpata) was roughly 3567 m3, 120 tonnes, and 26653 tonnes, respectively.

Sundarban's forest resources and biodiversity are threatened by natural disasters such as cyclones and storm surges, as well as overexploitation. The hurricane Sidr (in 2007) wreaked havoc on the Sundarban and its surrounding areas, wiping out vast swaths of biodiversity. Sea level rise as a result of climate change is another threat to the Sundarban's biodiversity. Increased salinity is expected to put the Sundari in the mangrove forests in jeopardy. Furthermore, city wastewaters, industrial pollution, oil pollution, and shipbreaking, among other things, are detrimental to coastal and marine biodiversity, particularly in the Chittagong and Khulna regions.

The Sundarbans, South Asia's largest mangrove forest, is near to six districts and seventeen polders. Bagerhat, Sathkhira, and Khulna are all within the Sundarbans' effect zone (10 km outside the Sundarbans). The quantity and pattern of water flow inside the Sundarbans' canals may be affected indirectly by polder rehabilitation and reconstruction.



Figure_Apx 112: Sundarban Reserve Forest
(Source: CEIP I review report 2019)

A10.8 High level risk assessment

Hazard assessment for storm surge for utilization in risk assessment

Physical vulnerabilities, delineated by cyclonic induced storm surges spans the entire Bangladesh coastline. The 19 cyclones which made a landfall in Bangladesh between 1960 and 2009, can collectively define the current cyclone related vulnerability in Bangladesh. While historical records of storm surge height are scarce in Bangladesh, the existing literature suggests typical storm surge height during severe cyclones is between 1.5 and 9.0 meters, while storm surge heights in excess of 10 m are less common[85], and are expected to occur approximately every 25 years[86]. When combined with an expected rise in sea level, cyclone-induced storm surges are projected to inundate an additional 15% of the coastal area.

Each cyclonic event generates different storm surge levels along the coast, following diverse amplification or compression patters after intersecting with the low-lying areas and the waterbodies, whose dynamics are determining factors. Hence, for the sake of this assessment, the coastal zone of Bangladesh is divided in zones which present similar characteristics, observing which Upazilas experience similar storm surge levels.

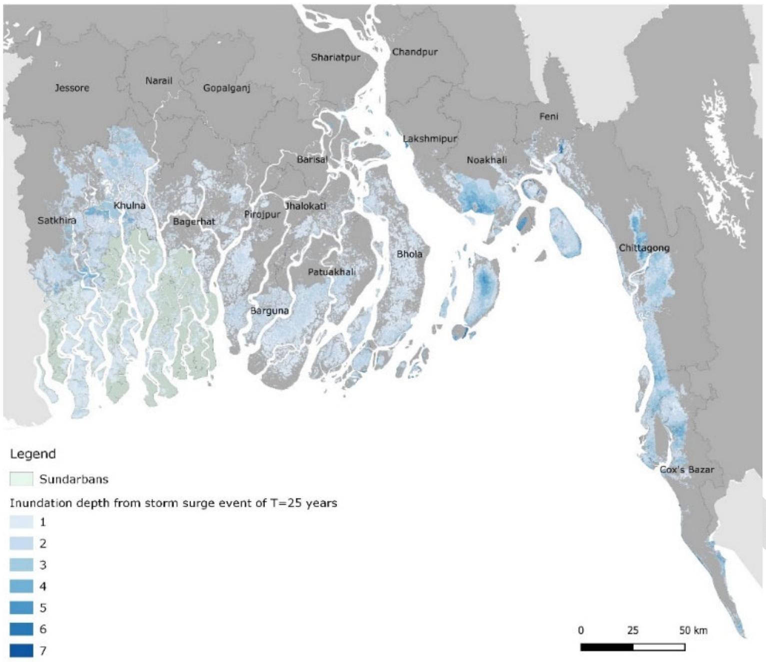
The storm surge levels used within this exercise are the ones defined within CEIP-1[87]. Two scenarios have been assessed: baseline and climate change. The climate change scenario's storm surge levels have been generated under climate change scenario of RCP 8.5 (IPCC, AR5).

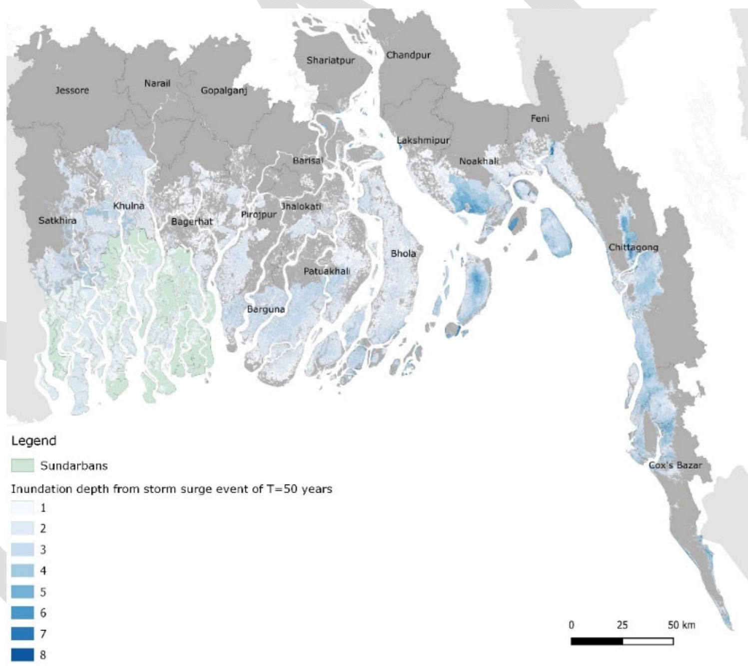
The predominantly low-lying topography of the coastal zone determines the inundation levels and extents as follows (examples are presented for storm surge of 25 and 50 years return period for the climate change scenario in Figure_Apx 113).Those figures should be treated with caution considering the exposure underprediction which follows the use of global freely available Digital Elevation Models such as the MERIT DEM.

[85] SMRC (SAARC Meteorological Research Centre). 2000. The Vulnerability Assessment of the SAARC Coastal Region due to Sea Level Rise: Bangladesh Case. Dhaka: SAARC Meteorological Research Centre, SMRC Publication

[86] Multi-purpose Cyclone Shelter Project (MCSP). 1993. Summary Report. Dhaka: Bangladesh University of Engineering and Technology and Bangladesh Institute of Development Studies

[87] CEIP-1 (2018). IWM: Technical Report on Storm Surge, Wave, Hydrodynamic Modelling and Design Parameters on Drainage System and Embankment Crest Level, Package III





Figure_Apx 113: Inundation extent and depth for different return periods
(indicatively presented 25 and 50 years storm surge return periods)

Physical and socio-economic vulnerability

With physical vulnerability describing the ability of the built environment to withstand impacts, it is generally represented as the monetary value of physical assets in the hazardous zone[88]. In other words, physical vulnerability can be expressed by the expected damage to physical structures such as buildings, bridges, roads, and public utilities, which is one of the most devastating impacts of cyclonic induced storm surges. By definition, damage expressed the amount of money needed to restore the area back to its original condition before the disaster[89]. In recent years, vulnerability assessments have moved away from being solely focused on physical assets and are increasingly incorporating social vulnerability, defined as the susceptibility of social groups to the impacts of hazards, as well as their ability to adequately recover from them[90].

Determining direct flood damage is commonly done using depth-damage curves[91], which denote the flood damage that would occur during certain storm surge return periods and associated water depths per asset or per land-use class. In essence, combining the extent and depth of inundation with asset information such as houses, roads, and other damage classes provides a damage cost estimation. Distinctly, damage curves are assigned to particular asset classes and construction types. For instance, the values and respective damage functions are different for residential buildings and industrial buildings. Likewise, construction type and quality even within the same structure also presents significant variations[92]

The specific asset categories considered for this present vulnerability assessment are the following:

- Housing units (Population and housing units from Population and Housing Consus , 2011);
- Classification of housing among (pucca, semi-pucca, kutcha, jhupri) (Population & Housing Census – 2011) – *for definition of main character of each poler (urban, semi-urban and rural) and subsequently apply damage value reduction factors*;
- Roads (LGED, 2018);
- Agriculture areas (Word Bank, Bangladesh Interactive Poverty maps https://www.worldbank.org/en/data/interactive/2016/11/10/bangladesh-poverty-maps);
- Economic zones (Word Bank, Bangladesh Interactive Poverty maps https://www.worldbank.org/en/data/interactive/2016/11/10/bangladesh-poverty-maps);
- Education facilities (LGED, 2017);
- Health facilities (LGED, 2018).

Overlaying the inundation depth/extent with the foregoing types of assets and combining with the flood damage curves, introduces the area distributed damages. Since the land elevation is

[88] Sierra Woodruff, Todd K. BenDor (2018), in Comprehensive Geographic Information Systems, 2018
[89] Kang, J., Su, M., & Chang, L.. (2005). Loss functions and framework for regional flood damage estimation in residential areas. Journal of Marine Science and Technology, 193–199.
[90] Sierra Woodruff, Todd K. BenDor (2018), in Comprehensive Geographic Information Systems, 2018
[91]European Comission (2017) Global flood depth-damage functions
[92] World Bank (2016). Methods in Flood Hazard and Risk Assessment

not precise in portraying the protective structures in place (which provide an average protection from a storm surge event of 10 years return period without climate change), in order to avoid overestimating the figures, the damages have been reduced for the case of a 10 year return period storm surge event including climate change.

Appendix 11 Pre-screening polders

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
1	1	Medium		High				Average
2	2 & 2 Ext.	Medium		High				Average
3	3	Medium		Medium				Average
4	4	High	Bank erosion, wave action, overtopping and storm surge	Medium	High		Recommended by BWDB	Average
5	5	High	Bank erosion, wave action, overtopping and storm surge	Medium	Medium			Bad
6	6-8 and 6-8 & 6-8 Ext.	Low		Medium				Average
7	7/1	High	Bank erosion, wave action, overtopping and storm surge	Medium	High		Recommended by BWDB	Average
8	7/2	High	Bank erosion, wave action, overtopping and storm surge	Medium	High		Recommended by BWDB	Average
9	9	Medium		High				
10	10-12	High	Bank erosion, wave action, overtopping and storm surge	High	High		Recommended by BWDB	Bad
11	13-14/2	High	Bank erosion, wave action, overtopping and storm surge	Medium	High		Recommended by BWDB	Bad
12	18/19	Low		Medium				Average
13	20, 20/1	Low		Medium				Average

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
14	21	Low		Low				Average
15	22	Low		Medium		Blue Gold		Average
16	24	Low		Medium				Good
17	25	Low		High		Blue Gold		Average
18	26	Medium	Lareg climate change impact in storm surge	High		Blue Gold		Good
19	27/1, 27/2			Low		Blue Gold		
20	28/1	Medium		High	Medium	Blue Gold		Average
21	28/2	Medium		Medium	Medium	Blue Gold		Average
22	29	High	Bank erosion, wave action, overtopping and storm surge. Large climate change impact in storm surge	High	High		Recommended by BWDB	Average
23	30	Medium		Medium		Blue Gold		Average
24	31	High	Bank erosion, wave action, overtopping and storm surge. Damaged during AILA and Sidr. Breached in many places.	Medium	High		Recommended by BWDB	Bad
25	31 Part	Medium		Medium	Medium	Blue Gold		Average
26	34/1	Medium	Bank erosion, wave action, overtopping	Medium	Medium			
27	36/1	Medium		High	Low	Rehabilitation of 36/1 project is goging on		Average
28	39/1A	High	Bank erosion, wave action, overtopping. Large climate change impact in storm surge	High	High	Rehabilitated under ECRRP Programme	Recommended by BWDB	Bad

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
29	39/1B	Medium	Bank erosion, wave action, overtopping	High	Medium	Rehabilited under ECRRP Programme		
30	39/2A	Medium		Low		Rehabilited under ECRRP Programme		
31	40/1	High	Bank erosion, wave action, overtopping and storm surge. Severely damaged during AILA , Amphan and Sidr. Large climate change impact in storm surge	Medium	Medium	Rehabilited under ECRRP Programme		Average
32	41/2	High		Medium				
33	41/3	High	Lareg climate change impact in storm surge	Medium	Medium			
34	41/4	Medium	Bank erosion, wave action, overtopping but not so vulnerable. Large climate change impact in storm surge	Medium	Medium	Rehabilited under ECRRP Programme		
35	41/5	Medium	Bank erosion, wave action, overtopping but not so vulnerable. Large climate change impact in storm surge	Medium	Medium	Rehabilited under ECRRP Programme		Good
36	41/6A	Medium	Bank erosion, wave action, overtopping but not so vulnerable. Large climate change impact. Large climate change impact in storm surge	Medium	High	Rehabilited under ECRRP Programme	Recommended by BWDB	Average
37	41/6B	Medium		Low		Rehabilited under ECRRP Programme		Good

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	**Polder No.**	**Score**	**Remarks**	**Score**	**Score**	**Programs**	**Stakeholder consultations**	**Score**
38	**41/7**	Medium	Bank erosion, wave action, overtopping and storm surge	Medium	High		Recommended by BWDB	Average
39	**Mirjaganj-Rampura**	High	Bank erosion, wave action, overtopping and storm surge	Low	Medium			
40	**41/7A**	High		Medium	High	Rehabilited under ECRRP Programme	Recommended by BWDB	Average
41	**Bibichini**							
42	**41/7B**			Low	Low	Rehabilited under ECRRP Programme		
43	**42**	Medium	Lareg climate change impact in storm surge	Medium	Low	Rehabilited under ECRRP Programme		Good
44	**43/1**	High		Low				Good
45	**43/1A**	Medium		Low		Blue Gold		Good
46	**43/1B**	Medium		Low				
47	**43/2A**	Medium		Low	High	Blue Gold	Recommended by BWDB	
48	**43/2B**	Medium	Large climate change impact in storm surge	Medium		Blue Gold		
49	**43/2D**	Medium		Low		Blue Gold		
50	**43/2E**	Medium		Low	Medium	Blue Gold		
51	**43/2F**	Medium		Low		Blue Gold		
52	**Dumki-laowkathi**	High						

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	**Polder No.**	**Score**	**Remarks**	**Score**	**Score**	**Programs**	**Stakeholder consultations**	**Score**
53	**ItbariaLabukhali**	High	Bank erosion, wave action, overtopping		Medium			
54	**44**	High		Medium		Rehabilited under ECRRP Programme		
55	**45**	High	Bank erosion, wave action, overtopping and storm surge. Large climate change impact in storm surge	Medium	Medium	Rehabilited under ECRRP Programme		Average
56	**46**	Medium	Bank erosion, wave action, overtopping	Medium	Medium	Rehabilited under ECRRP Programme		Average
57	**47/1**	high	Bank erosion, wave action, overtopping and storm surge and severely damaged during AILA , Amphan and Sidr.	Medium	Medium	Rehabilited under ECRRP Programme		Average
58	**47/3**	High	Large climate change impact to storm surge	Medium		Blue Gold		
59	**47/4**	High	Large climate change impact in storm surge	Medium		Rehabilited under ECRRP Programme and Blue Gold		Good
60	**47/5**	High		Low		Rehabilited under ECRRP Programme		Good

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	**Polder No.**	**Score**	**Remarks**	**Score**	**Score**	**Programs**	**Stakeholder consultations**	**Score**
53	**ItbariaLabukhali**	High	Bank erosion, wave action, overtopping		Medium			
54	**44**	High		Medium		Rehabilited under ECRRP Programme		
55	**45**	High	Bank erosion, wave action, overtopping and storm surge. Large climate change impact in storm surge	Medium	Medium	Rehabilited under ECRRP Programme		Average
61	**50/51**	High	Bank erosion, wave action, overtopping and storm surge	Low	High		Recommended by BWDB	Bad
62	**52/53A**	High		Low		Rehabilited under ECRRP Programme		
63	**52/53B**	High		Low		Rehabilited under ECRRP Programme		
64	**54**	High	Bank erosion, wave action, overtopping and storm surge	Low		Rehabilited under ECRRP Programme		
65	**55/1**	Medium	Bank erosion. Damaged during AILA and Sidr. Breached in many places. About 12 km area of the embankment is almost disappeared	Low		Rehabilited under ECRRP Programme		Average
66	**55/2A**	Medium		Low		Blue Gold		

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
67	55/2B	Medium		Medium		Rehabilited under ECRRP Programme		Good
68	55/2C	Medium		Medium		Rehabilited under ECRRP Programme and Blue Gold		
69	55/2D	Medium		Low		Rehabilited under ECRRP Programme		
70	55/2E	High		Medium	Medium			
71	55/3	High	Bank erosion, wave action, overtopping and storm surge	Medium		Rehabilited under ECRRP Programme		
72	55/4	High		High		Rehabilited under ECRRP Programme		
73	Satla-Bagda-1	Low						
74	Salta Bagda-2	Low						
75	Salta Bagda-3	Low						
76	56/57	High		Medium				Average
77	58/1	Medium	Bank erosion, wave action, overtopping but not so vulnerable	High	Medium			Average
78	58/2	Medium	Bank erosion, wave action, overtopping but not so vulnerable. Large climate change impact in storm surge	High	Medium			Average

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
79	58/3	Medium	Bank erosion, wave action, overtopping but not so vulnerable	Medium	Medium			Average
80	59/1A			High				
81	59/1B			Medium				
82	59/2			High				Average
83	59/2 Extension			Medium				Average
84	59/3B			High				
85	59/3C			High				
86	60			High				
87	61/1			High				Good
88	61/2 (Chittagong)			High				Good
89	62			High				Good
90	63/1A			High				Average
91	63/1B			High				
92	64/1A			High				Good
93	64/1B			High				Good
94	64/1C			High				Average
95	64/2A	Medium		High				Average
96	64/2B Mognama	Medium		High				Average
97	65	Medium		High				Average

		Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
SL. No.	Polder No.	Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
98	65/A			Medium				Good
99	65/1A			Medium				Good
100	65/A3			Medium				Good
101	66/1	Medium		High				Good
102	66/2	Medium		High				Good
103	66/3	Medium		High				Average
104	66/4			High				Average
105	67			Medium				Good
106	67/A			Medium				Good
107	67/B			Medium				Average
108	68	Medium		Medium				Good
109	69/NE			Medium				Average
110	69/Pase-1			Medium				Good
111	70	Medium		High				Good
112	71			High				Average
113	72			High		In CTG-2 Division		Good
114	73/1 (A&B)			High				Average
115	73/2			High				Good
116	Boyerchar							
117	CDSP-II							

SL. No.	Polder No.	Vulnerability to coastal threats		Storm surge risk level	Coastal zone development			Condition of infrastructure
		Score	Remarks	Score	Score	Programs	Stakeholder consultations	Score
118	Charbagerdona-1							
119	Charbagerdona-2							
120	Char mujit							
121	Kumira to Sonaichari flood control project							Good
122	Kukri-Mukri				Low	Flood Control Embankment was constructed during FY 2014-2015 under CCTF fund. Drainage structure is under construction under an ADP Project, implemented by Bhola O&M Division-2		

Appendix 12 Risk based design approach

A12.1 Risk based design approach

Consultant considers innovations in the Bangladesh design practice of polder rehabilitation on three levels

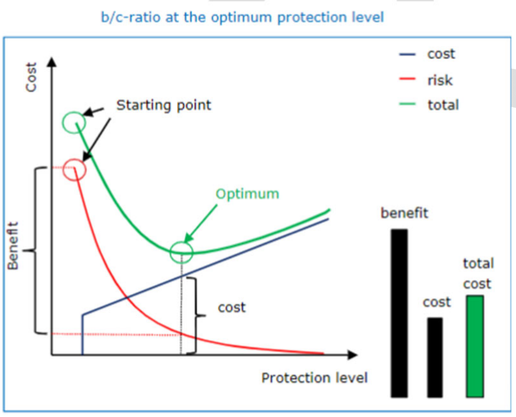
A12.1.1 Introduction risk based design aproach

Within the framework of CEIP-2 it is provided to apply more detailed techniques and analysis for optimizing the design criteria for embankments and sluices. The design criteria for the structures in a polder system (embankments and sluices) depend on the probability of flooding which is allowed. In the actual designs a fixed protection level of T25 has been selected based on a deterministic relation between cost and benefits (preventing damage cost). A more probabilistic approach of the flood risk and a differentiation of the failure probability of different parts enables us to define more specific norms for structures and embankments.

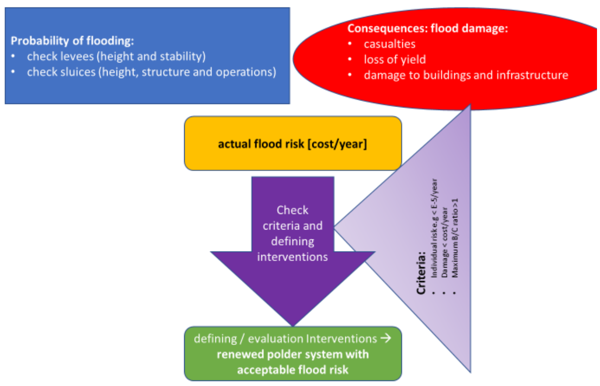
It is provided to analyse the flood risk in 2 characteristic polders and test whether this approach lead to different design criteria: one polder near the coast with typical hydraulic loads from the sea, and one polder more inland with typical hydraulic loads from the river.

A12.1.2 General outline

For definition of design criteria for embankments and sluices in the selected polders a risk approach will be applied to determine the most effective protection level. The most effective protection level follows from a check whether the actual flood risk meets criteria as the maximum accepted individual risk or the maximum accepted economic risk. When the actual flood risk is considered too high, measures can be defined to improve this risk by reducing the probability of flooding. The interventions can be optimized by determining the best cost – benefit ratio.



Figure_Apx 114: Relation cost and protection level[93]



Figure_Apx 115: Scheme for definition of interventions

The determination of the most effective measures which can be taken to meet the required protection level forms the base for the specific design criteria of the embankments and sluices. In the design criteria for example the crest height and stability criteria are defined.

This advanced approach of determining the required protection level is based on Dutch practice[93] and gives clear insight how the proposed measures can be justified. The scheme for defining the interventions is summarized in Figure_Apx 115 . The steps in this scheme are explained as follows:

Determining the flood risk.

The flood risk is a combination of probability and consequences. The flood risk within a levee system is identified by determining the probability that certain parts of the flood defences (sections levees and structures) will fail and the potential consequences of failure.

Figure_Apx 116: Flood risk visualized
(source: report The National Flood Risk Analysis for the Netherlands)

The probability of flooding is determined by calculating the probability that the flood defences will fail. The calculation will involve 2 steps:

1. Division of the flood defence into homogenous stretches;
2. Calculation failure probability of each stretch based on statistics for the loading and strength of the defence, using models which describe the failure behaviour of the flood defence. The failure mechanisms of levees and structures are indicated in the figure below.

The failure probability anywhere in the levee system is greater than the probability that the levee will breach in a particular location. The longer the flood defences, the greater the probability that the levee will fail within that section. This principle is known as the length effect and will be considered.

[93] The National Flood Risk Analysis for the Netherlands, published by Rijkswaterstaat VNK Project Office and commissioned by the Ministry of infrastructure and the Environment, Association of Dutch Water Authorities and Association of Provincial Authorities.

Levee failure mechanisms

Overflow and overtopping

Overflow and overtopping can damage the landside slope of the levee. If this exposes the core of the levee it will erode, which can lead to a breach. Or the inner slope can saturate and slide.

Shearing of the landside slope

The inner slope of a levee can shear due to the pressure of the water against the levee during high water events. The probability of this happening depends heavily on the subsurface: if it includes weak peat or clay layers, there is a greater probability of shearing.

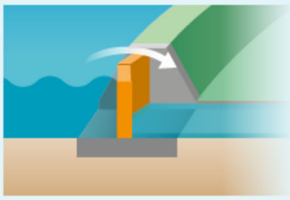
Erosion due to revetment damage

If the facing of the levee is damaged, erosion can occur. This failure mechanism is particularly relevant in areas where large waves can occur, such as along the coast, estuaries and large lakes. In the rivers area the probability that waves will be powerful enough to damage and erode the levee is much lower. Saturation and slope instability remains possible.

Piping, backward internal erosion

If a high water level persists for a long time water can flow under the levee. If the water washes sand along with it, flow channels or 'pipes' can form, undermining the structure. This causes the levee to subside and lose its flood defence capability.

Hydraulic structure failure mechanisms



Overflow and overtopping

Overflow and overtopping can contribute to the failure of hydraulic structures in two ways. The water pouring over the structure can cause parts of it to collapse, with a chance that the entire structure will give way. The influx of water can also cause such a rise in the water level in the water system behind it that the secondary defences subsequently fail.

Failure to close

A hydraulic structure must be closed during high water events so that the entire flood defence system is intact. Human error can disrupt the closing process. It is important that the structure is closed in time. If water is already pouring through it is often difficult or impossible to close it.

Outflanking, seepage and piping under structures

During sustained periods of high water levels due to seepage flow channels carrying sand can form under or along the structure (internal backward erosion), weakening the link with the levee or weakening the structure's foundations.

Structural failure

Flood defences are generally very robust. However, parts may give way as a result of a major difference in the water levels on either side of the structure. A ship colliding with the structure can also weaken it. Failure of a flood defence structure can lead to a breach.

Figure_Apx 117: Failure mechanisms
(source: report The National Flood Risk Analysis for the Netherlands)

Flooding can also occur due to heavy rainfall inside the polder and will also be considered

These probabilities form the total probability of inundation of the polder.

The consequences of a flood depend on the flood pattern and are determined by computer models which calculate the flood characteristics as water depth, velocity and rise rate. The consequences consist of economic losses and fatalities. The economic losses consist of direct damage to capital goods such as homes, infrastructure, and loss of business in the affected area (agricultural yield, other industries) and indirect losses because economic activity outside the affected area also comes to a standstill. The number of fatalities caused by a flood is calculated based on the number of people living in the area combined with flood characteristics such as the velocity and the rise rate of the water.

The risk consist of

- Economic risk; this is the annual expected value of economic losses.
- Individual risk; this is annual probability that an imaginary person at a particular place in the protected area will die as a result of flooding in the area; the individual risk is independent of the actual presence of people in the protected area. the loss of life risk in a protected area.
- Societal risk, expressed by the probability that a certain number of fatalities will occur. A rare flood with a larger number of fatalities has a greater societal impact than more frequent less severe incidents.

Once the actual flood risk for a polder system has been determined, we can confront the flood risk with requirements. In het Netherlands the base- acceptable flood risk is defined by the requirement that individual risk must be less than 10E-5/year. Another indicator can be formed by the maximum acceptable economic loss. In case of necessary interventions to reduce the probability of flooding, the most effective measure can be derived from a cost-benefit analysis, in which the benefit – cost ratio is maximized.

To determine the cost of improvement the levees and the drainage system of a polder in the feasibility design a conservative sketch design which makes it possible to calculate the cost in relation to a certain height or a probability of failure.

This makes it possible to determine the most optimum protection level and determine the lay out of the interventions.

A12.1.3 Concretization of steps and activities

For the 2 selected polders the following steps will be taken.

1. Determination of the actual probability of flooding.
    a. Structural failure probability of the levees: stability inner slope, piping, erosion A determination of the probability will be done with an estimate of the probability that the loads are less than the strength (R<S) per section. Therefore, first a logical division in sections with the same features will be selected. It is estimated that average sections with a length of 10km are selected.

    b. Probability of failure probability of structures: structural failure (instability of the inner slope), failure of closure, overflow and overtopping, seepage, and piping.

    c. Probability of overflow: the height of the levees and the probability that significant overflow (more than 5 l/s/m) occurs and will cause flooding.

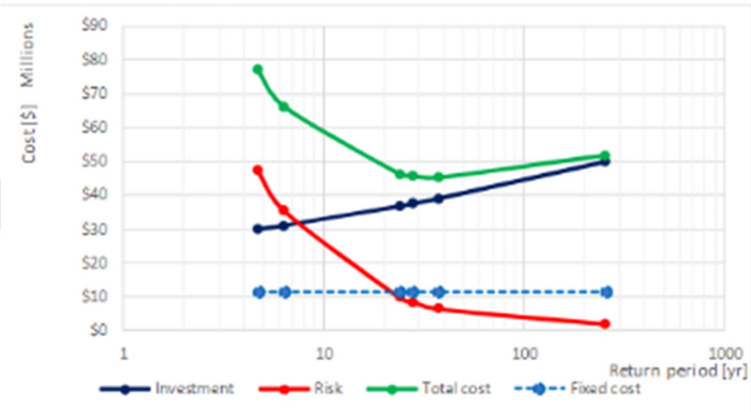
   d. Probability of flooding caused by too little drainage capacity combined with heavy rainfall.

2. Determination of flooding pattern in the polder. The flooding pattern will be analysed by defining a breach in a certain section, and calculate with a hydraulic model (Sobek 1D2D) how a storm surge event of approximate 5 to 7 days will lead to a certain depth of inundation. It is provided to analyse 3 flooding scenario's per polder.

3. Determination of the individual risk and the economic risk. This will be based on a prediction of land use and number of inhabitants of a polder in future, combined with the flooding pattern which has been calculated in step 2. The actual flood risk will be assessed by combining the probability of a flooding scenario with the expected damage or casualties. The damage cost will be assessed for different return periods (T10, T25, 1/50, 1/100) and based on the investigations which were carried out for the selection of polders.

4. Determination of cost of interventions for different protection levels (T10, T25, T50, T100). The interventions are restricted to the existing levees and structures. This means that no alternative lay-outs of the polder system will be considered (as differentiating the protection level within the polder area or setting back the levee and creating more room for the rivers).

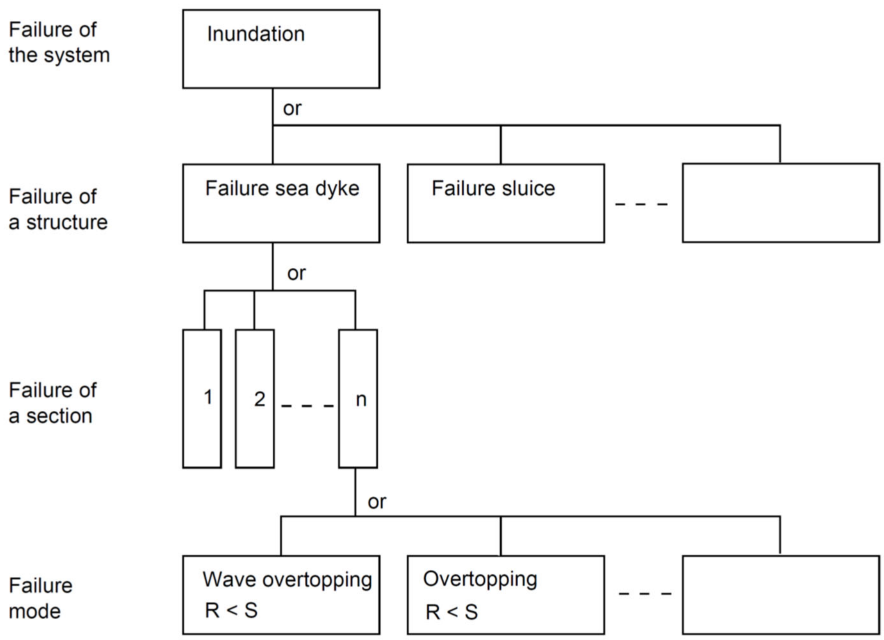
5. Evaluation with 2 criteria (individual risk and economic risk, cost benefit ratio). It depends on the land use and economic activities which criterion is dominant for the required protection level. In the case a polder is more densely populated the criterion for individual risk will be dominant. When a larger area contains agricultural land the cost benefit ratio will be leading the optimization. The cost-benefit ratio will be determined for the 5 return – periods (as mentioned in step 2 and 3), which enables to choose the optimum. The individual risk criterion leads to a minimum protection level to be accomplished. It is proposed to set the maximum individual risk to 10E-5/year (according to Dutch practice). The cost benefit ratio will be presented in a graph where cost versus return period is presented.



Figure_Apx 118: Investment, risk and cost curves per return period

6. Decision on the required protection level. Based on the evaluation of 2 criteria the optimum protection level can be extracted.

7. Definition of design criteria for the sluices, drainage canals and levees. The total probability of flooding of the polder system will be translated in acceptable (maximum) failure probabilities for the different structural parts of the polder system. Based on the assessment of the allowed probability of flooding e.g. 1/25 per year a so called "probability-budget" per failure mechanism can be made. The failure budget defines the contribution for each failure mechanism to the probability of flooding. This will be the maximum probability of failure, which can be allowed for the elements of which a polder system consists.



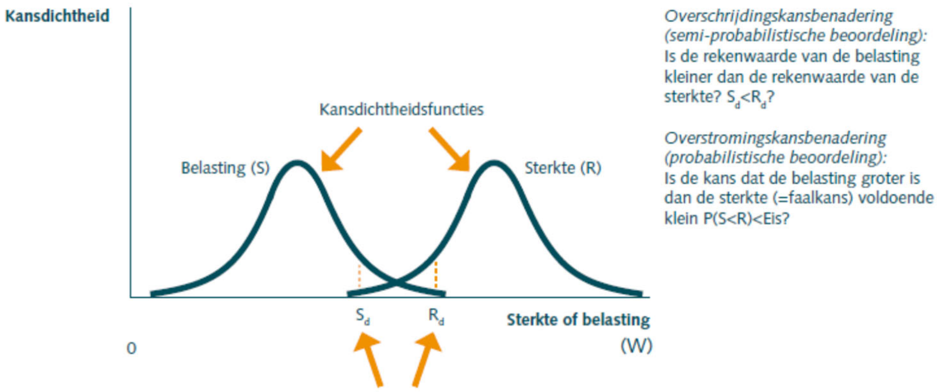
Figure_Apx 119: Example of a failure[94]

For a flood protection level of 1/25, the division of probability of failure can be as follows:

- Overflow / overtopping: maximum failure probability 50% of 1/25 = 1/50 over the whole circle of levees;
- Instability of levels: 30% of 1/25 = 1/77;
- Structural failure for all structures: 10% of 1/25 =1/250;
- Reservation for unknown failure mechanisms: 1/250.

The division of the total probability of failure is based on Dutch experience of flood risk analysis. Tolerable probability of failure leads to a definition of required material properties in the structures (soil, revetment, concrete) and loads which must be taken into account. The works to be implemented can be defined more in detail. In the design a probabilistic approach can be followed to optimize the structures and levees.

[94] Technical University Delft, 2005



Figure_Apx 120: Relation between probability density function and calculation values

The maximum tolerable probability of failure will be put in a (semi-) probabilistic approach of the structures and levees and to define the strength of some parts of the structures. E.g. the revetment at the outer slope, or the core material of the levee. It requires some effort in statistical analysis of material strengths and features, which influence for example geotechnical stability, but it is worthwhile because it gives the opportunity to optimize structures and levees. The level of detail of the probabilistic analysis depends on the availability of data of strength parameters the soil which can be applied and a good description of the way a structure collapse. With a quick scan the available data will be checked and proved, with a decision whether it is suitable and worthwhile to decide to what level of detail a probabilistic approach can be applied.

A12.1.4 Consideration for applying results in detailed designs

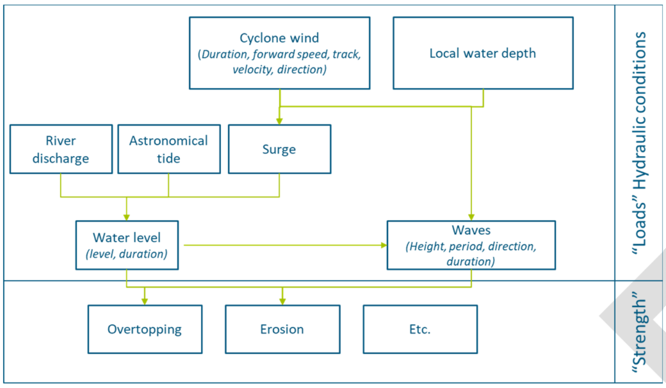
When the 13 polders are known, it will be considered if this Level 1 innovation will be taken forward.

A12.2 Joint probability occurrence of storm surges and tides

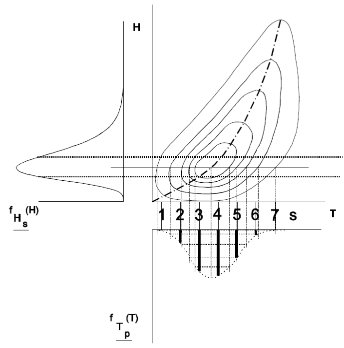
A12.2.1 Introduction

The hydraulic conditions for the design of an embankment consist a design water level and a design wave for a defined return period, e.g. 1/25 year return period. High water levels and high waves in Bangladesh occur during cyclones and therefore the magnitude of these hydraulic conditions are strongly correlated to the wind speed during a cyclone. The water level during such an event at a specific location is a combination of storm surge (effect of the cyclone), astronomical tide, river discharge and any seasonal oceanographic effect, whereby the geography and local water depth plays an important role. Similarly, the wave height, period and direction are strongly dependent on the cyclone wind conditions, the surge levels, tides and the local water depth.

The design of the flood protection structure should ensure that the structure can withstand the hydraulic boundary conditions, i.e. the flood protection structure "strength" should be larger than the "loads". Hence, the design of flood protection structures will use the different hydraulic boundary conditions (water levels and waves) as input for design to determine the required strength (see Figure_Apx 121).



Figure_Apx 121: Strength and hydraulic load conditions



Figure_Apx 122: Example of relation between wave height and wave period.
The 100 year return period wave height does not necessary coincide with the 100 yr return period wave period

A12.2.2 Methods

Basically three methods can be applied which will be elaborated upon here below.

Method 1 Statistics of hydraulic parameters independent

The most simplistic method to determine the hydraulic conditions is to simply add the various parameters, whereby the design return period of each individual component is taken independently. The combination of all there parameters are used as input into design.

25 year return period surge + high tide + 25 year return period wave height + 100 year return period wave height < strength

Example: MHWS + Surge 1:100 year + Sea level rise in 50 years + 0.5m over height < crest level embankment

Method 2 Statistics of hydraulic parameters including dependencies

A more sophisticated method is to consider a set of hydraulic boundary conditions that correspond to a 1/25 event, whereby some dependency between parameters is considered. For instance a 1:25 year storm surge may well coincide with MSL and not with a very high astronomical tide.

25 year return period combined hydraulic boundary condition event (surge + tide + wave height + wave period) < strength

Example: 1:25 year return period water level (tide + surge + sea level rise) + 0.5m over height < crest level embankment

Various methods are available to calculate the various dependencies, e.g.:

- Using historic events and perform extreme statistics
- Re-running actual historic cyclone conditions and vary astronomical tides using a distribution that covers tidal levels
- Statistical methods using extreme value distributions of individual components using bivariate statistics, or monte carlo calculations, Ditlevsen and applying correlation functions.

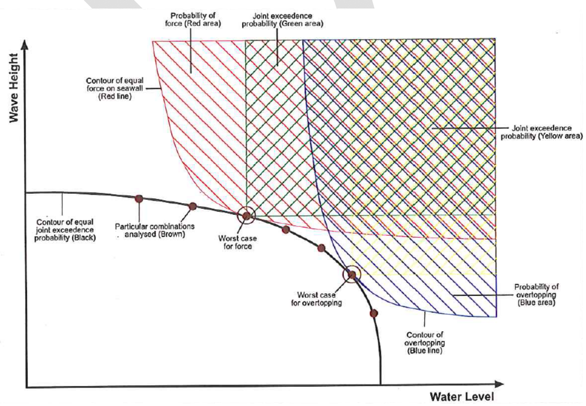
Figure_Apx 122 gives an example of the results of such method, whereby the figures show that the most benefit of this method is found where there is weak dependency.

Method 3 Probabilistic method

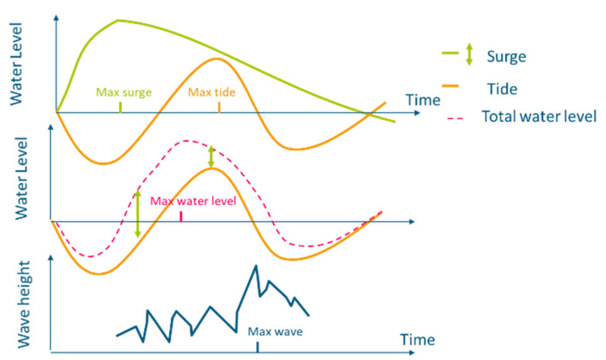
100yr return period failure event (surge + tide + wave height + wave period + strength)

Example: Probability of failure of the flood structure should be less than 1% during the lifetime of a structure. (So this combines the loads but also the probability it fails considering a range of loads, smaller (more frequent) and larger (less frequent),

This method combines statistical information of the hydraulic boundary conditions with statistical strength parameters e.g. for overtopping or strength of the revetment to prevent erosion. The benefit of this method is that it avoids over-design, however the large disadvantage is that often statistical descriptions of failure mechanisms are not available or need to be taken from literature, There are various probabilistic method available, from fully integrated design to more "semi-probabilistic design". A good example is presented below where different points on the joint exceedance contours are taken for overtopping and for wave force on hydraulic structures, considering that for overtopping the water level is of more relative importance and for wave force the wave height. So "knowledge" of the strength is taken into consideration without diving into individual Full probabilistic design is often very complicated on the side of the strength of structures whereby statistical distributions are absent. Statistical methods using extreme value distributions of individual components using bivariate statistics, or monte carlo calculations, ditlevsen and applying correlation functions can be used.



Figure_Apx 123: Strength and hydraulic load conditions



Figure_Apx 124: Occurrence of storm surge and tides

A12.2.3 Effect of time and duration

The above methods consider implicitly that there is some effect of time in the correlation. If we would combine the 25 year condition with a 25 year surge, it may not be taken into account that larger waves may occur after peak surge occurs. This is especially important to consider when not only the peak is of importance, but for instance also the duration of the hydraulic loads (see Figure_Apx 124). Progressive failure modes (such as overtopping that erodes the inner slope or results in an increase of water level within a polder) would need to consider the duration of the hydraulic load as well. 2 hours of 100 l/s/m may be less an issue than 6 hours 25 l/s/m. A study of the surge hydrograph for a set of individual cyclones may be required.

A12.2.4 Selection of preferred method

The selection of the preferred method for the design of the embankments should be based on the following argumentation:

- Knowledge of the physical relationship between the various parameters;
- Experience in other projects of similar nature with similar site characteristics;
- Availability of model calculations for required analysis;
- Application in the design;
- The method should be transparent and robust, to avoid overly complicated statistical relationships that will be 1) difficult to reproduce and 2) that are subject to high uncertainties in absence of actual measured data (typically the cases for extreme value statistics).

Depending on the data which can be obtained, a method will be selected. As mentioned, this innovation would have the potential to be taken forward on short notice if the Project Director and the BWDB Chief Engineer Design would approve.