



Environmental Impact Assessment (EIA)

Local Government Engineering Department

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Bangladesh: Climate and Disaster Resilient Small-Scale Water Resources Management Project



Prepared by Local Government Engineering Department, Government of Bangladesh for the Department of Environment (DoE), Ministry of Environment, Forest and Climate Change (MEF&CC), GoB

Table of Contents

ABBREVIATIONS	ix
EXECUTIVE SUMMARY	xi
GENERAL INFORMATION	xv
1 INTRODUCTION	16
1.1 Project Background	16
1.2 Objectives of the EIA Study	16
1.3 Approach and Methodology of the EIA Study	17
1.3.1 Sources of data collection for the EIA study	17
1.3.2 Scoping and Baseline Data Collection	18
1.3.3 Criteria followed for Selection of EIA Methodology	18
1.3.4 Objectives of methodologies	18
1.3.5 Methodology Requirements	19
1.3.6 Data Collection Procedures	19
1.3.7 Major Methodologies for EIA	19
1.4 Scope of the EIA Study	22
1.5 Structure of The EIA Report	23
1.6 The EIA Study Team Composition	24
2 POLICY, LEGAL, AND INSTITUTIONAL FRAMEWORKS	25
2.1 National Environmental & Social Laws, Rules, Policies and Guidelines	25
2.2 National Environmental Policy	25
2.3 National Conservation Act (ECA), 1995	26
2.4 National Conservation Rules (ECA), 2023	27
2.5 National Water Policy, 1999	28
2.6 Institutional Arrangement	29
2.7 Environmental Clearance Certificate General Procedure in Bangladesh	32
2.8 International Conventions, Treaties and Protocols	35
2.9 Applicable GOB Regulation and Legislation	38
2.10 Collection of NOCs from Respective Authorities	39
3 DESCRIPTION OF THE PROJECT CDRSSWRMP	41
3.1 Need for the project	41
3.1.1 Justification	41
3.1.2 Purpose and benefits of the project	42
3.2 Description of the Project	43
3.2.1 Project Activities	44
3.2.2 Project Location	46
3.2.3 Layout	49
3.2.4 Steps of project implementation	50
3.2.5 Work Schedule	51

3.2.6	<i>Probable extension information</i>	51
3.3	Amount of Land	52
3.3.1	<i>Necessary amount of land</i>	52
3.3.2	<i>Ownership of land</i>	53
3.3.3	<i>Land acquisition</i>	53
3.4	Project location and surrounding area	54
3.4.1	<i>Project location (location map)</i>	55
3.4.2	<i>Layout plan</i>	55
3.5	Project Activities and Implementation Schedule	56
3.5.1	<i>Infrastructure construction and list of major activities</i>	57
3.5.2	<i>Project development steps and implementation schedule</i>	61
3.6	Pollution Potential	62
3.7	Project Alternatives	63
3.7.1	<i>Brief description of alternatives</i>	64
3.7.2	<i>Selection of acceptable options and the possibility of cancelling options</i>	64
4	EXISTING ENVIRONMENTAL CONDITION OF 42 DISTRICTS	65
4.1	Physical Environment of 42 Districts	65
4.1.1	<i>Topography of 42 Districts</i>	65
4.1.2	<i>Geology of 42 Districts</i>	68
4.1.3	<i>Geomorphology of 42 project districts</i>	71
4.1.4	<i>Soil of 42 project districts</i>	74
4.1.5	<i>Drainage of 42 project districts</i>	76
4.1.6	<i>Hydrology and Water Resources of 42 Districts</i>	77
4.1.7	<i>Weather and Climate of 42 Districts</i>	80
4.1.8	<i>Air and Water Quality of 42 Districts</i>	83
4.1.9	<i>Sound level of 42 project districts</i>	86
4.1.10	<i>Sources of Existing Pollutions of 42 Districts</i>	88
4.2	Biological Environment	90
4.2.1	<i>Ecology (flora, fauna, terrestrial habitat, marine/aquatic habitat)</i>	90
4.2.2	<i>Water Land</i>	95
4.2.3	<i>Endemic/threatened/endangered species</i>	98
4.2.4	<i>Nearest Conserved, Sensitive or Critical Habitat</i>	102
4.3	Land Use of 42 Districts	108
4.3.1	<i>Existing and Proposed Land Use</i>	110
4.3.2	<i>Ecologically Important Areas for Conservation</i>	113
4.3.3	<i>Protected Areas of Bangladesh</i>	118
4.4	Social Environment of 42 Districts	119
4.4.1	<i>Population Distribution</i>	122
4.4.2	<i>Economic activities</i>	124
4.4.3	<i>Physical Infrastructure and Services</i>	127
4.4.4	<i>Socio-Cultural Amenities</i>	130
4.4.5	<i>Public health</i>	132
4.5	Update Scenarios of the Environment of Project and Surrounding Areas	135
4.6	Project Location	138
4.6.1	<i>Project Location (with longitude and latitude)</i>	138
4.6.2	<i>Geographical Boundary of the Project Area and Survey Area</i>	139
4.6.3	<i>Location Indicated Macro Scale Map of Proposed Project, Plan, Photo or Satellite Image</i>	140

4.6.4	Colored readable land use map.....	143
4.7	Other any Map Like Topography, Geological and Hydrological.....	144
5	ENVIRONMENTAL IMPACT PREDICTION AND EVALUATION	148
5.1	Impact Identification:.....	148
5.2	Environmental Impacts of Proposed Interventions under CDRSSWRMP ...	208
5.2.1	Re-sectioning of embankment	208
5.2.2	Re-excavation of Khal.....	210
5.2.3	Construction of Foot Bridge.....	211
5.2.4	Construction of Box Culverts	212
5.2.5	Construction of Sluice	214
5.2.6	Construction of WMCA Office Building	216
5.2.7	Rehabilitation of WMCA Office Building.....	217
5.2.8	Development of farm access road	219
5.2.9	Construction of new Regulator	220
5.2.10	Rehabilitation of existing Regulator	222
5.3	Construction of Rubber Dams	224
5.3.1	Requirements for Rubber Dam Construction under CDRSSWRMP.....	224
5.3.2	Construction Bakkhali Rubber Dam under CDRSSWRMP	226
5.3.3	Agricultural Benefits of Bakkhali Rubber Dam.....	226
5.3.4	Fisheries and Aquatic Benefits of Bakkhali Rubber Dam	227
5.3.5	Social Impact of the Bakkhali Rubber Dam	228
5.3.6	Climate Change Impacts on Bakkhali Rubber Dam.....	229
5.4	Impact Prediction	230
5.4.1	The nature, magnitude, extent and duration of significant impacts	231
5.5	Impact Evaluation.....	232
5.5.1	Magnitude of Environmental Impact.....	233
5.5.2	Extent of Environmental Effect	234
5.5.3	Duration of the Impact	235
5.5.4	Evaluating Significance of Impacts.....	238
5.5.5	Reversibility of Condition /Impact Area	240
5.5.6	Cumulative impact	241
5.5.7	No impact, Significant impact, Insignificant impact, Unknown impacts, Mitigated impact	241
5.6	Impact of fertilizers and pesticide use in agriculture	243
5.6.1	Impact of fertilizer on agricultural soil	243
5.6.2	Impact of fertilizer on agricultural water.....	243
5.6.3	Impact of pesticide on agricultural soil	243
5.6.4	Impact of pesticide on agricultural water.....	244
6	CLIMATE RISK SCREENING AND ASSESSMENT OF 42 DISTRICTS	251
6.1	Sensitivity of Project Components to Climate Conditions and Sea Level ..	251
6.2	Climate Risk Screening.....	252
6.3	Climate Risk and Adaptation Assessment	252
6.4	Climate Risk Screening Tool and / or Procedure Used	254
6.5	Climate Adaptation Plans within the Project.....	255
6.6	Environmental Impacts and Mitigation of Climate Adaptation Activity	255
7	MITIGATION MEASURES OF THE ENVIRONMENTAL IMPACT	283

7.1	Best Possible Solution to the Problem of Environmental Pollution	284
7.2	Description of Each Recommended Mitigation Measures	284
7.3	Nature Based Solution (Nbs)	285
7.4	Tree Plantation under CDRSSWRMP	286
7.5	Estimated Cost of All Proposed Mitigation Measures	287
8	MONITORING PROGRAMME	287
8.1	Monitoring the Implementation of Mitigation Measures	287
8.2	Environmental Impact Monitoring of Project	288
9	ENVIRONMENTAL MANAGEMENT PLAN (EMP)	288
9.1	Environmental Management of Different Subprojects	290
9.1.1	<i>Before Construction</i>	290
9.1.2	<i>During Construction</i>	290
9.1.3	<i>During Operation and Maintenance</i>	290
9.2	Summary of Environmental Management Plan with Mitigation Measures	291
10	GRIEVANCE REDRESS MECHANISMS (GRM)	297
10.1	Objectives of the GRM	297
10.2	Existing Grievance Redress Mechanisms of LGED	298
10.3	Public GRM During Construction	298
10.4	Public GRM During Operation	299
10.5	GRM Contact Information of LGED	300
10.6	GRM at PMU Level	300
10.7	GRM at PIU Level	300
11	PUBLIC CONSULTATION /STAKEHOLDER CONSULTATION	303
11.1	Scope of the Public Consultation	303
11.2	Objectives of Public Consultation	303
11.3	Methodology of Public Consultation	304
11.4	Focus Group Discussions	304
11.4.1	<i>Key Focus Areas for FGDs in CDRSSWRMP</i>	304
11.4.2	<i>Khal re-excavation FGD</i>	305
11.4.3	<i>Key Aspects of FGDs for CDRSSWRMP Khal Re-excavation</i>	305
11.4.4	<i>Embankment heightening FGD</i>	306
11.4.5	<i>FGD for WMCA formation</i>	307
11.5	Public Consultation Findings	308
11.5.1	<i>Location of Public Consultations</i>	308
11.5.2	<i>Tools and Techniques used for Consultation</i>	308
11.5.3	<i>Consultation with Community and Stakeholders</i>	309
11.5.4	<i>Opinions of Community About Problems</i>	309
11.5.5	<i>Summary of Public Consultation and Disclosure</i>	309
11.5.6	<i>Key Informant Interview (KII)</i>	310
11.5.7	<i>Public Consultation Meeting on Different Interventions and Safeguard Issue</i>	311
12	OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT PLAN	331

12.1	Health and Safety Measures During Construction	331
12.2	Health and Safety Measures During Operation	331
13	CAPACITY DEVELOPMENT TRAINING.....	332
13.1	PMU Level Environmental Training	332
13.2	PIU Level Environmental Training	333
13.3	Subproject Level (WMCA Level) Environmental Training	333
14	CONCLUSSION AND RECOMMENDATIONS	335
14.1	Conclusion	335
14.2	Recommendations	337
15	REFERENCES.....	338
16	APPENDICES (Appendix-1 to Appendix-19 is in Vol-II).....	341
	Appendix-1 Photographs of focus group discussion under CDRSSWRMP	341
	Appendix-2 Photographs of field visit under CDRSSWRMP	341
	Appendix-3 Photographs of existing infrastructures and interventions.....	341
	Appendix-4 Photographs of public consultation meeting (PCM)	341
	Appendix-5 Photographs of KII (Key Informant Interview).....	341
	Appendix-6 Google maps, Index maps, physical maps	341
	Appendix-7 Attendance sheets of FGD and stakeholders' consultations.....	341
	Appendix-8 List of NOCs Collected from Union Parishad	341
	Appendix-9: Field Environmental Assessment Checklist of CDRSSWRMP	341
	Appendix-10 Questionnaire for Environmental Field Data Collection	341
	Appendix 11: Field Climate Risk Screening Assessment Checklist of CDRSSWRMP	341
	Appendix-12 Field Environmental Monitoring Checklist-CDRSSWRMP	341
	Appendix-13 TOR Approval Letter of DOE	341
	Appendix-14 Approved Terms of References of EIA study of CDRSSWRMP	341
	Appendix-15 Environmental quality parameter standard value of DOE	341
	Appendix-16 Mitigation of Impacts of Environmental Components During O&M.....	341
	Appendix-17 Water Quality Monitoring Plan Summary Under CDRSSWRMP	341
	Appendix-18 Stakeholders/Public Consultation Meeting meetings	341
	Appendix-19 Public Consultation Meeting Published in Newspaper	341

LIST TABLES

Table 1: Simple Checklist for Recognition of Environmental Impacts	20
Table 2: Descriptive Checklist Regarding Cumulative Impacts	21
Table 3: Representative Table of Scaling Checklist	21
Table 4: Example of Questionnaire Checklist	21
Table 5: Structure of the Environmental Impact Assessment Report	23
Table 6: EIA Study Team Composition	24
Table 7: Treaty or Convention and Responsible Agency	36
Table 8: International Conventions, Treaties, and Protocols Signed by Bangladesh ...	36
Table 9: Applicable National Regulation and Legislation for CDRSSWRMP	38
Table 10: Collection of NOC from Respective Authorities of 42 Project Districts	40
Table 11: List of Proposed New Subproject Type under 42 Districts	58
Table 12: List of Proposed Performance Enhancement (PE) Subproject Type	58
Table 13: Proposed Infrastructures/Works/Machineries in Proposed 42 Districts	59
Table 14: Proposed Interventions of Subprojects Under CDRSSWRMP	60
Table 15: Extinct Mammalian Species of Bangladesh, 2015	100
Table 16: Extinct Wildlife Species of Bangladesh (IUCN, 2015)	101
Table 17: List of Protected Areas (51) of Bangladesh	105
Table 18: Declared Ecologically Critical Areas (ECAs) of Bangladesh	116
Table 19: Bangladesh Ecologically Critical Areas with Their Ecosystem Type	117
Table 20: Project districts (42) with GPS coordinates and area & population	139
Table 21: Environmental Impacts of Proposed New Subproject Type	149
Table 22: Environmental Impacts of Proposed PE Subproject Types of 42 Districts ..	162
Table 23: Overview of Environmental Impacts by Subproject Type	207
Table 24 : Potential Impacts and Mitigation of Rehabilitation of WMCA Office	219
Table 25: Table Impacts and Mitigation Measures of Rubber Dams	225
Table 26 Magnitude of Environmental Impacts	235
Table 27: Assessing Magnitude of Impact	236
Table 28: Sensitivity Ranking and Contributing Criteria	237
Table 29: Assessing Significance of Impact	238
Table 30: Interactions and Potential Impact	239
Table 31: Potential Impacts of Project Activities and the Mitigation Measures	245
Table 32: Residual Impact, Mitigation Measures, and Potential Benefits	248
Table 33: Environmental Impacts and Mitigation of Climate Adaptation Activity	257
Table 34: Impact, Mitigation and Enhancement Measures During Project Phases	291
Table 35: Formation of Grievance Redress Committee at PMU Level	300
Table 36 : Formation of GRC at PIU Level	301
Table 37: Upazila and District Grievance Redress Committees	302
Table 38: FGD and PCM Done with GPS Coordinates & No. of participants	311
Table 39: Findings of Public Consultation on Khal Re-excavations	312
Table 40: Findings of Public Consultation on Re-sectioning of Embankment	319
Table 41: Findings of Public Consultation on Bakkhali Rubber Dam Rehabilitation ..	326
Table 42: Training Program for Environmental Management	334

LIST OF FIGURES

Figure 1: The organizational structure of LGED	31
Figure 2: The diagram showing the operation area of LGED	32
Figure 3: General Environmental Clearance Procedure of DOE	33
Figure 4: Environmental Clearance Procedure for Red Category Project.....	35
Figure 5 : PMU, PIU, PISC and local people visited project sites.....	46
Figure 6:Project Area Districts and Bangladesh Delta Plan Hotspots	48
Figure 7:Seismic Zoning in Bangladesh (Source: National Building Code, 2015)	71
Figure 8: Agroecological Zones of Bangladesh	94
Figure 9:Bio-ecological Zoning Map of Bangladesh.....	95
Figure 10: Adverse Eco-system of Bangladesh	107
Figure 11: Bangladesh Bioecological Zones Map.....	116
Figure 12: Map of Bangladesh Showing the Protected Areas (PAs).....	119
Figure 13: Map of Disaster-Prone Areas.....	142
Figure 14: Saline Zone of Bangladesh	143
Figure 15: land use map of Bangladesh	144
Figure 16:Topographic Map of Bangladesh.....	145
Figure 17:Geological Map of Bangladesh	146
Figure 18: Hydrological Map of Bangladesh	147
Figure 19:Hydrological Regions of Bangladesh.....	148
Figure 20: Climatic Zone Map of Bangladesh.....	253
Figure 21: Grievance Redress Mechanism Process.....	299
Figure 22: GRM Process Flow Diagram	303

ABBREVIATIONS

ADB	Asian Development Bank
ADTA	Advisory Technical Assistance
ATI	Agriculture Training Institute
AWD	Alternate Wetting and Drying
BADC	Bangladesh Agricultural Development Corporation
BARD	Bangladesh Academy for Rural Development (Cumilla)
BCAS	Bangladesh Center for Advanced Studies
BECA	Bangladesh Ecologically Critical Areas
BFRI	Bangladesh Fisheries Research Institute
BME	Benefit monitoring and evaluation
BWDB	Bangladesh Water Development Board
CAD	Command area development
CALIP	Climate Adaptation and Livelihood Projection
CBO	Community-based organization
CCRIP	Coastal Climate Resilient Infrastructure Project
CDRSSWRMP	Climate and Disaster Resilient Small Scale Water Resources Management Project
CESMP	Construction Environmental and Social Management Plan
CIP	Chandpur Irrigation Project
CTCRP	Coastal Towns Climate Resilient Project
DAE	Department of Agricultural Extension
DAM	
DDM	Department of Disaster Management
DLIPEC	District Level Inter-Agency Project Evaluation Committee
DLS	Department of Livestock Services
DOC	Department of Cooperatives
DOF	Department of Fisheries
DPHE	Department of Public Health and Engineering
DPP	Development Project Pro Forma
DR	Drainage
DTO	District Training Officer
DWA	Department of Women's Affairs
DWT	Deep Tubewell
ECA	Ecologically Critical Areas
ECNEC	Executive Committee of the National Economic Council
ECNWRC	Executive Committee, National Water Resources Council
EME	Effect monitoring and evaluation
ESU	Environment and Social Unit
FCD	Flood control and drainage
FGD	Focus group discussion
FM	Flood management
FMD	Flood management and drainage
FMWC	Flood management and water conservation
HDPE	High-density polyethylene
HILIP	Haor Infrastructure and Livelihood Improvement Project
HSSMS	Health, Safety and Security Management System
HSSE	Health, Safety, Security, and Environment
ICCCAD	Integrated Centre for Climate Change & Development
IDP	Infrastructure Development Project
IFAD	International Fund for Agriculture Development
IWRMU	Integrated Water Resources Management Unit
JICA	Japanese International Cooperation Agency
KPI	Key Performance Indicator
LCS	Labor contracting society

LGA	Local Government Area
LGD	Local Government Division
LGED	Local Government Engineering Department
LLA	Locally Led Adaptation
MOFL	Ministry of Fisheries and Livestock
MOLGRDC	Ministry of Local Government, Rural Development and Cooperatives
MOWR	Ministry of Water Resources
MPAs	Marine Protected Areas
MSMEs	Micro, Small, and Medium Enterprises
NAPA	National Adaptation Plan
NEC	National Economic Council
NGO	Non-government organization
NWMP	National Water Management Plan
NWRC	National Water Resources Council
O&M	Operation and maintenance
PAM	Project Administration Memorandum
PCR	Project completion report
PCC	Project Coordination Committee
PCM	Public Consultation Meeting
PD	Project Director
PE	Performance enhancement
PISC	Project Implementation Support Consultant
PKSF	Palli Karma-Sahayak Foundation
PMO	Project Management Office
PRA	Participatory rural appraisal
RESP	Rural Employment Sector Program
RMTP	Rural Microenterprise Transformation Project
SCC	Stakeholder Coordination Committee
SEP	Stakeholder Engagement Plan
sm	Staff-months
SoB	Survey of Bangladesh
SOP	Standard Operating Procedure
SP	Subproject
SPS	Safeguards Policy Statement (ADB 2009)
SRDI	Soil Resources Development Institute
SSW	Small scale water
SSWRDP	Small Scale Water Development Project
TOT	Training of trainers
TTM	Temporary Traffic Management
TTML	Temporary Traffic Management Layout
TTMP	Temporary Traffic Management Plan
TMP	Traffic Management Plan
TRM	Tidal River Management
TRTA	Transaction Technical Assistance
UAO	Upazila Agriculture Officer
UFO	Upazila Fisheries Officer
uPVC	Unplasticized polyvinyl chloride
WARPO	Water Resources Planning Organization
WASA	Water supply and sanitation
WC	Water conservation
WFP	World Food Program
WMA	Water Management Association
WMCA	Water Management Cooperative Association
WRM	Water resources management

EXECUTIVE SUMMARY

Brief description of the Project: The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), is a joint initiative of the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD). The project is being implemented by the Local Government Engineering Department (LGED) in accordance with the National Water Policy and under the guidance of local government institutions. Its overarching goal is to reduce rural poverty by enhancing sustainable, inclusive, and climate-resilient agricultural and fishery productivity in selected areas of the project districts of the country. The project will potentially invest in water management infrastructure in 42 districts located throughout Bangladesh. As shown in the map, these districts are associated with hotspots identified under the Bangladesh Delta Plan 2100: Barind and drought prone areas, Haor and flash flood areas, Coastal zone, and river systems and estuaries.

The CDRSSWRMP will establish small-scale, participatory water resources management systems that directly benefits the poorer and more vulnerable segments of the rural population. The Outcome is to increase climate-and disaster-resilient agricultural productivity and profitability in 381 subprojects, which extend over 220,000 hectares, ultimately improving the livelihoods of approximately 380,000 households. Progress will be monitored through improvements in crop yields, cropping intensities, and farm incomes. The project consists of three components namely: (1) Participatory Subproject Development and Management, (2) Small-Scale Water Resources Infrastructure with Climate and Disaster-Resilient Features constructed and (3) Agribusinesses Enhanced at the Upazila and WMCA (Subproject) Levels, and Vulnerable People's Livelihoods supported.

Consultancy support for the project started in June 2025. Prior to 30 June 2025, no physical works have been commenced under the subprojects. However, preparatory actions—including environmental planning, institutional coordination, and training design—were underway to ensure effective execution once works begin. The CDRSSWRMP is fully committed to ensuring substantial compliance with the environmental safeguard requirements set by the Government of Bangladesh (GoB), Asian Development Bank (ADB) and International Fund for Agriculture Development (IFAD). This commitment must be upheld by all concerned parties, including Upazila Engineers and Executive Engineers (XENs) of LGED.

The proposed interventions aim to enhance water resource management and agricultural development in 381 small scale water resources subprojects spread over 42 districts. The key works include re-excavation of khals, strengthening of embankments, and constructing water retention structures to retain freshwater and, in coastal areas, to prevent saline water intrusion. Excavating selected Khals and rehabilitation or upgrading of existing regulators enhances monsoon water drainage, and increases water retention for irrigation during the Rabi season, supporting consistent crop production. To improve irrigation efficiency and flexibility, buried pipe systems will be introduced, allowing farmers to diversify crops particularly to meet the rising demand from the growing urban markets. Additionally, the Bakkhali rubber dam reconstruction will help secure a dependable raw water supply to the under-construction Department of Public Health Engineering intake facility near the previous rubber dam site. The Project is also expected to expand local agriculture, create employment, reduce poverty, and improve nutrition and health outcomes. Furthermore, the improved water infrastructure will open new opportunities for sustainable aquaculture development in the subprojects' areas and their surrounding Khals.

EIA study findings: Based on the Environmental Impact Assessment (EIA) and project documents for the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) (ADB Project 53237-001), the environmental assessments found the Project to be generally beneficial with manageable, site-specific impacts. The project, classified as Category “Red” for environment involves upgrading or construction of small-scale water infrastructure (drainage, irrigation, water conservation) to improve agricultural productivity in a changing climate. This EIA study covered 42 districts comprising the Coastal zone (17 districts), the Barind drought prone areas (16 districts), and Haor flash flood areas (9 districts) including river systems & estuaries.

Major environmental impacts findings

- **Positive Impacts:** Significant improvements to local agriculture are expected through better water management, increased cropping intensity, enhanced flood control, and stronger disaster resilience for rural communities.
- **Construction-Phase Impacts:** Anticipated adverse impacts are primarily temporary and localized, including noise and dust pollution, temporary disruption of traffic or local business access, tree removal, and potential soil erosion.
- **Location Risk:** Some subprojects may face risks from extreme climate events, such as excessive flooding, cyclones, or salinity intrusion, rather than inducing these events.
- **Ecological Impacts:** Minimal or no impact on protected areas, though site-specific assessments found potential impacts on local flora/ fauna, which are manageable.

Impacts of fertilizer use in agriculture

Chemical fertilizers significantly boost agricultural productivity and crop yields by providing essential nutrients like Nitrogen, Phosphorus, and Potassium. However, excessive use leads to severe negative effects, including soil degradation (acidification, reduced microbial activity), water pollution through nutrient runoff, greenhouse gas emissions, and decreased long-term soil fertility.

To mitigate these impacts, sustainable practices such as using organic fertilizers and balanced, soil-tested fertilization are recommended.

Impact of pesticide used in agriculture on soil and water

Agricultural pesticides severely degrade soil health by killing beneficial microorganisms and disrupting nutrient cycling, while runoff and leaching contaminate surface water and groundwater, harming aquatic ecosystems. These chemicals, including glyphosate, accumulate in the topsoil and, via erosion, can be transported into water bodies, causing algal blooms, reduced oxygen levels, and biodiversity loss.

Mitigation of agricultural pesticides in soil and water involves implementing Integrated Pest Management (IPM), using buffer zones, reducing application rates, and employing bioremediation to lower environmental exposure. Key strategies include choosing less hazardous chemicals, optimizing application timing, enhancing soil health through cover crops, and using technology to reduce runoff and leaching into water systems.

Mitigation and management measures of EMP:

To address the potential impacts, the project mandates the implementation of an Environmental Management Plan (EMP), which includes:

- Dust and noise control through regular spraying of water and installation of noise barriers during construction.
- Water Quality Management: Protecting water bodies from construction debris and fuel leakage.
- Safety Measures: Implementing occupational health and safety protocols for workers.
- Community Engagement: Strengthening Water Management Cooperative Associations (WMCAs) to ensure sustainable operation and maintenance (O&M) and to handle grievances.
- Compensatory Tree Planting: Replacing any trees removed during infrastructure development.

Environmental management will be enhanced through institutional capacity strengthening at both the local level (LGED Upazila and District offices) and Headquarters level to ensure effective implementation. LGED's institutional arrangement for environmental management should be standardized across all the subprojects, and environmental compliance should be treated with the same importance as the quality of civil works. LGED will ensure that EMPs and environmental clauses in tender documents are properly implemented during construction. Post-construction environmental responsibilities such as tree plantation, tree care, and turfing for slope protection would also be implemented and monitored as these are crucial elements for long-term environmental sustainability.

Major EMP monitoring activities include:

- Environmental Compliance Monitoring: Reviewing the implementation of mitigation measures outlined in the Environmental Impact Assessment (EIA) for construction impacts.
- Site Inspections & Reporting: Conducting regular site visits and producing monitoring reports to ensure that contractors adhere to environmental safeguards, such as proper waste management, pollution control, and erosion protection.
- Safety & Risk Mitigation: Monitoring occupational health and safety measures for personnel and ensuring safety protocols are followed during construction, particularly regarding embankment construction and water management infrastructure.
- Grievance Redress Mechanism (GRM): Operating GRMs at Upazila and district levels to receive and resolve community complaints regarding environmental or social performance.
- Water Quality & Environmental (Baseline) Monitoring: Assessing impacts on water resources and ensuring that hydrological, morphological, and ecological conditions are maintained, especially when dealing with re-excavation or new construction near water bodies.
- Institutional Strengthening: Involving contracted firms/NGOs to support the Local Government Engineering Department (LGED) in monitoring, ensuring that environmental mitigation plans are effectively implemented.

These activities are part of the broader efforts to manage climate risks and enhance agricultural productivity while mitigating negative environmental impacts.

Environmental Benefits:

- Improved Water Quality: Reduced silt, fertilizer, and pollutant runoff.
- Water & Energy Savings: Efficient systems like buried pipe water distribution reduces water losses and the energy needed for pumping, reducing carbon footprints.
- Enhanced Biodiversity: Creation of habitats through green infrastructure.
- Ecosystem Preservation: Conserving water keeps more in natural systems, supporting wetlands and aquatic habitats.
- Climate Resilience: Systems infrastructure designed for future climate extremes, including temperature change and water demand, sea level rise, and so on.
- Reduced Property Damage: Better infrastructure and water management lowers flood damage costs.
- Soil Health: Control and management of excess water reduces waterlogging, soil erosion, and salinization, maintaining soil fertility and structure.
- Reduced Drought/Flood Impacts: Better infrastructure and management buffers against extreme weather events.

Project benefits:

(1) Reducing the duration of floods, (2) Decrease in flood depth, (3) Waterlogging reduction, (4) Increase in irrigation water supply, (5) Increasing water supply for fish farming, (6) Increasing the efficiency of irrigation systems, (7) Improving the drainage system, (8) Water conservation, (9) Salinity control, (10) Increasing local navigation facilities, (11) Increase in tidal water for irrigation, (12) Increasing water supply for domestic purposes, (12) Increase in irrigated area, (13) Development of irrigated areas, (14) Flood management, and (15) Tidal water irrigation

Key project outcomes (results):

Development of 150 new subprojects and performance enhancement of 231 existing subprojects giving the following benefits:

- Increase in cropping intensities and crop productivity over 220,000 ha.
- Reduction of flood risk over 87,000 hectares of land.
- 230,00 households (60% of 380,000 households in subproject areas, including 45,000 landless/ vulnerable households) have improved access to water for agriculture and aquaculture purposes.
- 57,000 households (15% of total beneficiary households) have improved physical access to markets.
- Livelihoods of 30,000 women of poor and smallholder households improved by income generation activities.

GENERAL INFORMATION

Project Name: Climate and Disaster Resilient Small Scale Water Resources Management Project

Name of the Project Director: Engineer Md. Enamul Kabir

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Information related to the EIA study:

Name of the responsible person: Engr. Shahidul Haque

Position of responsible person: Deputy Team Leader (DTL)

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Environmental Consultant:

Name of Consultant: Dr. Md. Kabil Hossain

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1 INTRODUCTION

1.1 Project Background

The Climate and Disaster Resilient Small Scale Water Resources Development Project (the project), was approved on 19 September 2023, signed on 29 October 2023, and the Asian Development Bank (ADB) Ordinary Capital Reserve (OCR) Loan 4346 for \$106.00 million along with the Government of the Netherlands (GoN) Grant 0906 for \$17.80 million became effective on 29 January 2024. The International Fund for Agriculture Development (IFAD) Loan 8456 for \$42.98 million became effective earlier on 15 November 2023. The project will be implemented until 30 June 2029.

The Local Government Engineering Department (LGED) is the project executing agency. A project management unit (PMU) in Dhaka has been established but is yet to be fully staffed. Also, to be established and fully staffed are 42 project implementation units (PIUs) in 42 districts, headed by each LGED district executive engineer.

The contract between LGED and the Project Implementation Support Consultants (PISC) was signed on 22 May 2025 and the consulting team began mobilizing on 15 June 2025.¹ About three-quarters of the team were mobilized by early July 2025.

1.2 Objectives of the EIA Study

The project objective is to develop sustainable stakeholder-driven, small-scale water resource management systems with special attention to the poorer section of the population. The project will address related issues including low productivity, variable climate, degrading natural resources, diversion of agricultural land to other uses, and value chain inefficiencies. The objectives of the EIA study are to assess the environmental impacts, identify avoidance and mitigation measures, and develop an environmental management plan. Specifically, this involves:

- To describe the project and subprojects
- To conduct a regulatory framework review and describe the legal and institutional framework
- To prepare an environmental baseline and profile of the project and the project area
- To assess environmental impacts of the project and subproject
- To develop avoidance, mitigation, and enhancement measures and prepare an Environmental Management Plan
- Assess alternatives and recommend the preferred alternatives.
- To anticipate and appraise any foreseeable impact the project may have on the environment, the climate and/or on social factors (including human rights),
- To identify and prevent any negative impact, or limit it to a tolerable level and (provided that the negative impact is inevitable but still tolerable) introduce compensation measures. In addition, the assessments should identify, monitor and manage any residual risks.
- The objective of the climate change assessment is also to recognize climate change impacts that may impair the achievement of objectives in due time so that, if applicable, required adaptation measures can be taken into consideration in the project conception.

- EIA and climate change assessments are a core element of the assessment procedure of Asian Development Bank.
- The essential steps of an EIA and climate change assessment include a preliminary appraisal, called screening, to determine the environmental, climate and social relevance of a project;
- The steps mentioned above must cover the entire project; they must not be limited only to those parts of the project which are financed by ADB.
- This also applies to the rehabilitation and/or expansion of existing facilities. Moreover, it is important to consider relevant alternatives to reach the project objective. One possible outcome of an EIA or climate change assessment may be that the original project design or the location has to be modified.

1.3 Approach and Methodology of the EIA Study

Approach:

The primary approach of the EIA is to investigate and describe impacts of the proposed project to the existing environmental elements. Specifically, the study aims to predict the potential impacts of the project activities and recommend mitigation and abatement measures for impacts (in the pre-construction, construction, after completion of work and operational stages of development) that are considered potentially adverse to the surrounding environment and society.

The EIA in general intends to:

- Assess and describe the existing status of the various ecological, physical and human related components surrounding the sub-project area;
- Predict the potential significant impacts of the subproject on the surrounding environment and society during the pre-construction, construction, after completion of work, operations and maintenance stages and recommend appropriate mitigation and abatement measures; and
- Identify residual impacts of the subproject and recommend appropriate short-term and long-term management plans.

Methodology of EIA:

EIA methodology is a structural approach developed to identify, predict and value changes of an action. Changes are reflected to the sequence of activities, steps regarding the environmental issues (physical, chemical, biological, socioeconomic, cultural, landscape values and processes). The methodology uses in process quantify these changes.

The EIA process includes the methodology of collection of the data required to identify and assess the main effects which the development is likely to have on the environment; identify any significant adverse impacts and propose measures where possible to avoid, reduce or remedy any adverse impacts.

1.3.1 Sources of data collection for the EIA study

The following documents are used as reference in the preparation of the EIA report:

- Available laws, rules, regulations, acts, policies from Bangladesh Government websites
- Maps from open sources and various governmental and non-governmental websites
- Data from secondary literatures including journal and relevant websites

- Available technical reports from various organizations and Local Government Engineering Department

1.3.2 Scoping and Baseline Data Collection

The scoping of issues to be addressed in the EIA was conducted early in the assessment process through field visit to collect the appropriate baseline information so that collected data and the EIA study can focus on the relevant issues needed.

The objectives of undertaking the scoping activities are:

- To ensure that the EIA will address only relevant issues and concerns;
- To provide an early link among the implementing agency, the recipient and affected community and the EIA preparer;
- To present the scope of environmental, issues and alternatives that requires thorough examination and consideration in the subproject plan;
- To ensure complete coverage of the environmental conservation rules (ECR) 2023.
- To ensure complete coverage of potential environmental and social issues that is required under the Social, Environmental and Climate Assessment Procedures (SECAP), 2021 of IFAD, and
- To ensure complete coverage of potential environmental and social issues that is required under the ADB SPS 2009.

This EIA is involved field-level studies, public consultations, and stakeholder engagement to assess the environmental, social, climate, and economic dimensions of the project. The study includes a basic climate risk assessment, detailed environmental assessment, and incorporating a Participatory Rural Appraisal (PRA) of local livelihoods. Special attention has been given to the agriculture and fisheries prospects in the subproject area, including potential increases in crop yield resulting from improved water management and irrigation. The EIA is fully aligned with the guidelines of government of Bangladesh (DOE, ECR 2023). Furthermore, the project adheres to several national and international policy frameworks to ensure that environmental protection, social inclusion, and economic benefits are sustainably addressed throughout its planning and implementation phases.

1.3.3 Criteria followed for Selection of EIA Methodology

Simplicity: The methodology is simple and based on available manpower & background knowledge. It can adapt without much difficulty.

Budget and Time: The methodology has been applied by small group with under approve budget and limited time span.

Flexibility: The method is flexible and allow the modifications and changes during course of study.

Choosing a Method

The methodology of EIA ranges from simple to complex and requires different kinds of data, several data formats, expertise and technological skill for their interpretation. Their analyses produce differing levels of precision and certainty. All of these factors have been considered for selecting a suitable methodology.

1.3.4 Objectives of methodologies

- Understand the nature and location of the project and possible alternatives

- Identify factors of analysis and assessment objectives
- Preliminary identification of impacts and scoping
- Baseline studies and evolution in the absence of project
- Prediction and assessment of impacts and alternatives comparison
- Mitigation
- Monitoring and impacts management

Focus of Methodology

Potential impacts and their types of environmental components, Natural and social systems, Time and space

1.3.5 Methodology Requirements

The vast varieties of raw and unorganized information that must be collected and analyzed in preparation of an EIA report. The best methods are able to:

- Organize a large mass of heterogeneous data, allow summarization of data
- Aggregate the data into smaller sets with least loss of information
- Display the raw data and the derived information in a direct and relevant fashion
- Target audience should also be considered (example if target audience are not educated then, use of color code, size, cross etc. should be used rather than figures and tables)

1.3.6 Data Collection Procedures

- Through Questionnaire Preparation
- Using checklists
- Focus Group Discussion (FGD)
- Key Informant Interview (KII)
- Public / Stakeholder consultation meeting
- Field visit

1.3.7 Major Methodologies for EIA

a) Checklists:

Checklists are standard lists of the types of environmental potential impacts, which is associated with respective project. The lists are prepared with highly structured approaches and involve importance with weighing of factors and ensure that no potential impact is overlooked. Checklists are very effective in impact identification and capable to spread awareness & attention for respective people.

Checklists enable identification of impacts on Soil, Water, Atmosphere, Flora, Fauna, Resources, Recreation and Cultural etc. status.

A typical checklist contains entries such as:

- Earth: Construction Material, Soils, Land form, Unique physical features
- Water: Surface water like rivers, lakes and reservoirs, estuaries, coastal seas and ocean, Groundwater quality
- Atmosphere: Quality (regarding gases & particles), Climate, Temperature

- Flora: Trees, Shrubs, Grass, Crops, Micro & Macro flora, aquatic plants; endangered species; barriers; corridors
- Fauna: birds; land animals including reptiles; fish and shellfish; benthic organisms; insects; micro fauna; endangered species; barriers; corridors
- Land Use: Wilderness and open space, Wetlands, Forestry; Grazing, Agriculture, Residential, Commercial, Industrial, Mining and Quarrying

Types of Checklists Used

(i) Simple Checklist

Simple checklist consists a list of environmental parameters and no information needed on the magnitude or importance of impacts. Checklist can recognize resource/environmental component, which affects by particular activities.

The example given below (**Table 1**) for construction sites, the tick mark confirm that impact is there, where no tick mark or leaving the box means no impact.

Table 1: Simple Checklist for Recognition of Environmental Impacts

Resources	Potential Impact from Construction Activities				
	Site Clearance	Earth Moving	Lay Foundation	Important Materials	Cumulative Impacts
Air Quality	√	√		√	√
Water Quality	√	√			
Landscape	√	√	√	√	√
Ecology	√				
Noise	√	√	√	√	√
Traffic	√	√	√	√	√

Tick mark indicates issues the project has an impact. The lack of the symbol indicates that the impact will not occur or insignificant. Simple Checklist can also give idea about type of impacts like short term, long term, reversible, irreversible etc.

(ii) Descriptive checklist

Descriptive checklist is extension of simple checklists and adds background information of each aspect. It also includes guidelines on the measurement of parameters. Simple checklist consists only aspects, whereas descriptive checklist gives both aspect and their background information.

Descriptive checklists are strong for impact identification of environmental parameters and also incorporate to measurement of impact measurements, interpretation & evaluation of impacts as well as in decision making process. It guides mainly how to impacts assess and include data requirements, information sources and predicted techniques.

Descriptive checklist delivers more information about the nature and magnitude of the impacts rather than just identification, whether it occurs or not. **Table 2** is an example of a descriptive checklist and includes past, present and future actions. The checklist can also discuss the cumulative impacts due to past activities, project and other nearby sources.

Table 2: Descriptive Checklist Regarding Cumulative Impacts

Resources	Past Activities	Present Impacts	Future Activities	Future Impact	Cumulative Impact
Groundwater	Contamination from industrial or other use	Contamination from surface water percolation	Excavation of site would result in mobilization of contaminants	Contamination from surface water percolation	Contamination exceeds standards
Air Quality	No significant impact from emissions	Emissions from existing power station within standards	Addition emissions	Emissions from existing power station within standards	Combined emissions of two power stations result in significant impact

(iii) Scaling Checklist

Scaling checklists are similar to the descriptive checklist with additional information of subjective scaling of the impacts on the environmental parameters.

The meaning of scaling is rating or grading system. Example: The rating of Water Quality, i.e. best is 3 and 1 for worst. A representative example is given below for scaling of parameters in **Table 3**:

Table 3: Representative Table of Scaling Checklist

Factors	Beneficial Impact			Adverse Impact		
	1	2	3	1	2	3
Habitat Quality						
Species						
Size/Abundance						
Duration						
Magnitude						
1=Low, 2=Medium, 3=High						

(iv) Questionnaire Checklist

The checklist is prepared on the basis of questions for Public Consultation (**Table 4**). It gives information about the stakeholder's awareness and responses for their proposed project. The questionnaire is further evaluated in spread sheets to find the scale of impacts and weight of parameters based on public opinion.

Table 4: Example of Questionnaire Checklist

SN.	Issue	Questions	Yes	May be	No observation
1	Noise	Will the project: ▪ Increase existing noise levels?			
2	Vegetation	Will the project: ▪ Change the diversity or productivity of species or the number of any species (including trees, shrubs, aquatic plants, etc.)?			
3	Energy	Will the project: ▪ Suse of substantial amounts of energy?			
4	Transport and traffic	Will the project: ▪ Generate additional traffic?			

SN.	Issue	Questions	Yes	May be	No observation
		Have effects or increase demand of parking infrastructures?			
5	Public Service	Will the project have effect on or result in, need for new services in or changes in the following areas: Fire services?			
6	Public Reaction	Is the project: - Potentially conserve? - Conflict with objective in environmental plans locally adapted?			

b) Matrix

Matrix method provides a framework for interaction between project activities and their environmental impacts. It can evaluate degree of impacts of project activities on environmental resources. It is a grid like table that one axis displayed project activities and other axis displayed environmental characteristics. It can also evaluate the cumulative and indirect impacts as well as interaction with resources.

c) Networks

Network method identifies the pathway of an impact using a series of chains (networks) between a proposed action and the receptor of an impact. It attempts to recognize a series of impacts that may be triggered by a project action.

Networks are those methodologies which integrate impact causes and consequences through identifying interrelationships between casual actions and the impacted environmental factors, including those representing secondary and tertiary effects.

Network diagrams, flowcharts and impacts trees are the effective major to analysis of the inter-relationship between causes and effects and enable the analysis of indirect and cumulative impacts.

1.4 Scope of the EIA Study

The EIA study describes the following important features:

- A review of the environmental legislative, regulatory and policy guidelines and considerations relating to the implementation of the project;
- A general description of the project and existing physical, biological and socio-economic conditions;
- Analysis of different alternatives to the project in terms of environmental and social perspectives;
- Identification and assessment of the potential impacts on the natural and human environment in the project area, from the construction of the project;
- Consultation with the locals/stakeholder involving concerned people in order to identify and act on any undocumented or perceived environmental issues and;
- Identify and assess any potential additional E&S impacts resulting from the change in location if any. This shall include but not limited to the following:
 - Economic/livelihood losses through material impacts caused by restricting access to and use of natural resources, if any;

- Livelihood losses through non-material impacts related to social, recreational, cultural, knowledge and educational values of the land/resource to be restricted, if any;
- Impacts related to reduced access to any social services such as education or health services by prohibiting or limiting physical access to places where those services are delivered;
- Disturbances to patterns of social relations and community cohesion;
- Impacts on human health and safety including injuries or death considering proximity to socio-cultural sensitivities
- Review the change in design of the project particularly with respect to additional land requirement and procurement process, stakeholder/landowners likely to be affected, identification of any socio-economic, cultural sensitivities, if any in the purchased and abutting property etc.
- Identify, assess and evaluate the potential impacts of the project decommissioning with respect to following as may be applicable – disruption of fishing activity, disposal of wastes, impact of aquatic flora and faunal habitat etc. and develop a management plan for the decommissioning activity.
- Provide recommendations on safety distances between the subproject and sensitive receptors, stakeholder engagement on emergency response plan catering to matters of, soil & groundwater monitoring requirements specific to the site conditions (i.e. in elevation above receptors; backfill/soil composition, stability and permeability; monsoon, dry season; etc.) (and if required suggest a supplementary Resettlement Action Plan);

1.5 Structure of The EIA Report

The structure of the report is as described in **Table 5**.

Table 5: Structure of the Environmental Impact Assessment Report

Section	Title	Description
1	Introduction (this section)	Introduction to the project and the EIA
2	Legal and Institutional Framework	Discussion of the applicable national and international environmental regulatory framework
3	Project Description	Description of the project and detailed description of the subprojects
4	Baseline Data	Outline and summary of the baseline of the physical, environmental, ecological, and socio-economic setting.
5	Environmental Impacts	Identification and assessment of the environmental risks of impacts and identification of avoidance and mitigation measures.
6	Analysis of Alternatives	Discussion of between and within subproject alternatives considered and recommendations of preferred alternatives.
7	Environmental Management Plan	Outline of the Environmental Management Plan for the Pre-Construction/ Design, Construction, and Operations Phases, including mitigation, management and enhancement measures, Responsibility, and verification and monitoring procedures.

1.6 The EIA Study Team Composition

Project Implementation Support Consultant (PISC) is involved in EIA works starting from site visit, field data collection, data compilation, data analysis, report preparation and up to final submission to DOE (Department of Environment). The EIA team composition is as follows (Table 6):

Table 6: EIA Study Team Composition

SL	Name	Educational Qualification	Experience	Area of Study	Declaration (Signature)
1	Mr. Alan K. Clark	B.Sc. in Civil Engineering M.Sc. in Irrigation	35 years	Water Resources	
2	Md. Shahidul Haque	B.Sc. in Civil Engineering, Masters in Irrigation Engineering	37 years	Water Resources Management	
3	Manik Chandra Rudra	B.Sc. in Civil Engineering	45 years	Hydraulic Design & foundation Design	
4	Dr. Quazi Rezaul Islam	B.Sc. in Agriculture (Hons)	33 years	Agronomy & Crop production	
5	Dr. Kabil Hossain	Ph.D. in Environmental Science	30 years	Environment & Climate Change	
6	Akhter Jahan	M.S.S in Economics	30 years	Gender Development	
7	Nasrin Akter Jahan	M.S.S in Political Science	24 years	Social Safeguard	
8	Sankar Chandra Sutradhar	B.Sc. in Fisheries (Hons.) & M.Sc. in Environmental Science	35 years	Fisheries and Aquaculture	
9	M. Nurul Anwar	B.A & M.A in Social Science	32 years	Institution Development	
10	Md. Sohrab Hossain Khan	B.Sc. in Agriculture and M.Sc. (Ag.) in Soil Science	33 years	Agronomy & Soil Science (Ag.)	
11	Md. Aminul Islam	M.A in Economics	38 years	Agro-economy	
12	Omar Faruk	B.Sc. in Agriculture, M.Sc. in Entomology Ph.D. in Entomology	11 years	Agronomy	
13	Md. Monirul Islam	B.Sc. in Civil Engineering	18 years	Water Resource Planning	
14	Tanvir Ahsan Haque	M.Sc. GIS for Environment & Development	10 years	Environment & Ecology	
15	Tanjid Bin Taslim	M.Sc. GIS for Environment & Development	8 years	Water Resources Development & GIS	

LGED is responsible to coordinate with the Consultant to carry out the EIA study along with EMP in accordance with environmental guidelines of GOB (ECR 2023). The team acknowledges the cooperation of Engineer Md. Enamul Kabir, Project Director, CDRSSWRMP, LGED.

2 POLICY, LEGAL, AND INSTITUTIONAL FRAMEWORKS

This chapter reviews the national policy, legal, and regulatory framework relevant to the environmental and social aspects of the Project, including applicable environmental standards. It also presents key provisions of the applicable international standards.

2.1 National Environmental & Social Laws, Rules, Policies and Guidelines

Key legislation governing the environmental approvals process for the proposed subproject is the Bangladesh Environment Conservation Act (ECA), 1995 (BECA, 1995)¹ and the Environment Conservation Rules (ECR, 2023)².

According to Rule 5 of the ECR 2023, proposed developments within Bangladesh are classified as one of four categories, as follows:

- Green;
- Yellow;
- Orange; and
- Red

These categories define proposed developments according to their potential environmental impact. Section 12 of the ECA states that 'No industrial unit or project shall be established or undertaken without obtaining an Environmental Clearance Certificate from the Director General, in the manner prescribed by the Rules'.

This section summarizes the National Laws and describes the procedure for obtaining environmental permits to allow project implementation. Over the years, the Government of Bangladesh has enacted environmental acts, rules, policies and regulation toward imposing restrictions facilitating minimization / mitigation of likely impacts due to development projects. The most important Act is Environmental Conservation Act, 1995 (ECA, 1995) and Environmental Conservation Rules (ECR, 2023).

2.2 National Environmental Policy

The National Environmental Policy was adopted in 1992 and is now under revision. It embraces different sectors related to agriculture, forest, power, health, transport, housing etc. The central theme of policy is to ensure protection and improvement in environment. The policy gives a thrust to sustainable development and long-term use of natural resources. The National Environment Policy contains policy statements and strategic options with regard to population and land-use management, management and utilization of natural resources and other socio-economic sectors, as well as the necessary arrangements for the implementation of the policy. The policy enables:

- the country to strike a dynamic balance between population and resources while complying with the balance of ecosystems;
- to contribute to sustainable and harmonious socio-economic development such that, both in rural and urban areas, and well-being in a sound and enjoyable environment; and

¹ The Act was amended by Act Nos 12 of 2000, 9 of 2002, and 50 of 2010.

² The ECR 2023

- To protect, conserve and develop natural environment

Relevance to the project - With regard to the project, the environmental policy aims at prevention of pollution and degradation of resources caused by the building construction. The policy mentions that Environmental Assessments (EA) should be conducted before project is undertaken.

2.3 National Conservation Act (ECA), 1995

The ECA is currently the main legislation relating to environment protection in Bangladesh. This Act is promulgated for environment conservation, environmental standards development and environment pollution control and abatement.

The main objectives of ECA are:

- Conservation and improvement of the environment; and
- Control and mitigation of pollution of the environment.

The main focuses of the Act can be summarized as:

- Declaration of ecologically critical areas and restriction on the operations and processes, which can or cannot be carried out/ initiated in the ecologically critical areas (ECA);
- Regulations in respect of vehicles emitting smoke harmful for the environment;
- Environmental clearance;
- Regulation of industries and other development activities' discharge permits;
- Promulgation of standards for quality of air, water, noise and soil for different areas for different purposes;
- Promulgation of a standard limit for discharging and emitting waste; and
- Formulation and declaration of environmental guidelines.

Before any new project can go ahead, as stipulated under the ECA, the project promoter must obtain Environmental Clearance from the Director General (DG), DoE. An appeal procedure does exist for those promoters who fail to obtain clearance. Failure to comply with any part of this Act may result in punishment to a maximum of 5 years imprisonment or a maximum fine of Tk.100,000 or both. The DoE executes the Act under the leadership of the DG.

The Project will be undertaken in line with the aims and objectives of the Act by conserving the environment and controlling and mitigating potential impacts throughout the construction program.

- ***Environmental Conservation Act (Amendment 2000)***

The Bangladesh Environment Conservation Act (Amendment 2000) focuses on ascertaining responsibility for compensation in cases of damage to ecosystems, increased provision of punitive measures both for fines and imprisonment and the authority to take cognizance of offences.

- ***Environmental Conservation Act (Amendment 2002)***

The 2002 Amendment of the ECA elaborates on the following parts of the Act:

- Restrictions on polluting automobiles;

- Restrictions on the sale, production of environmentally harmful items like polythene bags;
- Assistance from law enforcement agencies for environmental actions;
- Break up of punitive measures; and
- Authority to try environmental cases.

- ***Environmental Conservation Act (Amendment 2010)***

This amendment of the act introduces new rules and restriction on:

- No individual or institution (Gov. or Semi Govt., / Non-Govt. / Self Governing) can cut any Hill and Hillock. In case of national interest; it can be done after getting clearance from the respective department
- Owner of the ship breaking yard will be bound to ensure proper management of their hazardous wastes to prevent environmental pollution and Health Risk
- No remarked water body can be filled up/changed; in case of national interest, it can be done after getting clearance from the respective department; and
- Emitter of any activities/incident will be bound to control emission of environmental pollutants that exceeds the existing emission standards.

Relevance to the project - According to this law no industrial unit or project shall be established or undertaken without obtaining an Environmental Clearance Certificate from the Director General in the manner prescribed by rules.

2.4 National Conservation Rules (ECA), 2023

These are a set of rules, promulgated under the ECA, 1995 and its amendments. The Environment Conservation Rules provide categorization of industries and projects and identify types of environmental assessment required against respective categories of industries or projects. The Rules set:

- The National Environmental Quality Standards (NEQS) for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc.;
- The requirement for and procedures to obtain environmental clearance; and
- The requirement for IEE and EIA according to categories of industrial and other development interventions.

The Environment Conservation Rules, 2023 were issued by the GOB in exercise of the power conferred under the Environment Conservation Act (Section 20), 1995. Under these Rules, the following aspects, among others, are covered:

- Declaration of ecologically critical areas;
- Classification of industries and projects into four categories;
- Procedures for issuing the Environmental Clearance Certificate (ECC); and
- Determination of environmental standards.

Rule 3 (ECR 1997) defines the factors to be considered in declaring an 'ecologically critical area' as per Section 5 of the ECA (1995). It empowers the Government to declare the area as the Ecologically Critical Areas (ECA), if it is satisfied that the ecosystem of the area has reached or is threatened to reach a critical state or condition due to environmental degradation. The

Government is also empowered to specify which of operations or processes may be carried out or may not be initiated in the ecologically critical area. Under this mandate, the Ministry of Environment, Forest and Climate Change (MoEFCC) has declared Sundarbans, Cox's Bazar-Teknaf Sea Shore, Saint Martin Island, Sonadia Island, Hakaluki Haor, Tanguar Haor, Marzat Baor and Gulshan-Baridhara Lake as ecologically critical areas and prohibited certain activities in those areas.

Rule 7 of the 2023 ECR provides a classification of industrial units and projects into four categories, depending on environmental impact and location. These categories are:

- Green;
- Yellow;
- Orange; and
- Red;

The categorization of a project determines the procedure for issuance of an Environmental Clearance Certificate (ECC). All proposed industrial units and projects that are considered to be low polluting are categorized under "Green" and shall be granted Environmental Clearance. These are yellow & Orange for work that requires Initial Environmental Examination (IEE) and Red for work that requires full environmental assessment.

Depending upon location, size, and severity of pollution loads, projects/activities have been classified in ECR, 2023 into four categories: Green, Yellow, Orange, and Red respectively, to nil, minor, medium, and severe impacts on important environmental components (IECs).

A detailed description of those four categories of industries has been given in Schedule-1 of ECR 2023. Apart from general requirement, for every "Red" category proposed industrial unit or project, the application must be accompanied with feasibility report on Initial Environmental Examination, Environmental Impact Assessment based on approved TOR by DOE, Environmental Management Plan (EMP) etc.

The environmental assessment has been carried out using a field environmental assessment standards requirements checklist for the improvement the project. As per GOB guideline³ it is a **"Red" category project**. This EIA has been prepared in accordance with ECR 2023 requirements for a category "Red" project and also provides mitigation and monitoring measures to ensure potential impacts because of the project. Both for ADB and GOB, an EIA with Environment Management Plan (EMP) is required to determine the environmental and social impacts.

Relevance to the project - In accordance with the Environment Conservation Rules (ECR) of 2023, the Project is classified as Red Category, requiring an Environmental Impact Assessment (EIA) to obtain clearance for construction.

2.5 National Water Policy, 1999

The policy aims to provide guidance to the major players in water sector for ensuring optimal development and management of water. The policy emphasizes efficient and equitable management of water resources, proper harnessing and development of surface and ground water, availability of water to all concerned and institutional capacity building for water resource

³ Environment Conservation Rules, 2023, GOB

management. It also addresses issues like river basin management, water rights and allocation, public and private investment, water supply and sanitation and water need for agriculture, industry, fisheries, wildlife, navigation, recreation, environment, preservation of wetlands, etc. The policy has several clauses related to the project for ensuring environmental protection.

Relevance to the project - Clause 4.6b of this policy states that natural depressions and water bodies in major urban areas must be preserved in order to recharge of underground aquifers and rainwater management. Moreover, measures must be taken to minimize disruption to the natural aquatic environment in streams and water channels (Clause 4.9b). In addition, this policy requires each water resources development project or rehabilitation program to provide consideration to environmental protection, restoration and enhancement measures consistent with National Environmental Management Action Plan (NEMAP) and the National Water Management Plan (NWMP) and adhere to a formal environment impact assessment (EIA) process, if required by the Government (Clause 4.12a and clause 4.12b).

2.6 Institutional Arrangement

The Environmental Management Plan (EMP) implementation requires an organization support structure in the form of organizational requirements, training needs and plan, and information management system. The following section captures these institutional arrangements for EMP implementation by concerned officials of LGED, their consultants and working contractors.

The main Ministry, Department, Institutions and Boards responsible for development of policy, framing regulation, developing projects, monitoring and approval of issues related to environment protection and conservation are presented in this section.

The organizational structure for LGED (Local Government Engineering Department) at the district level in Cox's Bazar is headed by a District Executive Engineer or an equivalent senior official, who reports to higher-level authorities within the LGED hierarchy, such as the Superintending Engineer, Chief Engineer, and ultimately the Secretary of the Local Government Division. The district office functions through various departments, including roles for Planning, Finance, Audit, Maintenance & Operations, Environment, Research, and Project Management.

The organizational structure of LGED is given in **Figure 1**. However, an organizational structure shall be developed at the corporate, regional and site level to aid effective implementation of the ESMP document. Various departments will be involved during implementation of the project. Contractor is responsible for implementation of ESMP during works and Project Implementation Support Consultant (PISC) is primarily responsible for supervision of monitoring of the implementation of the ESMP. LGED will be supported by a Project Management Unit (PMU) to advise and assist LGED in quality and capacity enhancement and independent quality monitoring. Contractor will be responsible for implementation of ESMP during work activities stage. Relevant departments responsible for implementation and supervision of proposed mitigation and monitoring measures are given in the EMP.

The Department of the Environment in 1977, Environment Pollution Control Board with 16 members headed by a Member of the Planning Commission and Environment Pollution Control Cell headed by a director with staff complement of 26 was established. This was followed in 1977 by the establishment of the Environment Pollution Control Project, in 1985 by the establishment of the Department Pollution Control and finally, in 1989 by the restructured and

renamed the Department of Environment (the Department) the activities of which are overseen by a Director General. The Department discharges its responsibilities through a head office and six Divisional offices located in Dhaka, Chittagong, Khulna, Bogura (Rajshahi), Barisal, and Sylhet.

DoE activities affect every socio-economic sector and direct and influence all activities wherever they might take place in Bangladesh. The department was created in 1989 to ensure sustainable development and to conserve and manage the environment of Bangladesh. Over the last decades, the major activities performed by the department had undergone significant metamorphosis from a limited scope of performing merely regulatory and routine function to a wider and broader horizon comprising more action-intensive and research-oriented endeavors of investigating, identifying, conserving and nurturing as well as enhancing the qualities of the various ecosystems encompassing the overall environment of the country.

The Ministry of Environment, Forests and Climate Change (MoEFCC) is the nodal agency in the administrative structure of the Central Government, for the planning, promotion, co-ordination and overseeing the implementation of environmental and forestry programs. MoEFCC oversees all environmental matters in the country and is a permanent member of the Executive Committee of the National Economic Council. The Ministry also plays a pivotal role as a participant of United Nations Environment Programme (UNEP).

The principal activities undertaken by MoEFCC consist of conservation & survey of flora, fauna, forests and wildlife, prevention & control of pollution, forestation, & regeneration of degraded areas and protection of environment, in the framework of legislations. The main tools utilized for this include surveys, impact assessment, control of pollution, regeneration programme, support to organizations, research to solve solutions and training to augment the requisite manpower, collection and dissemination of environmental information and creation of environmental awareness among all sectors of the country's population. The organizational structure of the ministry covers a number of divisions, directorate, board, subordinate offices, autonomous institutions, and public sector undertakings.

[illegible]

LGED also develops infrastructure database, maps, technical specifications, manual etc. required for development projects. Regular training courses conducted by LGED for enhancing skill of its own employees, members of the Local Government Institutions and other stakeholders.

Page | 31



Figure 2: The diagram showing the operation area of LGED

2.7 Environmental Clearance Certificate General Procedure in Bangladesh

Step 1: Submit application with supporting documents.

Step 2: Verification of application and supporting documents by DOE

Step 3: Inspection by the authorized officer after verification of all report and documents.
[Then make decision about the clearance (Only Green and Yellow)]

Step 4: Meeting of Environmental Clearance Committee (for Orange and Red Category)

Step 5: Meeting Decision

Environmental Clearance Certificate's shall be issued to all existing industrial units and projects and to all proposed industrial units and projects falling in the Green Category. For industrial units and projects falling in the Yellow, Orange, first a Site Clearance Certificate and thereafter an Environmental Clearance Certificate shall be issued. In case of "Red" category industries, firstly a Location Clearance Certificate, then Environment Impact Assessment (EIA) approval and thereafter an Environmental Clearance Certificate shall be issued.

Documents Required for Different Categories of Industrial Units or Projects for Environmental Clearance Certificate.

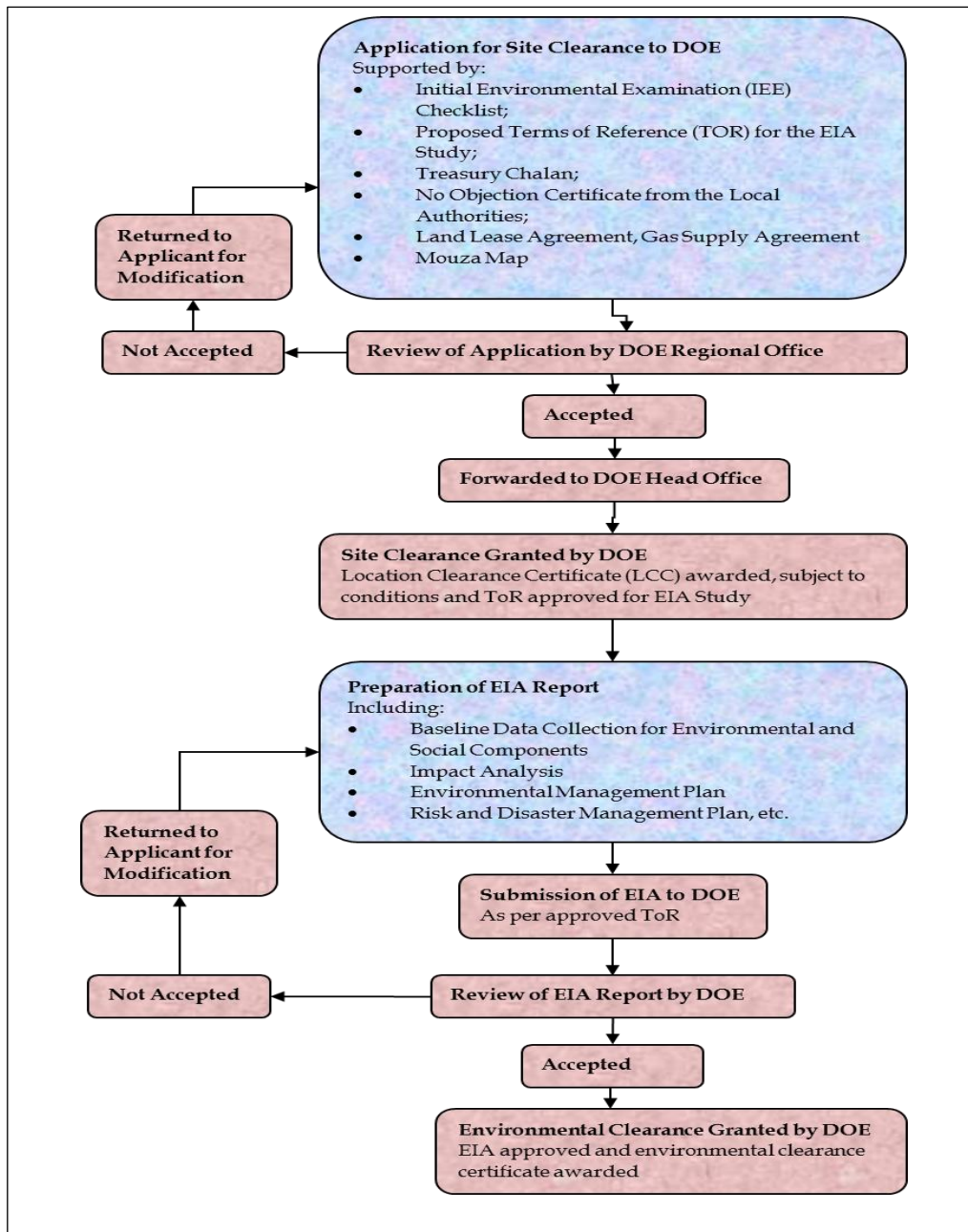


Figure 3: General Environmental Clearance Procedure of DOE

Red Category: Documents Required for Red Category for Environmental Clearance Certificate.

- Application through prescribed form-3 under Environment Conservation Rules 2023
- Prescribed fees under schedule-13 under Environment Conservation Rules 1997 (Amended 2002)

- Report on the feasibility of the industrial unit or project (applicable only for proposed industrial unit or project)
- Environmental Impact Assessment (EIA)
- Process Flow Diagram (showing location of Effluent Treatment Plant)
- Layout Plan (showing location of Effluent Treatment Plant)
- Design and Time Schedule of the Effluent Treatment Plant (ETP)
- Report on the Environmental Management Plan (EMP)
- No objection certificate (Prescribed Form) of the local authority
- Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution
- Outline of relocation, rehabilitation plan (where applicable)
- Other necessary information (where applicable)

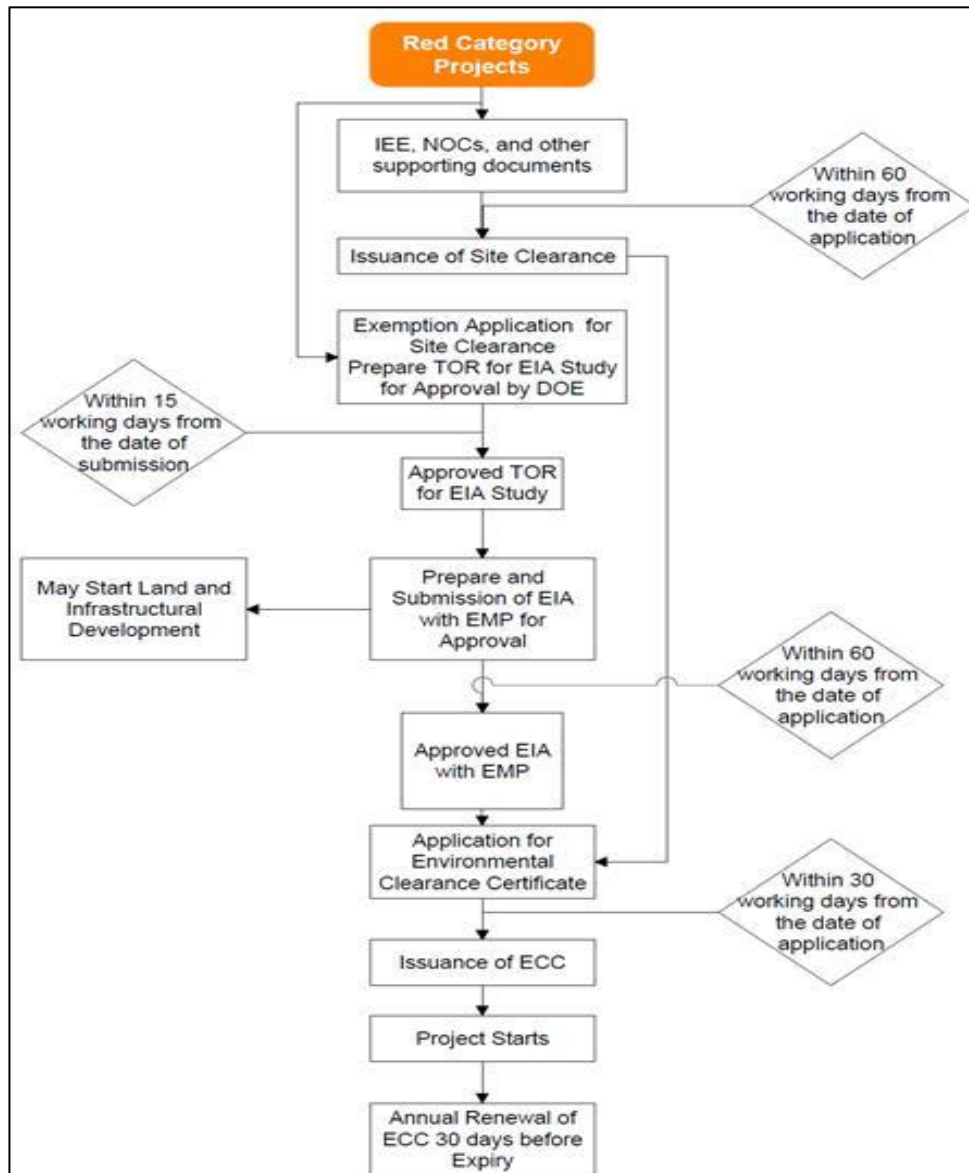


Figure 4: Environmental Clearance Procedure for Red Category Project

In addition to ECA 1995 and ECR 1997 (subsequently ECR 2023), there are a number of other policies, plans, and strategies, which need to be considered in the project. The detailed description of all these relevant legislations is provided afterward in Section 2 of this report. Following the approved ToR of DoE the EIA study specially EIA Study has been done (**Appendix 13 and Appendix 14**)

2.8 International Conventions, Treaties and Protocols

Bangladesh is a signatory to several international environment-related treaties, conventions, declarations and protocols. The following are the relevant international treaties and conventions to which Bangladesh is a party:

Table 7: Treaty or Convention and Responsible Agency

Treaty	Year	Brief Description / Relevance for CCAUD	Relevant Department
Ramsar Convention	1971	Protection of wetlands.	DoE/DoF
World Cultural and Natural Heritage (Paris)	1972	Protection of major cultural and natural monuments.	DoArch
Occupational safety and health in working environment (Geneva)	1981	Prevent accidents and injuries to health by minimizing hazards in the working environment.	MoH
Occupational Health services	1985	To promote a safe and healthy working environment.	MoH
UN Framework convention on Climate Change (Rio de Janeiro)	1992	Regulation of greenhouse gases (GHGs) emissions.	DoE
Convention on Biological Diversity (Rio de Janeiro)	1992	Conservation of biodiversity, sustainable use of its components and access to genetic resources.	DoE
International Convention on Climate Changes (Kyoto Protocol)	1997	International treaty on climate change and emission of greenhouse gases.	DoE

Aside from the legal framework on environment, Bangladesh is also a party to several international conventions, treaties, and protocols related to environmental protection. Bangladesh has signed most international treaties, conventions and protocols on environment, pollution control, bio-diversity conservation and climate change, including the RAMSAR Convention, the Bonn Convention on Migratory Birds, the Rio de Janeiro Convention (1992) on Biodiversity Conservation, and the Kyoto Protocol (1997) on Climate Change. The applicable international conventions, treaties, and protocols are described in **Table 8**.

Table 8: International Conventions, Treaties, and Protocols Signed by Bangladesh

Conventions	Years	Ratified/Accessed (AC)/Accepted (AT)/ Adaptation (AD)	Relevance
International Plant Protection Convention (Rome,) & Plant Protection Agreement for SE Asia and Pacific (1999 Revision)	1951 1999	04.12.1974 (AC) 01.09.1978 (Entry into Force)	Ensuring that the Project work or construction materials do not introduce plant pests
Convention on Wetlands of International Importance ("Ramsar Convention":1971)		20.04.1992 (ratified)	Protection of significant wetland and prevention of draining or filling during construction
Convention on Biological Diversity, (Rio de Janeiro, 1992)	1992	05.06.1992	Protection of biodiversity during construction and operation.
Convention on Persistent Organic Pollutants, Stockholm.	2001	In process	Restrict use of different chemicals containing POPs.
United Nations Framework Convention on Climate Change, (New York, 1992.)	1992	15.04.94	Reduction of emission of greenhouse gases.
Convention on Biological Diversity, (Rio De Janeiro, 1992.)	1992	03.05.94	Conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits

Conventions	Years	Ratified/Accessed (AC)/Accepted (AT)/ Adaptation (AD)	Relevance
			arising out of the utilization of genetic resources.
Kyoto protocol to the United Nations Framework Convention on Climate Change		21.8.2001 (AC) 11.12.1997 (AD)	Reduction of emission of greenhouse gases.
International Convention for Protection of Birds, Paris	1950	Signed	Protection of the birds in their wild state.
Convention Concerning the Prevention and Control of Occupational Hazards caused by Carcinogenic Substances and Agents, Geneva.	1974	Signed	To protect workers against hazards arising from occupational exposure to carcinogenic substances and agents.
Convention Concerning the Protection of Workers Against Occupational Hazards in the Working Environment due to Air Pollution, Noise and Vibration, Geneva	1977	Signed	Protection of workers' health against occupational hazards in the working environment due to air pollution, noise and vibration.
Convention Concerning Occupational Safety and Health and the Working Environment, Geneva.	1981	Signed	Ensuring occupational health and safety of workers in all branches of economic activity.
Vienna Convention for the Protection of the Ozone Layer, Vienna	1985	02.08.90 (AC) 31.10.90 (entry into force)	Preventing human activities that may have adverse effects on ozone layer.
Convention Concerning Occupational Health Services, Geneva.	1985		Convention Concerning Occupational Health Services, Geneva.
Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal.	1987	31.10.90 (Entry into force)	Reduction of the abundance of the substances that deplete the ozone layer in the atmosphere, and thereby protect the earth's fragile ozone Layer.
Convention Concerning Safety in the Use of Chemicals at Work, Geneva.	1990	Signed	Regulating the management of chemicals in the workplaces in order to protect workers from the harmful effects of these substances.
London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, London.		18.03.94 (AC) 16.06.94 (entry into force)	To strengthen the control procedure and extend the coverage of Montreal Protocol to new substances.
Preparedness, Response and Cooperation (London, 1990.) 30.11.90 United Nations Framework Convention on Climate Change, New York	09.06.92	15.04.94	Achieving stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
Convention on Biological Diversity, Rio De Janeiro	05.06.92	03.05.94	Conservation of biological diversity (or biodiversity) and sustainable use of its components.
Agenda 21, UNCED, Rio de Janeiro	1992	Signed	Ensuring sustainable development.

Conventions	Years	Ratified/Accessed (AC)/Accepted (AT)/ Adaptation (AD)	Relevance
Copenhagen Amendment to the Montreal protocol on Substances that Deplete the Ozone Layer, Copenhagen, 1992	1992	27.11.2000 (AT) 26.2.2001 (Entry into force)	Extending the coverage of Montreal Protocol to new substances
Montreal Amendment of the Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal		27.7.2001 (Accepted) 26.10.2001 (Entry into force)	Controls in the trade of ozone depleting substances and the use of licensing procedures to control the import and export of new, recycled and reclaimed ozone depleting substances.

2.9 Applicable GOB Regulation and Legislation

The National legislation that will be triggered by the activities under nine subprojects has been analyzed as shown in **Table 9**.

Table 9: Applicable National Regulation and Legislation for CDRSSWRMP

Regulation	Applicability	Relevance to sub-projects
Bangladesh Environmental Conservation Act, 1995 as amended in 2010	Triggered	The ECA makes it mandatory to obtain environmental clearance for industrial units and projects. Ecologically Critical Areas in coastal zone, defined by DoE under this act, will not be covered by any of the CDRSSWRMP Subprojects. But other important environmental concerns described by this Act, such as conservation of wetlands and hazardous waste disposal are relevant with few subprojects.
Bangladesh Environment Conservation Rules (ECR), 2023	Triggered	Considering the scope of works involved with the subprojects in CDRSSWRMP, it can be considered that, embankment construction, riverfront development, dredging of different Khals, improvement of unlined link canals and construction of sluice gates along with establishment of new pumping station will fall in to 'Red' category and rest of the subprojects will fall in to 'Orange' category. Therefore CDRSSWRMP 'Red' category subprojects require Feasibility Study, IEE, EIA and EMP for environmental clearance from DOE while 'Orange' category subprojects require Feasibility Study, IEE and EMP only to obtain ECC. The application for ECC from the DOE has two steps: (i) site clearance certificate is obtained at the initial stage and (ii) the ECC at the advanced stage. A site clearance and ECC are required for the categories (i.e., Yellow, Orange, and Red) where the green category only requires ECC. Provides environmental standards for quality of air, water, noise, vehicle emissions, odor, and sewerage discharge.
The Acquisition and Requisition of Immovable Property Act (ARIPA), 2017:	Triggered	Khal excavation, sluice development, water retention structure will cause potential relocation or a significant number of resettlements of buildings, unofficial housing/dwellings and business are located along this stretch of the proposed site.
Water Act 2013	Triggered	The subproject activities will take place to distribute, use, develop, protect, and conserve water resources through directing waste or storm water using drainage systems into the wetlands, dredging, lining & bank protection works and restoring aquatic environment through rehabilitation of ponds respectively.
Natural Water Bodies Protection Act 2000	Triggered	Few sub-projects may change the character of water body i.e., rivers, canals, or ponds identified as water bodies in the master plans.
Bangladesh Wildlife (Protection and Safety) Act 2012	Not triggered	The CDRSSWRMP subprojects are implemented in an urban setting and highly modified habitat. They will not take place in any wildlife sanctuary, game or reserve forest.

Regulation	Applicability	Relevance to sub-projects
Bangladesh Wildlife (Preservation) Order (1973) and Act (1974)	Not triggered	The CDRSSWRMP subprojects are implemented in an urban setting and highly modified habitat. They will not take place in any wildlife sanctuary, game or reserve forest.
The Private Forest Act of 1959	Not triggered	Within the project area, improperly managed private forest lands or any private lands that can be afforested or any land lying fallow for more than three years have not been identified.
Embankment and Drainage Act, 1952	Triggered	CDRSSWRMP subprojects are mostly relevant with drainage improvement & embankment construction to protect the area from flooding.
Bangladesh National Building Code, 2006	Triggered	Usually, CDRSSWRMP project area or new development area of LGED satisfies the criteria of Flood Prone Area mentioned in BNBC. WMCA office building will follow building code.
The Bangladesh Labor Act, 2006	Triggered	Broadly applicable during the construction and O&M activities under the project. Appropriate mitigation and protective measures will be included in the EMP.

2.10 Collection of NOCs from Respective Authorities

The project covers 42 districts and the subproject is located at union level. So, NOC has been obtained from Union Parishad for respective subproject. Subproject selection, reconnaissance, PRA, feasibility study, detail design and implementation are a continuous process till completion of the project. Therefore, one NOC obtaining from one union parishad will represent as NOC from the respective district because NOCs from all of the UPs of that district will be collected accordingly. Status of NOC collection is shown in **Table 10**.

Table 10: Collection of NOC from Respective Authorities of 42 Project Districts

Sl. No.	District	Subprojects	Type (New/ PE)	Name of UP/WMCA	Name of Chairman	Mobile No.
1	Barguna	Nalbunia	New	Nishanbaria	Md. Dulal Foraji	01740-810853
2	Barishal	Chandpura	PE	Chandpura	Md. Zahid Hossain	01740-639095
3	Bhola	Nilkamal	PE	Nilkomol/WMCA	Iqbal Hossain Likhon	01716-174047
4	Patuakhali	Paler Danga	New	Lohalia	Md. Kabir Hossain	01714-598029
5	Jhalokathi	Rajpasa	New	Siddhakati	Kazi Jesmine Akhter	01712-065666
6	Pirojpur	Amtola	New	Nazirpur	Md. Mosharef Hossain Khan	01713-952038
7	Chandpur	Rupsha Rumur Khal	PE	Rupsha (North)	Md. Omar Faruq	01738551210
8	Laxmipur	Bhuluar Khal	PE	Dighali/WMCA	Altaf Hossain Khokon	01711-712896
9	Noakhali	Olipur	PE	Char Kakra	Md. Hanif Sabuj	01817-075175
10	Chattogram	Mirzakhil Darbar Sharif	New	Sonakanian	Md. Mohiuddin(Act)	01796-495877
11	Cox's Bazar	Bakkhali Rubber Dam	PE	PmKhali/WMCA	Fakir Ahmed	01812-662463
12	Cumilla	Rajitpur Boroshapmara	PE	Manikarchar	Md. Zakir Hossain	01813-776041
13	Khulna	Bajua Charar Beel	PE	Bajua	Manos Kumar Roy	01910-664161
14	Bagerhat	Dier Khal	PE	Baroipara/WMCA	Md. Hydar Ali Morol	01719505711
15	Jashore	Dolpur Mukteshwary	PE	Churamon Kathi	Md. Dawood Hossain	01720-94444
16	Narail	Khatnur Beel	PE	Tularampur, Shekhhati, Jamdia/WMCA	Arup Kumar Goshymy	01860-362788
17	Satkira	Chakarkhali Beel	PE	Magura	Ganesh Debnath	01718-049693
18	Chuadanga	Baradi Kamarpara FCD	PE	Parkrishnopur Madna	Md. Abul Hassan	01752-902144
19	Meherpur	Madiar Beel	PE	Mohajonpur	Md. Moyanddin	01711-313998
20	Bogura	Bosonbari Khal	PE	Noshrotpur	Md. Golam Mostafa	01718-414923
21	Chapai Nawabgonj	Choitonopur-Poranpur CAD	PE	Dhainagor	Md. Abdul Latif	01726-434440
22	Natore	Rawta Astikpara	PE	Chandai/WMCA	Abu Bakkar Siddique	01731-832997
23	Pabna	Beelvaduria Khal	PE	Malanchi	Md. Kabir Ahmed	01711-968312
24	Rajshahi	Dhuroil	New	Dhuroil	Md. Kazim Uddin	01711-366221
25	Sirajganj	Monohara	PE	Durganagor	Md. Afsar Ali	01711-167090
26	Joypurhat	Chri Khal	PE	Rukindipur	Md. Abu Motaleb	01733-428681
27	Naogaon	Kazipur	New	Aranagor	Mosaddequr Rahman	01711-987060
28	Gaibandha	Madarpur-Choutpur	PE	Dorbosto	A.R.M. Shariful Islam	01716-063919
29	Dinajpur	Tangaon River Rubber Dam	PE	Chhatil	Md. Noor Sultan	01303-728999
30	Nilphamari	Duhuli Chonkhar beel	PE	Kachukata	Md. Abdur Rouf Chowdhury	01716-963844
31	Panchagar	Akandapara	New	Chilahati	Kamal Mostaharul Hasan Noyon	01716-884457
32	Rangpur	Hieler Beel	PE	Milonpur/WMCA	Md. Ashikur Rahman	01750-550808
33	Thakurgaon	Anjila Khal	PE	Rajagaon/WMCA	Md. Moshur Rahman	01740-921941
34	Kurigram	Kachakata Boroshapmara	PE	Kachakata	Md. Shahadat Hossain Mondol	01734-969064
35	Lalmonirhat	Bhateshwar	PE	Dolgram	Md. Iqbal Hossain	01737-458308
36	Gopalganj	Pathor Ghata -Ratoil-Chapta	PE	Kalivita	Rathindra Nath Biswash	01712-081407
37	Kishoreganj	Kosra Korail	PE	Jinari/WMCA	Md. Akbor Ali	01716-665788
38	Habiganj	Darveshpur Khal	PE	Ramgaon/WMCA	Md. Samsul Haque	01726-611985
39	Moulvibazar	Boro Chara	PE	Mirzapur/WMCA	Abdul Hoque	01717-281394
40	Sunamganj	Noiganag Chhara	New	Rangarchar	Md. Abdul Hai	01712-263571
41	Sylhet	Shialichara	PE	Fatehpur/WMCA	Md. Jubaer Ahmed	01715-356070
42	Netrokona	Bipinganj	PE	Kullagora/WMCA	Delwara Begum	01996-623484

3 DESCRIPTION OF THE PROJECT CDRSSWRMP

3.1 Need for the project

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is driven by the urgent need to address vulnerabilities in the agriculture sector due to climate change, improve rural livelihoods, and manage water resources sustainably in high-risk areas.

The core needs for the project are:

- **Climate Change Adaptation:** Bangladesh is highly vulnerable to climate change, with increased flooding, sea-level rise, and saltwater intrusion affecting agricultural land. The project aims to build resilience through climate-proofed, small-scale water infrastructure like embankments and regulators.
- **Agricultural Productivity & Food Security:** Low productivity, inefficient water use, and crop damage during natural disasters (floods, droughts) necessitate better water management to boost farm income for rural households.
- **Infrastructure Improvement:** Many existing rural infrastructures are inadequate or outdated. The project provides necessary upgrades to irrigation, drainage, and water conservation systems across 42 districts in four specific "hotspots" (Barind/drought-prone, coastal, haor/flash flood, and river systems).
- **Sustainability via Community Management:** Previous projects highlighted that long-term success requires local ownership. The project establishes or strengthens 150 new and 230 existing Water Management Cooperative Associations (WMCAs) to operate and maintain the infrastructure.
- **Poverty Reduction & Job Creation:** By enhancing agricultural productivity and providing employment through construction and maintenance activities, the project directly supports the livelihoods of 380,000 households, including 45,000 functionally landless or vulnerable families.
- **Value Chain Development:** The project moves beyond just water management to improve the profitability of farming by developing market facilities, including cold storage and better market access for agricultural products.

The project is aligned with the Bangladesh Delta Plan 2100 and the Eighth Five Year Plan (FY2021–FY2025).

3.1.1 Justification

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh is justified by the urgent need to protect rural livelihoods, agricultural productivity, and food security from the intensifying impacts of climate change.

Co-financed by the International Fund for Agricultural Development (IFAD), the Asian Development Bank (ADB), and the Government of the Netherlands, the project addresses key vulnerabilities in Bangladesh's rural, agricultural-dependent population.

Core Justifications for the CDRSSWRMP

- **High Climate Vulnerability:** Bangladesh is among the countries most exposed to natural hazards, facing increased risks from floods, droughts, saline intrusion, and sea-level rise. These climate-induced events threaten to disrupt agricultural production.
- **Protection of Rural Livelihoods:** Approximately 85% of the poor in Bangladesh live in rural areas. The project aims to secure the livelihoods of about 335,000 farming households and 45,000 functionally landless people.
- **Enhanced Agricultural Productivity:** The project supports the transition from subsistence to commercial farming by improving water management, which is expected to increase crop yields, cropping intensities, and farm incomes.
- **Infrastructure Climate-Proofing:** It focuses on building or enhancing small-scale water resources infrastructure (e.g., drainage, irrigation, water conservation) to be resilient to disasters.
- **Participatory Water Management:** The project utilizes a participatory approach, establishing Water Management Cooperative Associations (WMCAs) to ensure sustainable, community-led management of infrastructure.
- **Alignment with National Strategy:** The project aligns with the Seventh Five Year Plan of Bangladesh, which prioritizes sustainable development, poverty reduction, and climate change adaptation.

In summary, the project is necessary to build resilience in rural areas, directly combating the adverse effects of climate change on food security and economic stability.

3.1.2 Purpose and benefits of the project

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), is a 6-year initiative in Bangladesh designed to reduce rural poverty and improve livelihoods by increasing climate-resilient agricultural productivity. It is implemented by the Local Government Engineering Department (LGED) with funding from the Asian Development Bank (ADB), the International Fund for Agricultural Development (IFAD), and the Government of the Netherlands.

Purpose of the Project

The core purpose of CDRSSWRMP is to shift traditional water management towards a sustainable, stakeholder-driven approach that can withstand climate-induced disasters (floods, droughts, and salinity).

- **Targeted Areas:** The project focuses on 42 districts in Bangladesh, specifically targeting four "hotspots" identified in the Bangladesh Delta Plan 2100: the Barind (drought-prone) areas, the coastal zone, the Haor and flash flood areas, and river systems.
- **Infrastructure & Development:** The project intends to establish 150 new, inclusive subprojects managed by Water Management Cooperative Associations (WMCAs), and strengthen and enhance performance of 230 existing subprojects and WMCAs.
- **Capacity Building:** It aims to enhance the capacity of LGED's Integrated Water Resources Management Unit (IWRMU) to plan and monitor sustainable infrastructure.

Benefits of the Project

The project offers significant, multifaceted benefits to rural communities:

1. Improved Agricultural Productivity & Livelihoods

- **Increased Yields:** By upgrading small-scale water resources (sluice gates, embankments, drainage canals), the project will increase irrigation efficiency and reduce crop damage during disasters, directly boosting farm incomes.
- **Crop Diversification:** The project promotes the cultivation of higher-value crops beyond just rice, increasing profitability for farmers.
- **Fisheries Development:** Support for cage aquaculture and floodplain fisheries, enhancing income opportunities.

2. Enhanced Climate Resilience

- **Climate Adaptation :** It provides infrastructure designed to handle projected climate change impacts, such as increased occurrence of extreme rainfall events, sea level rise, rising and extreme temperatures, and salinity intrusion.
- **Water Conservation:** Increased water retention capacities in *Beels* and *Khals* (canals) to increase water availability during droughts.
- **Flood Protection:** strengthened and heightened flood embankments to prevent flooding and flood damage.
- **Drainage:** deepened khals for improved drainage and water storages.
- **Irrigation water distribution:** modern buried pipe pumped water distribution systems for efficient irrigation and reduced energy requirement.

3. Socio-Economic Empowerment

- **Support for the Poor:** The project area includes 380,000 households, including 45,000 functionally landless and vulnerable individuals.
- **Women's Participation:** WMCAs ensure the inclusion of women, youth, and small ethnic communities in decision-making, with specific support for women's income-generating activities and, in some cases, land titles for women.
- **Modern Markets:** Upgrading of market facilities and construction of cooling/ cold storages for fish, meat, fruits, and vegetables.

4. Sustainable Management

- **Community Ownership:** WMCAs are responsible for the operation and maintenance (O&M) of the subproject infrastructure, ensuring sustainability beyond the project period.
- **Value Chain Enhancement:** Training members in agribusiness, marketing, and business planning to move from subsistence to commercial farming.

Overall, the project is expected to deliver a high economic return (estimated at 20.2%) while building long-term resilience against climate-induced disasters.

3.2 Description of the Project

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), is a 6-year initiative in Bangladesh designed to reduce rural poverty and improve livelihoods by enhancing climate-resilient water management infrastructure. Funded by the Asian Development Bank (ADB), the International Fund for Agricultural Development

(IFAD), and the Government of the Netherlands, the project is implemented by the Local Government Engineering Department (LGED).

Project Overview

- **Duration:** 6 years.
- **Scope:** Covers 42 districts in Bangladesh, focusing on four "hotspots": Barind/drought-prone areas, the coastal zone, the haor/flash flood areas, and river systems/estuaries.
- **Goal:** Climate- and disaster-resilient agricultural productivity and profitability increased
- **Total Cost:** Approximately \$225 million USD including taxes.

Key Components or Outputs

1. **Participatory Subproject Development (Output 1):** The project establishes 150 new, inclusive Water Management Cooperative Associations (WMCAs) and strengthens 2301 existing ones, including the Bakhali rubber dam. These associations are responsible for operating and maintaining the infrastructure.
2. **Climate-Resilient Infrastructure (Output 2):** Development and enhancement of small-scale water infrastructure, including re-excavation of canals, construction of sluice gates, regulators, embankments, and rubber dams. This includes the modernization of the Bakkhali Rubber Dam.
3. **Agribusiness Development (Output 3):** Increasing incomes by training WMCAs in climate-smart agricultural practices, improving marketing, establishing post-harvest facilities like cooling and/ or cold storages, and support for mechanisation.

Expected Impact:

Development of 150 new subprojects and performance enhancement of 231 existing subprojects giving the following benefits:

- Increase in cropping intensities and crop productivity over 220,000 ha.
- Reduction of flood risk over 87,000 hectares of land.
- 230,00 households (60% of 380,000 households in subproject areas, including 45,000 landless/ vulnerable households) have improved access to water for agriculture and aquaculture purposes.
- 57,000 households (15% of total beneficiary households) have improved physical access to markets.
- Livelihoods of 30,000 women of poor and smallholder households improved by income generation activities.

The project aligns with the Bangladesh Delta Plan 2100 and the Eighth Five-Year Plan, aiming to transition from conventional disaster response to sustainable, climate-adaptive water management.

3.2.1 Project Activities

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh is a six-year initiative (roughly 2020-2026) aimed at enhancing

rural livelihoods and agricultural productivity through climate-resilient water infrastructure, managed by the Local Government Engineering Department (LGED).

Key project activities are organized around building, enhancing, and managing small-scale water resources, covering 42 districts across four major geographical hotspots:

1. Water Infrastructure Development (Output 2)

- **New Subprojects:** Establishing 150 new, climate-resilient water management subprojects (drains, embankments, water control structures).
- **Enhancement of Existing Subprojects:** Improving 230–400 existing subprojects with additional infrastructure to boost performance.
- **Types of Intervention:** Includes flood management, drainage improvement, water conservation (re-excavating Khals/Beels), and command area development.
- **Specific Subprojects:** Rehabilitation and modernization of the Bakkhali Rubber Dam (BRD).
- **Nature-Based Solutions:** Using climate-resilient techniques like planting vetiver grass and using treated bamboo for embankment protection.

2. Participatory Management & Institutional Support (Output 1)

- **WMCA Formation/Strengthening:** Establishing and training 150 new inclusive Water Management Cooperative Associations (WMCAs).
- **Capacity Building:** Training WMCA members in Operation and Maintenance (O&M), financial management, and climate-smart agricultural practices.
- **Minor Maintenance:** Supporting WMCAs to undertake routine maintenance of infrastructure.

3. Agriculture, Value Chain, and Livelihood Support (Output 3)

- **Agribusiness Development:** Facilitating meetings between producers and buyers, and developing market analysis for 10 key crops (e.g., vegetables, spices, oilseeds, fruits).
- **Post-Harvest Management:** Building and operating storage units, cold chain facilities, and pack houses at the Upazila and WMCA levels.
- **Fisheries Development:** Developing fishponds and operating cage aquaculture.
- **Women's Empowerment:** Supporting income-generating activities (IGAs) specifically for women, landless people, and vulnerable groups.
- **Market Infrastructure:** Improving 10 local and 25 roadside markets.

4. Project Implementation & Monitoring

- **Technical Assistance:** Utilizing PIUs (Project Implementation Units) and NGOs to facilitate field-level activities.
- **Safeguards Management:** Implementing Resettlement Plans (RP) and Grievance Redress Mechanisms (GRM) for affected persons.
- **Monitoring:** Conducting semi-annual social monitoring, including land acquisition updates and beneficiary participation, to ensure compliance with ADB standards.



Figure 5 : PMU, PIU, PISC and local people visited project sites

3.2.2 Project Location

The following criteria have been followed to determine the appropriate location for the project:

Areas to avoid when selecting a project location (Schedule-9, ECR 2023):

(1) Areas protected by law for their environmental importance, heritage site, environmentally sensitive areas, sanctuary or area protected by international convention;

(2) Important or sensitive places for ecology or biodiversity such as habitat of endangered/threatened/native species, wetlands, mountains, natural forests, para-forests, coral islands, etc.;

(3) Forest land declared by the government;

(4) More important agricultural land; and

(5) High-value agricultural land, historical sites, memorial areas, park/playground, health center, residential area, hospital, archaeological site, educational institutions and areas designated as sensitive by the government or by law.

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is implemented by the Local Government Engineering Department (LGED) across 42 districts.

Project Locations and Scope:

- **Target Areas:** The project covers 341 Upazilas (sub-districts) within 42 districts across all eight divisions of Bangladesh.
- **Geographical Focus:** It focuses on four main hazard-prone "hotspots" identified in the Bangladesh Delta Plan 2100:
 1. Coastal zones (subject to salinity and tidal surges).
 2. Barind and drought-prone areas.
 3. Haor and flash flood areas.
 4. River systems and estuaries.
- **Project Management Unit (PMU):** The central office is located at LGED HQ, RDEC Bhaban (Level-14), Sher-E-Bangla Nagar, Agargaon, Dhaka-1207.

The project aims to enhance water management infrastructure to benefit approximately 87,000 hectares of land, with completion targeted by June 2029.

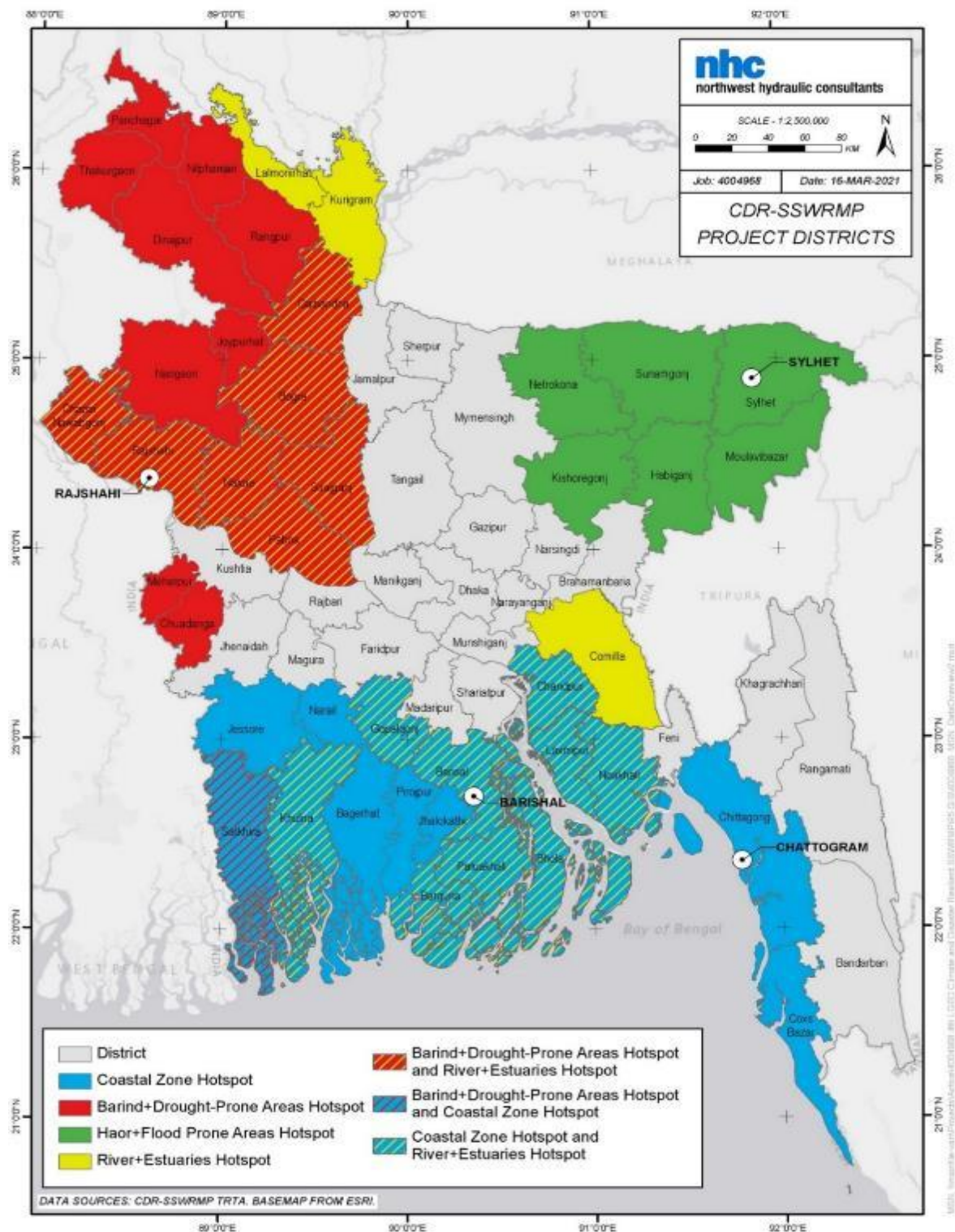


Figure 6: Project Area Districts and Bangladesh Delta Plan Hotspots

3.2.3 Layout

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a six-year, IFAD/ADB-supported initiative aimed at enhancing climate resilience in rural areas through the development of small-scale water infrastructure. It is implemented by the Local Government Engineering Department (LGED).

The project, which covers 42 districts (64% of the country), focuses on areas highly prone to natural hazards, including the coastal zone, the Barind and drought-prone areas, the haor and flash flood areas, and river systems.

Key Components of the Layout (Structure)

1. **Water Management Cooperatives (WMCAs):** A core component is strengthening and constructing Water Management Cooperative Association (WMCA) offices to manage water infrastructure, such as re-excavating canals (e.g., Gobar Khal) and building water control structures.
2. **Infrastructure Development:** The project focuses on small-scale, climate-resilient water infrastructure, including re-excavating natural channels, enhancing irrigation, and modernizing structures like the Bakkhali Rubber Dam (BRD).
3. **Climate-Resilient Design:** Subprojects are designed to handle climate risks, with a 8-12% increase in civil works to ensure sustainability against floods and droughts.
4. **Targeted Livelihoods Support:** The project aims to benefit 380,000 households, specifically targeting 30,000 women and 45,000 vulnerable or functionally landless individuals.
5. **Capacity Building:** The project includes training for farmers to adapt to climate changes like droughts and floods, and the establishment of early warning systems for communities (e.g., in the char regions).

Institutional Arrangement

- **Implementing Agency:** Local Government Engineering Department (LGED).
- **Supervision:** Divisional Additional Chief Engineers and Superintending Engineers (LGED).
- **Partnerships:** The project often involves technical assistance and partnership with entities like the Department of Disaster Management (DDM) and the World Food Programme (WFP) for specific components, such as building shelter-cum-schools.

Project Areas

The project spans 42 districts, focusing on 4 specific "hotspots" in the Bangladesh Delta Plan 2100:

1. Barind and drought-prone areas.
2. Coastal zones.
3. Haor and flash flood areas.
4. River systems and estuaries.

3.2.4 Steps of project implementation

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, implemented by the Local Government Engineering Department (LGED) with funding from the Asian Development Bank (ADB) and IFAD, aims to boost agricultural productivity through sustainable water management.

The implementation follows a participatory, phased approach spanning six years (approx. 2022–2028), focusing on 150 new subprojects and 230 enhanced subprojects across 42 districts.

Key Steps of Implementation:

1. Institutional Setup & Planning (Preparatory Phase):

- **Formation of PMU/PIU:** A Project Management Unit (PMU) is established in Dhaka, with Project Implementation Units (PIUs) at the district level within LGED.
- **Stakeholder Mobilization:** Recruitment of Project Implementation Support Consultants (PISC), NGOs, and outsourcing staff to support the field-level activities.
- **Subproject Identification:** Selection of 150 new subprojects and 230 enhancements based on criteria focused on climate vulnerability, poverty levels, and water management needs (flood, drainage, water conservation, command area).

2. Participatory Subproject Development (Water Management Cooperative Association - WMCA):

- **Formation/Strengthening of WMCAs:** Establishing new and strengthening existing WMCAs for each subproject, ensuring inclusion of women, youth, and ethnic communities.
- **Capacity Building:** Training WMCA members in agricultural practices, climate-smart water management, business planning, and maintenance.
- **Participatory Planning:** Involving stakeholders in designing infrastructure (re-excavating canals, building embankments/sluice gates).

3. Construction and Infrastructure Development:

- **Infrastructure Implementation:** Building climate-resilient water management infrastructure, including embankments, sluice gates, and re-excavation of canals.
- **Market Facilitation:** Constructing/improving 10 local and 25 roadside markets with cold storage for agricultural products.
- **Labor Contracting Societies (LCS):** Engaging local, marginalized, and women workers in construction activities to generate employment.

4. Value Chain Development and Sustainability:

- **Business Plan Implementation:** Assisting WMCAs with equipment and training for post-harvest management, aquaculture, and agriculture, including value chain support for crops like fruits, vegetables, and fish.
- **Support for Female Entrepreneurs:** Implementing targeted support for business activities managed by women.

5. Operation, Maintenance, and Monitoring:

- **O&M Transfer:** Handing over the operation and maintenance (O&M) of the infrastructure to the WMCAs.
- **Monitoring and Evaluation (M&E):** Regular monitoring by PMU/PIUs to ensure environmental and social safeguards (via Grievance Redress Mechanisms) and progress reporting to ADB.

6. Emergency and Modernization:

- **Bakkhali Rubber Dam:** Specific focus on the urgent reconstruction and modernization of the Bakkhali Rubber Dam.

Project Timeline & Scope:

- **Duration:** 6 years.
- **Coverage:** 150 New WMCAs, 230 Existing WMCAs, 110 km farm access roads, 60 sluice gates.
- **Target:** 380,000 households, including 45,000 landless.

3.2.5 Work Schedule

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, executed by the Local Government Engineering Department (LGED), is a six-year project scheduled to run until **31 December 2029**.

Key details regarding the project's work schedule and timeline include:

- **Project Approval & Effectiveness:** Approved on 19 September 2023, the project was signed on 29 October 2023, with main loans becoming effective between November 2023 and January 2024.
- **Duration:** The project has a 6-year lifespan, spanning from early 2024 to the end of 2029.
- **Implementation Phases:** The project involves subproject preparation, involving land acquisition (approx. 20.3 ha planned) for Water Management Cooperative Association (WMCA) offices and infrastructure.
- **Operational Areas:** The project covers 341 upazilas across 42 districts, focusing on four specific hotspots identified in the Bangladesh Delta Plan 2100: Barind/drought-prone areas, coastal zones, haor/flash flood areas, and river systems.
- **Planned Activities:** Key activities include constructing/rehabilitating water management infrastructure, enhancing climate resilience, strengthening WMCAs, and improving agricultural value chains.

The project is designed to build upon previous small-scale water resource management initiatives in Bangladesh.

3.2.6 Probable extension information

Based on the latest reports and project documents, the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), implemented by the Local Government Engineering Department (LGED), is currently active and slated for completion in the coming years.

- **Project Duration:** The project was approved in September 2023 and signed in October 2023. It is designed as a **6-year project**.
- **Active Timeline:** The project is scheduled to run until **December 31, 2029**.
- **Probable Extension/Future Context:** While it is a new project with a 2029 end date, similar previous IFAD/ADB-funded LGED projects (such as the Coastal Climate Resilient Infrastructure Project) have faced calls for "no-cost one-year extensions" to consolidate achievements and handle external challenges. Therefore, a potential extension beyond 2029 to early 2030s could be possible if delays occur, though none is explicitly announced at this early stage.
- **Scope & Coverage:** The project operates across 42 districts, focusing on 4 key "hotspots" identified in the Bangladesh Delta Plan 2100: Barind (drought-prone), coastal zones, haor/flash flood areas, and river systems.
- **Focus Areas:** Key activities include establishing 150 new Water Management Cooperative Associations (WMCA), constructing climate-resilient water infrastructure, and rehabilitating existing systems to benefit roughly 335,000 farming households.

This project is a continuation of investment by IFAD and ADB in small-scale water resources management in Bangladesh.

3.3 Amount of Land

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh aims to cover a benefit area of over 220,000 hectares to enhance agricultural productivity and flood resilience. It involves 150 new sub-projects and 230 existing ones, benefiting a total, along with infrastructural improvements, of roughly 220,000 hectares, with 50.14 acres of land required for physical acquisition.

Key details regarding land and project scope:

- **Total Benefit Area:** The project spans over 220,000 hectares to address agricultural and fishery sector issues.
- **Infrastructure Coverage:** Approximately 86,000 hectares of land will be covered through 150 new, inclusive water management cooperative associations (WMCAs).
- **Rehabilitation Scope:** The project strengthens WMCAs at 230 existing sub-projects, benefiting another 130,000 hectares.
- **Land Acquisition:** Approximately 50.14 acres of land will be acquired for constructing infrastructure like sluice gates and 110 kilometers of farm access roads.
- **Bakkhali Rubber Dam:** Emergency reconstruction and modernization of this dam will benefit 3,000 hectares.
- **Goal:** The ADB-funded project reduces flood risks, manages water resources, and improves agricultural productivity.

3.3.1 Necessary amount of land

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh aims to improve water management across approximately **220,000 hectares** of land. The project focuses on enhancing agricultural productivity through new infrastructure for 86,000 hectares and strengthening existing systems.

Key Land and Scope Details for CDRSSWRMP:

- **Total Beneficiary Area:** Over 220,000 hectares (ha).
- **New Infrastructure Coverage:** 150 new water management cooperative associations (WMCAs) covering about 86,000 ha.
- **Strengthening/Existing Subprojects:** 230 existing WMCAs covering 130,000 ha.
- **Target:** Increased agricultural, fisheries, and irrigation efficiency in selected rural areas.
- **Location:** Nationwide, focusing on rural, climate-vulnerable areas.

The project, managed by the Local Government Engineering Department (LGED), is designed to reduce flood risks and improve agricultural production in these areas.

3.3.2 Ownership of land

Land ownership for the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh is managed through a combination of voluntary land contribution, lease agreements, and formal acquisition to minimize involuntary resettlement. The project, supporting infrastructure on about 220,000 ha, involves 20.3 hectares of acquired land.

Key details on land ownership and acquisition:

- **Voluntary and Lease-Based:** The project focuses on avoiding heavy land acquisition by prioritizing, where feasible, voluntary contributions, lease agreements, or negotiated settlements.
- **Acquisition Process:** The project adheres to national laws, particularly the Acquisition and Requisition of Immovable Property Ordinance of 1982 (amended), managed by the Deputy Commissioner (DC) office.
- **Community Involvement:** The project aims to establish, where appropriate, Water Management Cooperative Associations (WMCAs) to manage rehabilitated infrastructure, encouraging community ownership and sustainable management.
- **Resettlement Safeguards:** The project is categorized as "B" for involuntary resettlement, meaning impacts are expected to be minor, generally not exceeding 5% of the economic capacity for each affected household.
- **Project Locations:** The project operates in 42 districts across four hotspots identified in the Bangladesh Delta Plan 2100.

The project, funded by IFAD, ADB, and the Bangladesh government, seeks to enhance climate-resilient livelihoods.

3.3.3 Land acquisition

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh requires the acquisition of approximately 50.14 acres of land for constructing water management infrastructure, regulators, and embankments to reduce flood risks. The project, implemented by Local Government Engineering Department (LGED), will prioritize negotiated settlement for land acquisition, as indicated in ADB project documents.

Key Details on Land Acquisition & Project Scope

- **Total Land Required:** Approximately 50.14 acres.

- Approach: Due to high beneficiary participation, negotiated settlement is preferred over formal, compulsory acquisition for many subprojects.
- Project Goal: Construct climate-resilient water infrastructures, including 60 composite sluice gates, re-excavation of canals, and 110 km of farm access roads.
- Scope: Covers 341 upazilas across 42 districts, aimed at protecting 87,000 hectares of land from floods and boosting agricultural productivity on 2.20 lakh hectares.
- Affected Areas: Focuses on disaster-prone areas, including coastal zones, Barind, and Haor regions.
- Financing: The Tk 2,235.80 crore project includes funding from the ADB, IFAD, and the Netherlands.

The project, which runs until June 2029, focuses on enhancing water management, rehabilitating existing infrastructure, and supporting local communities through improved agricultural infrastructure.

3.4 Project location and surrounding area

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a large-scale initiative (2023–2029) aimed at improving water management, agriculture, and infrastructure resilience.

Project Location and Scope

- Coverage: The project covers 42 districts across all eight divisions of Bangladesh, targeting areas particularly vulnerable to climate change.
- Key Focus Areas: The intervention zones correspond to four main "hotspots" identified in the Bangladesh Delta Plan 2100:
 1. Barind and Drought-Prone Areas: (e.g., Rangpur, Rajshahi, Dinajpur divisions).
 2. Coastal Zone: (e.g., Khulna, Barishal, Noakhali, Patuakhali, Cox's Bazar).
 3. Haor and Flash Flood Areas: (e.g., Sylhet, Sunamganj, Netrokona).
 4. River Systems and Estuaries: Areas prone to erosion and flooding.
- Specific Highlight: A major component includes the rehabilitation and modernization of the Bakkhali Rubber Dam in Cox's Bazar.

Surrounding Area Characteristics

The project areas are characterized by high poverty, significant climate risk, and reliance on agriculture. Key surrounding features include:

- Hydrological Features: The locations are in close proximity to major rivers (Ganges, Brahmaputra, Meghna), coastal zones of the Bay of Bengal, and haor (wetland) basins.
- Environmental Hazards: The surroundings are heavily impacted by cyclones, salinity intrusion in the southern coastal districts, drought in the northwest (Barind Tract), and flash floods in the northeast (Haor region).
- Infrastructure: The project involves the construction of 110 kilometers of farm access roads and rehabilitation of existing water management infrastructures (regulators, embankments, canals).

- **Target Population:** The areas are home to 77% of the country's rural poor, with interventions focusing on 380,000 households, including smallholder farmers, fishermen, and landless, vulnerable communities.

The project is implemented by the Local Government Engineering Department (LGED) with support from the Asian Development Bank (ADB), IFAD, and the Government of the Netherlands.

3.4.1 Project location (location map)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a large-scale initiative covering 42 of the 64 districts across the country, focusing on specific geographical "hotspots" related to climate vulnerability.

The project is implemented by the Local Government Engineering Department (LGED).

Project Location and Scope

- **Geographical Focus:** The project operates in areas defined by the Bangladesh Delta Plan 2100, focusing on regions prone to floods, droughts, and salinity.
- **Target Areas:**
 - Haor Region: Northeast (Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona).
 - Coastal Region: Southern districts including Khulna, Barisal, Patuakhali, Noakhali, and Chittagong.
 - Barind Tract: Northwestern districts (Rajshahi, Dinajpur, Rangpur, Bogra, Joypurhat, Naogaon).
- **Subproject Specifics:** While the overall project covers 42 districts, individual subprojects are identified at the local level (e.g., Chuadanga district, Khadimpur Union).

Key Features

- **Coverage:** 220,000 hectares.
- **Components:** Development of small-scale water resources, including sluice gates, drainage, and embankment improvements.
- **Duration:** 6-year implementation period.

For a visual map, you would typically refer to the "Project Area Districts and Bangladesh Delta Plan Hotspots" map provided in the ADB's Initial Environmental Examination (IEE) report.

3.4.2 Layout plan

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, managed by the Local Government Engineering Department (LGED) with ADB/IFAD support, focuses on developing, rehabilitating, and enhancing community-based water management infrastructure across 42 districts.

Key Components of the Layout/Infrastructure Plan:

The project covers 4 distinct geographical "hotspots" (Barind, Coastal, Haor/Flash Flood, and River systems):

- **Water Management Infrastructure:** Construction and rehabilitation of drainage systems, irrigation networks, embankments, and water conservation structures.

- **Water Management Cooperative Associations (WMCAs):** Strengthening 230 existing WMCAs and establishing new ones for decentralized, participatory management of subprojects.
- **Specific Structures:** Construction of composite sluice gates, re-excavation of natural channels (e.g., Gobar Khal), and the rehabilitation of the Bakkhali Rubber Dam.
- **Access Infrastructure:** Construction of 110 kilometers of farm access roads to enhance connectivity to water-managed areas.
- **Field Facilities:** Construction of office buildings for WMCAs to facilitate local management.

Layout Approach:

The subprojects are designed based on participatory water management rules, focusing on small-scale interventions (less than 1,000 hectares per subproject) that are climate-resilient.

- **Design Focus:** 15 Drainage and Irrigation (DR & IRR), 10 Drainage and Water Conservation (DR & WC), 4 Flood Management & Drainage (FMD), and other specialized types.
- **Key Features:** Incorporation of climate-resilient, environment-friendly materials and designs, such as nature-based solutions and improved embankments.

The project aims to improve 130,000 hectares of land through these infrastructures.

3.5 Project Activities and Implementation Schedule

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a six-year initiative (2024–2029) designed to enhance agricultural productivity and climate resilience in rural areas. Implemented by the Local Government Engineering Department (LGED) with support from the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD), the project focuses on constructing and improving small-scale water management infrastructures across 42 districts.

Project Activities

The project is structured around three main outputs, targeting 150 new subprojects and 400 existing subprojects:

- **Participatory Subproject Development:** Establishing 150 new Water Management Cooperative Associations (WMCAs) and strengthening existing ones to operate and maintain water infrastructure.
- **Climate Resilient Infrastructure Development:** Constructing and enhancing small-scale water infrastructure, including flood management, drainage improvement, water conservation, and command area development.
- **Value Chain Development:** Implementing agricultural value chain activities at the Upazila and WMCA levels, focusing on crops like fisheries, spices, vegetables, and rice to increase incomes.
- **Emergency Reconstruction:** Modernizing key infrastructure, such as the Bakkhali Rubber Dam (BRD).

Implementation Schedule

The project is scheduled for completion by the end of 2029.

- Approval & Signing: Approved on 19 September 2023, and signed on 29 October 2023.
- Effectiveness: ADB and IFAD loans became effective on 29 January 2024 and 15 November 2023, respectively.
- Duration: The project will run for 6 years, ending on 31 December 2029.
- Geographical Coverage: 42 districts, focusing on hotspots identified in the Bangladesh Delta Plan 2100 (Barind, coastal zone, haor, and river systems).

Key Implementation Details

- Executing Agency: Local Government Engineering Department (LGED).
- Financing: Total cost includes ADB (\$106 million) and IFAD (\$42.98 million) loans, plus a \$17.80 million grant from the Government of Netherlands.
- Target Population: 380,000 households (including 45,000 landless/vulnerable).
- Scope: Approximately 86,000 hectares for new, and 130,000 hectares for enhanced, subprojects.

3.5.1 Infrastructure construction and list of major activities

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a 6-year, Tk 2,235.80 crore project (approx. \$180 million, supported by ADB, IFAD, and the Netherlands) implemented by the Local Government Engineering Department (LGED). It focuses on building climate-resilient water management infrastructure across 42 districts to reduce flood risks, enhance irrigation, and improve agricultural productivity.

Infrastructure Construction Activities

The core of the project involves building and upgrading, with a focus on "climate-proofing" and disaster resilience.

- **Small-Scale Water Resources Infrastructure:** Construction and rehabilitation of embankments, sluice gates, and regulators to manage water levels, reduce flood risks, and improve drainage for 150 new subprojects (approx. 86,000 hectares).
- **Re-excavation of Canals:** Excavation and re-excavation of drainage canals to enhance water flow, increase capacity, and support agriculture and fisheries.
- **Bakkhali Rubber Dam Modernization:** Urgent rehabilitation and modernization of the Bakkhali Rubber Dam in Cox's Bazar.
- **Irrigation and Water Supply Structures:** Development of 1,276 metric tons of irrigation infrastructure (water distribution systems) and 60 composite sluice gates.
- **Farm Access Roads:** Construction and improvement of 110 kilometers of farm access/village roads to enhance connectivity.
- **Post-Harvest Facilities:** Construction of modern market facilities, including cold storage for fruits, vegetables, fish, and meat, and improvement of 10 local/25 roadside markets.
- **Water Management Cooperative Association (WMCA) Offices:** Construction of facilities for WMCAs to manage the infrastructure.

List of Major Project Activities

1. **Establishment of WMCAs:** Forming 150 new, inclusive Water Management Cooperative Associations (WMCA) to ensure local ownership.
2. **Capacity Building and Training:** Training WMCA members on climate-smart agricultural practices, aquaculture, business planning, and infrastructure maintenance.
3. **Enhancement of Existing Schemes:** Rehabilitation and upgrading of 230 existing underperforming subprojects (130,000 ha).
4. **Land Acquisition:** Acquisition of approximately 50.14 acres of land for subproject structures.
5. **Agricultural Value Chain Development:** Implementing business plans and providing equipment to WMCAs to increase incomes through post-harvest management.
6. **Disaster Risk Reduction:** Integrating nature-based solutions and climate-resilient features in all infrastructure to protect against flooding and salinity intrusion.
7. **Gender and Social Inclusion:** Specific support for women, youth, and landless households through income-generating subcommittees.

The project aims to cover 341 upazilas across 42 districts, targeting four key "hotspots" identified in the Bangladesh Delta Plan 2100: Barind/drought-prone areas, the coastal zone, the haor and flash flood areas, and river systems (**Table 11 & Table12**).

Table 11: List of Proposed New Subproject Type under 42 Districts

SL	Hot Spot	New Subproject Type
1	Barind	Drainage & Water Conservation (DR &WC)
2	Barind	Flood Management and Drainage and Water Conservation (FMD&WC)
3	Coast S	Drainage and Tidal irrigation (FMD & Tidal Irrgn)
4	Coast S	Drainage (DR & T irri))
5	Coast S	Drainage & Water Conservation (DR & WC)
6	Coast E	Water Conservation (WC)
7	Coast W	Flood Control and Drainage (FCD)
8	Haor	Water Conservation (WC)

Table 12: List of Proposed Performance Enhancement (PE) Subproject Type

SL	Hot Spot	Performance Enhancement (PE) Subproject Type
1	Barind	Water Conservation (WC)
2	Barind	Flodd Management and Drainage & Water Conservation (FMD & WC)
3	Barind	Flodd Management and Drainage (FMD)
4	Barind	Water Conservation & Irrigation (WC & Irr)
5	Barind	Water Conservation & Drainage (WC & DR)
6	Barind	Drainage (DR)

SL	Hot Spot	Performance Enhancement (PE) Subproject Type
7	Costal	Water Conservation (WC)
8	Costal	Drainage and Tidal irrigation (DR & TIRR)
9	Costal	Water Conservation & Irrigation (WC & Irr)
10	Costal	Water Conservation & Drainage (WC & DR)
11	Costal	Flood Management and Drainage & Tidal Irrigation (FMD & TIRR)
12	Costal	Drainage & Command Area Development /Irrigation (Dr & CAD/IRR)
13	Costal	Drainage & Command Area Development (DR&CAD), Dam
14	Costal	Drainage (DR)
15	Haor	Flood Management and Drainage & Water Conservation (FMD & WC)
16	Haor	Water Conservation & Drainage (WC & DR)
17	Haor	Flood Management and Drainage & Irrigation (FMD& Irr)
18	Haor	Flood Management and Drainage (FMD)
19	Haor	Water Conservation (WC)
20	Haor	Water Conservation & Command Area Development (WC & CAD)

Providing modern infrastructure

Modern infrastructure includes buried pipe systems to increase irrigation efficiency and the replacement of diesel pumps with more easily operable electric pumps. It is expected that solar energy will be used to supply one-fifth of the power required for irrigating with the buried pipe systems. An overall component breakdown is given in the following **Table 13 and Table 14**.

Table 13: Proposed Infrastructures/Works/Machineries in Proposed 42 Districts

Sl. No.	Proposed Infrastructure/Works	Type of Subproject	Component
1	Existing Khal re-excavation	Performance Enhancement	Structure
2	Construction of regulators	Performance Enhancement	Structure
3	Embankment re-sectioning	Performance Enhancement	Structure
4	CC Block	Performance Enhancement	Structure
5	Regulator	Performance Enhancement	Structure
6	Farm access road	Performance Enhancement	Structure
7	Irrigation canal	Performance Enhancement	Structure
8	Solar pump	Performance Enhancement	Equipment
9	Culvert	Performance Enhancement	Structure
10	Power tiller	Performance Enhancement	Machinery
11	Harvester	Performance Enhancement	Machinery
12	New PVC irrigation buried pipe line	Performance Enhancement	Equipment
13	Replace PVC pipe with HDPE	Performance Enhancement	Equipment

Sl. No.	Proposed Infrastructure/Works	Type of Subproject	Component
14	WMCA Office building maintenance	Performance Enhancement	Structure
15	New buried pipe	Performance Enhancement	Equipment
16	Construction of WRS	Performance Enhancement	Structure
17	Construction of WMCA Building	Performance Enhancement	Structure

Table 14: Proposed Interventions of Subprojects Under CDRSSWRMP

SL.	Districts	Upazila	Subprojects (SP)	Proposed interventions
1	Barguna	Taltali	Nalbunia	Re-excavation of Khals
2	Barishal	Sadar	Chandpura	Re-excavation of Khals
3	Bhola	Char Fasson	Nilkamal	Re-excavation of Khals
4	Patuakhali	Sadar	Paler Danga	Re-excavation of Khals, Regulator, Foot Bridge, Box Culverts and WMCA Office Building
5	Jhalokathi	Nalcity	Rajpasa	Re-excavation of the proposed Khals
6	Pirojpur	Nazirpur	Amtola	Khal re-excavation
7	Chandpur	Faridganj	Rupsha Rumur Khal	Khal re-excavation for drainage & irrigation
8	Laxmipur	Sadar	Bhuluar Khal	CAD through Khal re-excavation
9	Noakhali	Ashwadia	Olipur	Re-excavation of Khals, Sluice, Culvert, WMCA Office Building
10	Chattogram	Satkania	Mirzakhil Darbar Sharif	Re-excavation of Khals,
11	Cox's Bazar	Sadar+Ramu	Bakkhali Rubber Dam	Rehabilitation of Bakkhali Rubber Dam
12	Cumilla	Meghna	Rajitpur Boroshapmara	Re-excavation of Khal
13	Khulna	Dacope	Bajua Chara Khal	Re-excavation of Khal
14	Bagerhat	Sadar	Dier Khal	Re-excavation of Khal
15	Jashore	Sadar	Dolpur Mukteshway	Re-excavation of Khal, Sluice and WMCA office maintenance
16	Narail	Sadar	Khatnur Beel	Regulator, sluice, re-sectioning of embankment, khal re-excavation
17	Satkhira	Tala	Chakarkhali Beel	Re-excavation of Khal
18	Chuadanga	Sadar	Baradi Kamarpara FCD	FCD
19	Meherpur	Mujibnagar	Madiar Beel	Re-excavation of Khal
20	Bogura	Adamdighi	Bosonbari Khal	Re-excavation of Khal and construction of regulator
21	Chapai Nawabgonj	Shibganj	Choitonnopur Poranpur CAD	CAD
22	Natore	Baraigram	Rawta Astikpara	Re-excavation of Khal, Regulator/WRS and WMCA office building
23	Pabna	Sadar	Beelvaduria Khal	Khal re-excavation
24	Rajshahi	Mohonpur	Dhuroil SP	Re-excavation of Khal and construction of regulator
25	Sirajganj	Ullapara	Monohara	Re-sectioning of Khal, re-sectioning of embankment, construction of regulators and WMCA office building
26	Joypurhat	Akkelpur	Chri Khal	Re-excavation of Khal, modification of regulators, construction of line canal

SL.	Districts	Upazila	Subprojects (SP)	Proposed interventions
27	Naogaon	Dhamoirhat	Kazipur	Re-excavation of Khal, construction of regulators,
28	Gaibandha	Gobindoganj	Madarpur-Choutpur	Re-excavation of Khal, construction of WRS (Culvert)
29	Dinajpur	Bochagonj	Tangaon River Ranirghor Rubber Dam	Re-excavation of Khal and re-sectioning of embankment
30	Nilphamari	Sadar	Duhuli Chonkhar Beel	Khal re-excavation
31	Panchagar	Debigonj	Akandapara	Re-excavation of river, construction of regulator and culverts
32	Rangpur	Mithapukur	Hielier Beel	Embankment re-sectioning
33	Thakurgaon	Sadar	Anjila Khal	Re-excavation of Khal
34	Kurigram	Nageshwari	Kachakata Boro Charar par	Re-sectioning of embankment
35	Lalmonirhat	Kaliganj	Bhateshwar	Khal re-excavation
36	Gopalganj	Kashiani	Pathor Ghata -Ratoil-Chapta	Re-excavation of Khal, rehabilitation of farm access road and construction of WMCA office
37	Kishoreganj	Sadar	Kosra Korail	Khal re-excavation, repairing of regulator and construction of WMCA office building
38	Habiganj	Nobiganj	Darveshpur Khal	Re-excavation of Khal, WRS and construction of WMCA office building
39	Moulvibazar	Sreemangal	Boro Chara	Re-excavation of Boro Chhara
40	Sunamganj	Sadar	Noiganag Chhara	Re-excavation of Noiganag Chhara and WRS
41	Sylhet	Gowainghat	Shialichara	Re-excavation of Khal
42	Netrokona	Kendua	Bipinganj	Re-excavation of Khal, re-sectioning of embankment along the river and construction of regulators

3.5.2 Project development steps and implementation schedule

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a six-year, donor-funded initiative aimed at increasing agricultural productivity and climate resilience for rural communities. The project is implemented by the Local Government Engineering Department (LGED) with financing from the Asian Development Bank (ADB), International Fund for Agricultural Development (IFAD), and the Government of the Netherlands.

Project Implementation Schedule

- Approval Date: 19 September 2023
- Signing Date: 29 October 2023
- Effectiveness Date: 29 January 2024 (ADB) / 15 November 2023 (IFAD)
- Duration: 6 years
- Expected Completion Date: 31 December 2029
- Total Cost: Approx. \$225 million (including ADB \$106M, IFAD \$42.98M, GoN \$17.8M, and Government of Bangladesh \$58.22M).

Project Development and Implementation Steps

The project adopts a participatory approach involving the following key steps:

1. Project Preparation and Design:

- Development of a Project Concept Paper (2019) and approval by ECNEC.
- Identification of four "hotspots" based on the Bangladesh Delta Plan 2100: Barind/drought-prone, coastal zone, haor/flash flood areas, and river systems.
- Feasibility studies and detailed engineering designs for subprojects.

2. Institutional Setup:

- Establishment of a Project Management Unit (PMU) within the LGED.
- Formation of 150 new Water Management Cooperative Associations (WMCAs) to ensure community participation.

3. Core Components Implementation:

- Infrastructure Development: Construction of small-scale water resources infrastructure (sluice gates, regulators, embankments) and rehabilitation of 400 existing subprojects.
- Canal Management: Excavation and re-excavation of canals for improved water flow.
- Agricultural Support: Introduction of climate-resilient crops, farming techniques, and value chain development for farmers.
- Road Connectivity: Construction of approximately 110 km of farm access roads.

4. Monitoring and Evaluation:

- Semi-annual monitoring of social safeguards, land acquisition, and project implementation progress.
- Compliance with environmental and social standards (Category B).

Key Targets

- Benefiting 380,000 households (including 45,000 landless/vulnerable).
- Reducing flood risk on 87,000 hectares of land.
- Bringing 2.20 lakh hectares under improved farming.
- Strengthening 150 new subprojects and 400 existing ones.

3.6 Pollution Potential

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, implemented by the Local Government Engineering Department (LGED) with Asian Development Bank (ADB) and IFAD support, is primarily designed to mitigate, not create, environmental damage.

However, any infrastructure development carries inherent environmental and pollution risks. Based on the project's Initial Environmental Examination (IEE), the potential pollution risks and environmental impacts of this project include:

1. Water Quality and Aquatic Ecosystem Risks

- Contamination of Waterways: During the construction and rehabilitation of water control structures (small dams, regulators), there is potential for increased suspended solids (sedimentation) in rivers and canals.
- Waste Generation: Construction sites may generate waste materials, including hazardous materials like oil or fuel from machinery.
- Aquatic Habitat Disruption: Improperly managed rehabilitation of water bodies could temporarily impact aquatic life and local fisheries.

2. Environmental Impacts of Intensified Agriculture

- Increased Use of Chemicals: By increasing water availability for irrigation (improved water management), there is a potential for intensified agricultural practices, which may lead to increased use of fertilizers and pesticides. This can lead to non-point source pollution in water bodies.
- Soil Salinity/Degradation: Poorly managed irrigation systems in coastal areas could contribute to waterlogging or salinity, though the project aims to improve resilience against these issues.

3. Construction and Operational Risks

- Land Degradation and Erosion: Construction activities for embankments or channels can cause temporary soil erosion.
- Noise and Air Pollution: Temporary pollution from machinery and construction activities, though likely to be localized.
- Solid Waste Management: Potential issues with waste management during the construction of water management infrastructure.

4. Management Mitigation

The project is categorized by the ADB as having minimal or manageable environmental impacts. It includes an Environmental Management Plan (EMP) to address these risks through:

- Proper construction site management.
- Mitigation measures for sediment control.
- Promotion of safe, integrated pest management practices for agriculture.

The project aims to improve 86,000 hectares of land and support 150 new Water Management Cooperative Associations (WMCAs) to enhance climate resilience.

3.7 Project Alternatives

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh focuses on climate-resilient, small-scale water management, with key alternatives focusing on:

- Flood Management: Rehabilitation and construction of embankments and sluice gates to minimize farmland flooding.
- Drainage Improvement: Re-excavating canals to increase capacity for agriculture and fisheries.
- Water Conservation: Enhancing water retention in *haors*, *beels*, and *khals* for irrigation.

- **Alternative Solutions:** Promoting nature-based solutions to strengthen grey infrastructure, strengthening local climate adaptation, and enhancing non-farm employment through skill development.

These alternatives aim to address climate vulnerability and enhance livelihood opportunities in flood-prone and drought-prone regions of Bangladesh.

3.7.1 Brief description of alternatives

Alternatives to the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh focus on localized, sustainable, and participatory development to enhance agricultural productivity and climate resilience. Key alternatives include:

- **Locally Led Adaptation (LLA) Platforms:** Initiated by ICCCAD, these promote community-driven solutions rather than top-down infrastructure.
- **Integrated Climate Projects (HILIP/CALIP):** Focused on haor (wetland) regions, these projects emphasize ecosystem-based adaptation, such as using Vetiver grass for slope protection.
- **Microfinance and Livelihood Support (PACE/RMTP):** Implemented by PKSF, these focus on increasing income through self-employment and value chain development, acting as an alternative to infrastructure-heavy approaches.
- **Coastal Climate-Resilient Infrastructure Project (CCRIP):** Focuses specifically on strengthening coastal infrastructure and improving road connectivity for climate resilience.
- **Sustainable Agriculture Initiatives:** Promoting saline-tolerant crops and aquaculture to adapt to changing environments, rather than just managing water resources.

These alternatives emphasize livelihood diversification, community ownership, and environmental protection.

- International Centre for Climate Change & Development (ICCCAD)

May 20, 2025 — SBC- Bhola The launching of the Barisal Divisional Platform and Policy Dialogue on Locally Led Adaptation (LLA) was held yesterday.

- People's Republic of Bangladesh COSOP completion review

Mar 31, 2022 — (a) Increase in income from self-employment (target: 50,000 women increase income by 50 per cent).

- Climate adaptive initiatives in Bangladesh communities - Facebook

Apr 9, 2024 — Vetiver grass-based bio-engineering slope protection measure training under Climate Adaptation and Livelihood Protection (CALIP).

3.7.2 Selection of acceptable options and the possibility of cancelling options

Acceptable adaptation options in Bangladesh focus on climate-resilient agriculture, including AWD irrigation, stress-tolerant crop varieties, and income diversification, driven by factors like education, extension services, and credit. Options can be modified or canceled based on local, environmental, and financial viability, as shown in climate adaptation strategies.

Key Aspects of Option Selection and Cancellation:

- **Acceptable Options (Adaptation Strategies):**
 - Agriculture: Adoption of Alternate Wetting and Drying (AWD) for water-saving, use of high-yielding (HYV) and stress-tolerant crop varieties, and adjusting cropping patterns (e.g., dual/triple cropping).
 - Techniques: Increased use of chemical fertilizers, improved irrigation infrastructure, and crop rotation.
 - Livelihood: Off-farm income diversification and improved access to credit.
- Drivers for Selection: The selection of these options is heavily influenced by farming experience, access to agricultural extension services, availability of credit, and the education level of the farmers.
- **Possibility of Cancelling/Modifying Options:**
 - Adaptation strategies are not fixed and are subject to change based on economic, social, and environmental sustainability assessments.
 - If a selected adaptation method (e.g., a specific crop variety or irrigation technique) fails to yield expected results, causes environmental degradation, or becomes financially unviable, it can be replaced by alternatives, such as switching to more resilient, drought-tolerant crop varieties.
- Policy Context: The National Adaptation Plan (2023-2050) and NAPA (2005) aim to provide frameworks for these actions, prioritizing community-based, participatory approaches.

The process involves selecting strategies that offer higher economic returns and sustainability, while allowing for flexibility to cancel or modify choices based on ongoing monitoring and evaluation of climate change impacts.

4 EXISTING ENVIRONMENTAL CONDITION OF 42 DISTRICTS

4.1 Physical Environment of 42 Districts

This section covers the information on the baseline environmental status of the Project area to provide a context within which the impacts of the Project are assessed. The baseline data includes the existing physical environment including topography, geology, soils, meteorology & climate, surface & underground water resources, ambient air quality and noise levels, land use and land cover, and landscape and visual amenity.

4.1.1 Topography of 42 Districts

(I) Topography of Coastal Region (17 districts)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) focus on 17 coastal districts in the southwest and central coastal regions of Bangladesh. The topography of these areas is characterized by an extremely flat, low-lying deltaic landscape, with elevations mostly below 5 meters above mean sea level, often featuring intricate networks of tidal channels and basins (Beels).

Topographical Features of Coastal Districts

- **Extreme Flatness:** The coastal districts (including Satkhira, Khulna, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, Bhola) consist of a very low-lying landscape, with many areas only 1–2 meters above sea level.

- **Ganges Tidal Floodplain (Southwest):** Predominantly found in Khulna, Satkhira, and Bagerhat, this area is characterized by low-lying, fine-textured sediment deposits crisscrossed by tidal rivers, creeks, and drainage basins. The area is highly prone to waterlogging and salinity intrusion, particularly during the dry season.
- **Active Delta/Meghna Estuary (Central/South-Central):** Includes areas like Bhola, Patuakhali, and Noakhali, this region is characterized by high rates of accretion (new land formation) and erosion. It is heavily influenced by the daily tidal fluctuations, with some areas having tidal ranges up to 2-3 meters.
- **Polder System:** The southwest coastal region is densely managed through 145+ polders (enclosed embankments) constructed in the 1960s to protect land from saltwater intrusion and tidal surges.
- **Soil and Drainage:** The soil is predominantly alluvial. The terrain is crisscrossed by a complex, dense network of rivers (e.g., Gorai, Arial Khan, Madhumati, Kobadak) that often become clogged, leading to severe waterlogging, particularly within enclosed polders.
- **Stable Eastern Zone:** In contrast, the far eastern coastal area (Cox's Bazar) is characterized by a narrow plain with a 145 km sandy beach, bordered by small hills, which is more stable than the central and western zones.

Key Regional Challenges

The topography makes the region highly susceptible to:

- **Salinity Intrusion:** Deep penetration of saltwater into agricultural land and water bodies.
- **Tidal Surge/Cyclones:** The low elevation provides poor defense against tidal surges.
- **Waterlogging:** Inadequate drainage during monsoon leads to long-term water retention, particularly in the polders.
- **Subsidence:** The land is undergoing natural subsidence at a rate of roughly 3 mm/year, exacerbating sea-level rise impacts.

Projected Focus Areas

The CDRSSWRMP and related initiatives focus on rehabilitating polders, upgrading coastal roads, enhancing drainage infrastructure, and supporting climate-resilient agriculture (e.g., floating gardens in inundated areas) in these vulnerable, low-lying regions.

(II) Topography of Barind Drought Prone Areas (16 districts)

The Barind drought prone areas, primarily located in the northwestern region of Bangladesh (including Rajshahi, Naogaon, and Chapainawabganj), are characterized by a distinct, elevated, and relatively dry landscape. Under initiatives like the Climate-Resilient Sustainable Small-Scale Water Resources Management Project (CRSSWRMP), this region is recognized as a Pleistocene terrace (or older alluvium) standing higher than surrounding floodplains.

Key Topographical Characteristics

- **Elevated Pleistocene Terrace:** The Barind Tract forms a small, elevated plateau, with elevations ranging from approximately 11 to 48 meters above mean sea level (amsl).

- **Undulating and Rolling Terrain:** The region is not entirely flat. It features undulating to rolling topography, particularly in the western sections. It is dissected by several, mostly small, rivers.
- **Soil Texture:** The soil consists of reddish and yellowish, clay-rich, and partially mottled soils that are generally low in organic matter and have poor water-holding capacity.
- **Slope Characteristics:** The eastern part of the Barind Tract has a relatively level topography with a regional slope towards the southwest. The western part has a more pronounced slope towards the southeast and southwest.
- **Drainage Pattern:** The area exhibits a dendritic drainage pattern.
- **Valleys and gullies:** The rivers in this area are generally narrow and entrenched, forming steep banks along the edge of the tract.

Districts and Regional Differences

The drought-prone region, often identified with the High Barind Tract, covers significant parts of:

- **Rajshahi:** Known for undulating, drier terrain.
- **Chapainawabganj:** Features elevated, older alluvium.
- **Naogaon:** Contains lower Barind areas.

These districts face high evaporative demands and limited groundwater recharge, creating an environment that is semi-arid during the dry season.

(III) Topography of Haor Flash Flood Area (9 districts)

The flash flood areas in Bangladesh, particularly those addressed by the Climate-Resilient Sustainable Water Management and Rural Livelihood Project (CDRSSWRMP) and similar initiatives (often encompassing the districts of **Sylhet, Sunamganj, Moulvibazar, Habiganj, Netrokona, Kishoreganj, and Brahmanbaria**), are characterized by a unique, low-lying, saucer-shaped topography.

Topographical Features

- **Bowl-Shaped Depressions:** The region constitutes a massive tectonic depression (backswamp) that sits lower than surrounding areas.
- **Elevation:** The majority of this land is located at an altitude of less than 8 meters, resulting in severe waterlogging during the monsoon season. Some areas, such as Tanguar Haor, are located at altitudes of 2.5–5.5 meters above sea level.
- **"Kanda" and Lowland:** The topography consists of deep, low-lying basin areas, interspersed with relatively higher elevated land known locally as *kanda*.
- **Geological Sinking:** The basin is actively sinking at a rate of 4 mm to 2.1 cm annually, which increases the depth of inundation.

Flash Flood Characteristics and Drivers

- **Upstream Runoff:** The region is bounded to the north and east by the hills of Meghalaya and Assam in India. Due to the steep slope of rivers draining these hills, heavy rainfall (3000–4000 mm annually) quickly discharges into the low-lying haors in Bangladesh.

- **Seasonal Inundation:** The haors transform from agricultural land during the dry season (November–April) to vast, connected waterbodies for 6–7 months of the year, with water depths reaching 5 meters or more.
- **Flash Flood Timing:** The most destructive flash floods occur in March–May (pre-monsoon), damaging the single-crop *Boro* rice harvest.

District-Specific Topography (Core Areas)

- **Sunamganj:** Contains the highest number of haors (133), characterized by intense depression and proximity to the Meghalaya hills.
- **Kishoreganj:** Features 122 haors, with a mix of deep basins and agricultural Kanda land.
- **Sylhet, Habiganj, Moulvibazar:** Known for large, interconnected, wetland ecosystems like Hakaluki Haor.
- **Netrokona & Brahmanbaria:** Contain floodplains that receive runoff from the surrounding uplands.

4.1.2 Geology of 42 Districts

(I) Geology of Coastal Region (17 districts)

The coastal districts under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh feature a dynamic, low-lying deltaic geology dominated by Holocene alluvial and marine deposits. Key zones include the active Meghna estuary (central), the stable Chittagong hilly region (east), and the tidal, saline-influenced Ganges plain (west), making the area highly vulnerable to subsidence, erosion, and sea-level rise.

Geological Characteristics by Zone

- **Western Zone (Satkhira, Khulna, Bagerhat):** Characterized by the Ganges tidal plain, this region is a semi-active delta with intricate creek systems, tidal flats, and saline clayey soils.
- **Central Zone (Barisal, Patuakhali, Bhola, Noakhali, etc.):** This is an extremely active zone of erosion and accretion, dominated by the Meghna River estuary, consisting of soft, recent sediments.
- **Eastern Zone (Chittagong, Cox's Bazar):** Composed of more stable, hilly terrain with tertiary sediments, sandy beaches, and coastal dunes.

Key Geological Features

- **Sedimentation:** Deep, unconsolidated sediments comprising silt, clay, and sand.
- **Processes:** Rapid shoreline changes, active sedimentation, and tidal interactions.
- **Risks:** High vulnerability to salinity intrusion, land subsidence, and storm surges.

(II) Geology of Barind Drought Prone Area (16 districts)

The Barind drought-prone areas in Bangladesh, which are frequently covered by projects like the Climate Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), are characterized by a unique, elevated Pleistocene terrace geological formation. Located in the northwestern part of the country—primarily covering Rajshahi, Naogaon, and Chapainawabganj districts—this region is defined by its "older alluvium" and distinct soil, which creates a semi-arid, water-stressed environment.

1. Geological Setting and Stratigraphy

- **Age and Formation:** The Barind Tract is the largest Pleistocene terrace (approx. 11-48m above sea level) in the Bengal Basin, composed of older alluvium, typically 10,000 to 100,000 years old.
- **Soil Type:** The surface is largely covered by reddish-brown, highly oxidized, and sticky clay known as **Madhupur Clay**. This clay is often referred to as "Barind Clay Residuum".
- **Subsurface Lithology:** The geology consists of a thick top clay layer (often 4m to over 35m thick) that acts as an **aquitard**, hindering groundwater recharge and increasing surface runoff. Below this, the primary aquifer is formed by **Dupi Tila sands**, consisting of fine to coarse sand, gravel, and silt.
- **Tectonic Nature:** The tract is a tectonically uplifted block (horst) bounded by fault lines (e.g., Malda-Kishanganj fault in the west, Karatoya fault in the northeast).

2. Hydrogeological Characteristics

- **Aquifer System:** The area has a two-part aquifer system: an upper shallow aquifer (10-30m thick) and a lower shallow aquifer (20-70m thick), which are frequently connected.
- **Groundwater Recharge:** Due to the thick surface clay layer, vertical seepage is very slow, making groundwater recharge poor and inefficient.
- **Declining Water Table:** Intensive groundwater extraction for irrigation (via deep tube wells) has led to significant, permanent declines in the groundwater table, often falling below the suction limit of shallow tube wells.

3. Geomorphology and Soil Properties

- **Topography:** The region is characterized by an undulating, high-terrace topography, as opposed to the flat, low-lying floodplains.
- **Soil Texture:** The soil is heavily dominated by clay to clay-loam, which possesses low porosity and low moisture retention capacity, directly contributing to drought conditions.
- **Drainage:** The area has a dendritic drainage pattern with entrenched, tightly meandering rivers like the Mahananda, Punarbhaba, and Atrai.

4. Impact on Water Resources

- **Drought Vulnerability:** The combination of low permeability, high evaporation, and low rainfall leads to severe hydrological drought.
- **Surface Water Limitation:** Most rivers in the Barind tract are seasonal and dry up during the dry season.

The geological structure (specifically the thick surface clay) makes traditional surface water retention difficult, forcing reliance on deeper groundwater resources which are now over-

extracted, resulting in the need for projects like CDRSSWRMP to develop alternative water sources, such as re-excavating canals and constructing water storage systems.

(III) Geology of Haor Flash Flood Area (9 districts)

The Haor flash flood area districts in Bangladesh, which are frequently under the purview of projects like the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), are primarily located in the northeastern region. These include **Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, Kishoreganj, and Brahmanbaria.**

Geological and Tectonic Features

- **Tectonic Location:** The region is situated on the **Sylhet Trough**, which is a rapidly subsiding, deep tectonic depression at the northern end of the Central Deep Basin of the Bengal Basin.
- **Subsidence Rate:** The area is experiencing active subsidence, with estimates indicating a sinking rate of roughly 20 mm per year.
- **Geological Boundary:** It is bounded to the north by the **Shillong Massif** (Meghalaya Plateau), which is separated by the seismically active **Dauki Fault**.
- **Origin of Haors:** The haors (large, bowl-shaped wetlands) are classified into two types:
 - **Subsidence Haors:** Primarily found in the Northern Depression (e.g., Sunamganj), formed by the tectonic sinking of the Sylhet Trough.
 - **Synclinal Haors:** Located in the Southern Depression (e.g., portions of Habiganj/Moulvibazar), formed in the synclines between folded anticlines.

Sedimentation and Soil Composition

- **Sediment Sources:** The basins are filled with thick sediments carried down from the surrounding Shillong Plateau and Assam hills, resulting in a combination of sandy to clayey soils.
- **Soil Type:** The soil is generally characterized as fine-textured, clayey, and often acidic due to heavy leaching, which creates an impermeable layer that helps retain water, but makes the soil sticky and difficult to manage.
- **Deposition:** High rates of sedimentation from the surrounding hilly areas are reducing the natural water storage capacity of the haor basins.

Geology-Induced Flash Flood Factors

- **Saucer-Shaped Topography:** The bowl-shaped, low-lying nature of the terrain (often only 2.5–5.5 m above sea level) acts as a natural reservoir, trapping runoff.
- **River System:** The area acts as a floodplain for the Surma-Kushiyara river system, which carries high-velocity water from the hills.
- **Dauki Fault Influence:** The rapid tectonically driven subsidence along the Dauki Fault creates a deep basin that quickly fills with water during high-intensity rainfall.

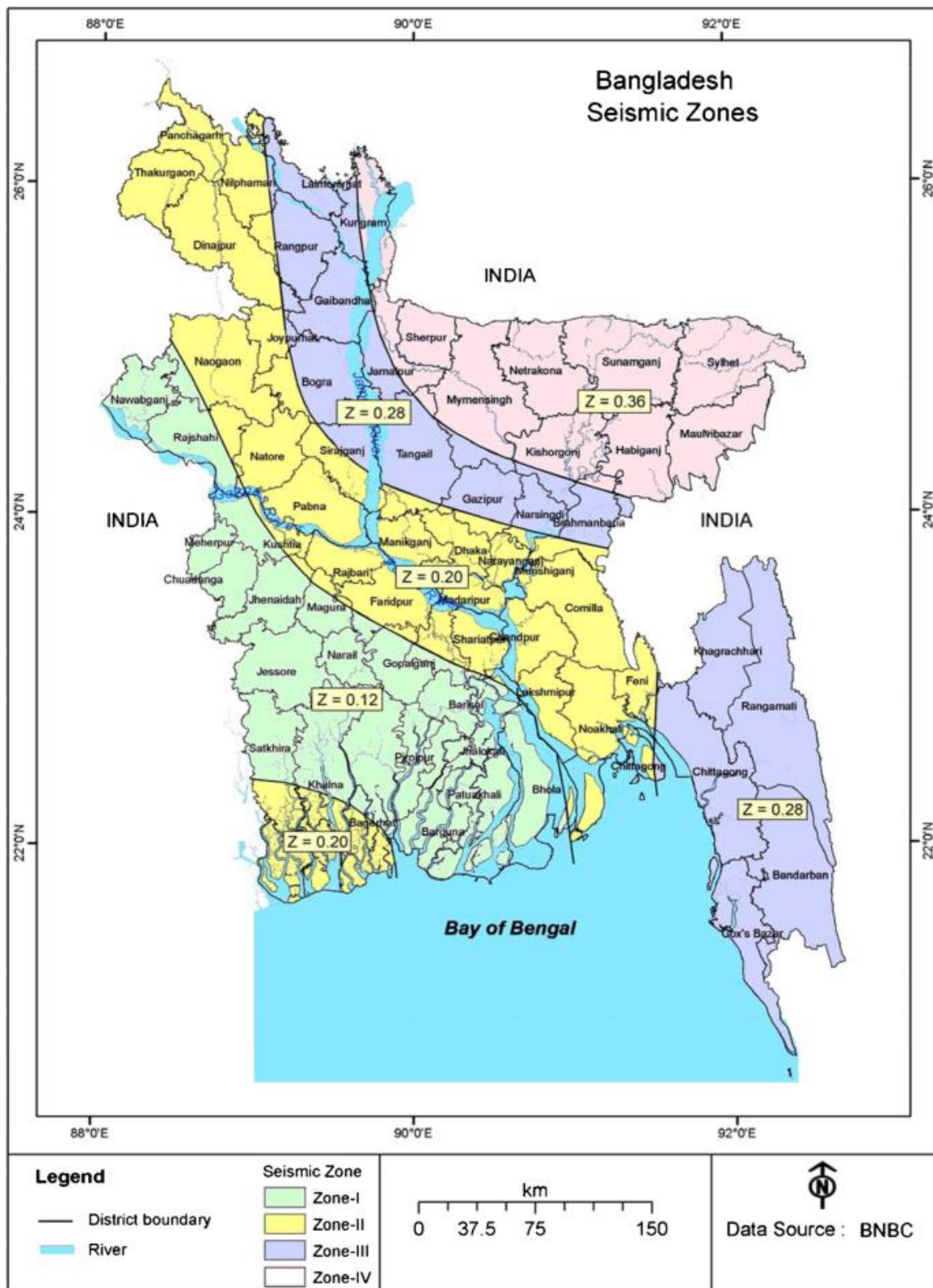


Figure 7: Seismic Zoning in Bangladesh (Source: National Building Code, 2015)

4.1.3 Geomorphology of 42 project districts

(I) Geomorphology of Coastal Region (17 districts)

The coastal region of Bangladesh, encompassing 17 project districts under CDRSSWRMP/ICZMP frameworks, is a highly dynamic, low-lying deltaic plain, divided into three distinct geomorphological zones: the western Ganges tidal plain, the central Meghna deltaic zone, and the eastern hilly region. It is characterized by rapid accretion/erosion, salinity intrusion, and significant vulnerability to climate change.

Key Geomorphological Zones of Coastal Districts

- **Western Region (Stable Deltaic/Tidal Plain):** Comprises Satkhira, Khulna, and Bagerhat districts. This area features a semi-active delta with numerous crisscrossed channels and the Sundarbans mangrove forest, experiencing relatively low erosion compared to the central region.
- **Central Region (Active Deltaic Plain):** Includes Bagerhat, Barguna, Barisal, Bhola, Pirozpur, Jhalakati, Patuakhali, and Lakshmipur. This is the most dynamic zone, dominated by the Meghna estuary, characterized by high rates of sediment deposition (accretion) and severe bank erosion.
- **Eastern Region (Hilly/Stable Coastal Plain):** Includes Chittagong, Feni, and Cox's Bazar. This region features a narrower, more stable coastal plain, characterized by marine deposits, sand dunes, and beaches, particularly in the Cox's Bazar coast.

Key Coastal Morphological Characteristics

- **Active Accretion and Erosion:** The Meghna estuary is highly volatile, resulting in the continuous formation of new land (chars) and loss of land due to bank erosion.
- **Hydrological Dynamics:** The region is heavily influenced by the Ganges-Brahmaputra-Meghna river system and the Bay of Bengal, causing high tidal, salinity, and sediment transport fluctuations.
- **Vulnerability:** The entire coastal zone is highly susceptible to sea-level rise, storm surges, and coastal flooding.

(II) Geomorphology of Barind Drought Prone Area (16 districts)

The Barind Tract, a major drought-prone area in the northwestern part of Bangladesh (principally covering Rajshahi, Naogaon, Chapainawabganj, Joypurhat, Bogra, and parts of Dinajpur and Rangpur districts), is characterized by its unique Pleistocene terrace geomorphology. The area is an elevated, relatively flat-to-undulating landmass, acting as an inlier within the surrounding, more recent floodplains.

Geomorphological characteristics of the Barind Tract within the drought-prone area include:

- **Elevation and Topography:** The Tract is an elevated, tectonic, or erosional terrace, situated at a height of 11–48 meters above mean sea level (amsl), often forming a sharp scarp line with neighboring floodplains.
- **Soil Composition:** The region is primarily characterized by "Barind Clay"—reddish to yellowish-brown, stiff clays that are sticky when wet and friable when dry. These soils have low permeability and low nutrient content, making them less suitable for traditional rice cultivation without proper water management.
- **Drainage Pattern:** The Barind region features entrenched, dendritic (tree-like) drainage patterns, with rivers showing low sinuosity (straightening) compared to the surrounding braided or meandering floodplain channels. Rivers like the Atrai, Punarbhaba, and

Mahananda have incised deeply into the terrain, forming V-shaped valleys within the tract.

- **Surface Morphology:** The landscape is generally flat but becomes increasingly undulating, rolling, or dissected, particularly in the western and northwestern parts.
- **Tectonic Influence:** The formation of the Barind Tract is attributed to the tectonic uplift of Pleistocene terraces. It is surrounded by faults (e.g., Malda-Kishanganj fault, Karatoya fault), which have contributed to its elevated nature compared to the surrounding subsided, active, or, Holocene floodplains.
- **Hydro-Geomorphology:** Due to the elevated, less-permeable clay soil and limited natural recharge areas, the area faces high runoff, making it highly susceptible to meteorological and agricultural drought. The groundwater table is significantly lower compared to the surrounding floodplains and has been rapidly declining.

Relevance to CDRSSWRMP:

The project aims to mitigate drought impacts by enhancing surface water storage through re-excavation of canals and ponds, and by improving irrigation efficiency in this specific geomorphological zone, which is critical for agricultural sustainability in the region.

(III) Geomorphology of Haor Flash Flood Area (9 districts)

The geomorphology of the Haor flash flood area districts in Bangladesh, particularly under initiatives like the Climate Resilient Infrastructure for Sustainable Community Life in the Haor Region (CDRSSWRMP/CRH Project), is characterized by a unique, tectonically depressed, bowl-shaped wetland ecosystem, often called the "Sylhet Basin".

Key Geomorphological Features:

- **Tectonic Depression:** The Haor region, encompassing Sylhet, Sunamganj, Habiganj, Moulvibazar, Netrokona, Kishoreganj, and Brahmanbaria, is a large, low-lying, saucer-shaped depression (basin) that is sinking at a rate of 4 mm to 2.1 cm annually due to the down-thrusting under the Shillong massif.
- **Wetland Components:** The landscape is a complex mix of rivers, streams, *Khals* (canals), and hundreds of *Beels* (small, permanent water bodies within the depression).
- **Elevations:** The region is situated at an altitude of 2.5 to 5.5 meters above sea level, making it highly vulnerable to inundation.
- **Drainage and Slope:** The area has a relatively flat landscape in the center, bordered by steep hilly topography in the north and east (Meghalaya and Assam hills of India).
- **Hydraulic Characteristics:** During the pre-monsoon (April–May), the heavy, rapid runoff from the steep, nearby Indian hills travel into this depressed, low-gradient basin, causing sudden, deep flooding that can persist for 5–7 months.
- **Siltation:** The riverbeds in the region are undergoing significant siltation, which reduces their water-carrying capacity and causes the rivers to change their shapes and locations.

Affected Districts:

- **Sunamganj & Sylhet:** Worst-hit, characterized by deep, bowl-shaped depressions (e.g., Tanguar Haor, Hakaluki Haor).

- **Netrokona & Habiganj:** Similar flat terrain with seasonal depressions.
- **Kishoreganj, Moulvibazar, & Brahmanbaria:** Part of the greater Sylhet basin.

Geomorphological Impact on Flash Floods:

The combination of rapid tectonic subsidence, high-intensity upstream rainfall, and a slow-draining, flat, basin-like landscape makes the region prone to early, flash-flood-induced damage to Boro crops, typically in April.

4.1.4 Soil of 42 project districts

(I) Soil of Coastal Region (17 districts)

The coastal soils under the Climate and Disaster Resilient Small-Scale Water Resources Management Project in Bangladesh are primarily characterized by high salinity, low plasticity silts, and clays. These soils, found in areas like Bhola, Chittagong, and Noakhali, contain 2–33% clay, 50–96% silt, and 1–25% sand. Key properties include high salinity intrusion due to climate change, low shear strength (15–40 kN/m²), and high compressibility.

Soil Characteristics of Coastal Regions:

- **Composition:** The topsoil is predominantly silty, with high silt content (50-96%).
- **Classification:** Generally classified as low plasticity silts (ML) and clays (CL).
- **Engineering Properties:** The soils exhibit low to medium plasticity (plasticity index 10-30%) and high compressibility.
- **Salinity Intrusion:** A major feature is high salinity, which significantly reduces soil fertility and affects agricultural productivity.
- **Structural Composition:** The soil structure is often soft to firm, which impacts the design of coastal infrastructure.

Districts Affected (Coastal Zone):

The coastal zone encompasses 17 project districts, including:

- **Southwest Region:** Satkhira, Khulna, Bagerhat, Pirozpur, Jhalakati, Barguna, Barisal, Patuakhali, and Bhola.
- **Central/Southeast Region:** Gopalganj, Chandpur, Lakshmipur, Noakhali, Chittagong, and Cox's Bazar.

These regions are highly vulnerable to climate change-induced disasters like storm surges and cyclones, which further exacerbate the saline, low-strength nature of the soil.

(II) Soil of Barind Drought Prone Areas (16 districts)

The soil in the Barind Tract of Bangladesh is primarily composed of reddish-brown, compacted, and oxidized Pleistocene sediments known as Madhupur clay, characterized by low water retention capacity and poor nutrient levels. It is often described as hard, clayey (about 49%), or loamy (about 34%), creating a high-risk, drought-prone environment.

Key Soil Characteristics of the Barind Tract:

- **Composition:** Primarily sticky, compact clay, often referred to as old alluvium.

- **Physical Properties:** The soil is notoriously hard, especially when dry, making cultivation difficult, with a tendency for surface cracking.
- **Moisture Retention:** The soil has low moisture retention capacity, which, combined with low rainfall (mm in some areas), exacerbates drought conditions.
- **Nutrient Levels:** It is generally poor in organic matter.
- **Color:** The soil is characterized by a reddish-brown color due to oxidation.

Management and Challenges:

- **Drought Vulnerability:** The soil is highly susceptible to erosion and, along with high temperatures (to), creates severe agricultural challenges.
- **Soil Amendment:** Farmers frequently use decomposed cow dung, compost, and, in some cases, pond soil to improve the structure and fertility of the soil.
- **Conservation Techniques:** To combat the rapid drying of the soil, farmers often use mulching techniques (using leaves or organic materials) to retain soil moisture and protect crop roots.
- **Land Use:** Despite its limitations, the soil supports agricultural activities through intensive irrigation, although this has led to significant groundwater depletion.

The region faces severe water scarcity, necessitating specialized, nature-based agricultural practices to maintain productivity.

(III) Soil of Haor Flash flood area (9 districts)

The soils of the Haor flash flood areas in northeastern Bangladesh are primarily characterized as **heavy clay to clay loam**, often referred to as basin clays. These soils are formed in the vast, low-lying, tectonic, bowl-shaped depressions that remain submerged or wet for 7–8 months of the year, transforming into an inland sea during the monsoon.

Key Characteristics of Haor Soils

- **Soil Composition:** The region is dominated by deep, fine-textured clay soils, with coarser silty or sandy soils deposited near river banks and levees.
- **Peat Deposits:** In the lowest parts of the basins, particularly in parts of Sunamganj, Netrokona, Kishoreganj, and Habiganj districts, organic-rich peat soils are found near the surface, formed by decomposing aquatic plants.
- **Fertility:** The soil is highly fertile due to the annual deposition of rich sediments from upstream hilly rivers, though it is heavily saturated with water.
- **Soil pH:** The soils are generally acidic, with pH levels ranging from extremely acidic (3.4) to slightly acidic or neutral (6.9).
- **Nutrient Profile:** While organic matter is generally high (2.03–3.45%), the soil is severely phosphorus-deficient and lacks adequate potassium.
- **Texture and Structure:** The soils are predominantly clay, but flash floods often cause erratic sedimentation, leading to localized sandy or silty layers.

Impact of Flash Floods on Soil

Flash floods in the Haor region (mainly from April to June) significantly alter the soil characteristics:

- **Siltation:** Intense runoff from the Meghalaya Hills brings vast amounts of sediment, causing rapid siltation and reducing the water-holding capacity of the basins.
- **Erosion:** The flash floods often cause severe bank erosion, reducing arable land.
- **Soil Compaction:** The heavy, water-saturated nature of the clay makes it challenging to work with, requiring specific conditions for rice cultivation.

Agricultural Suitability

- **Boro Rice Cultivation:** The soil is ideal for Boro rice (winter rice), which is the dominant crop grown in the dry season after the water recedes.
- **Cropping Limitations:** Due to being submerged for 7-8 months, these areas are primarily limited to a single crop (Boro-Fallow-Fallow system), though some elevated, drier areas (locally known as *kanda*) allow for more intensive cultivation.

4.1.5 Drainage of 42 project districts

(I) Drainage of Coastal Region (17 districts)

The CDRSSWRMP focuses on enhancing drainage, flood management, and water control infrastructure across 17 coastal districts to boost agricultural productivity. Key districts include Satkhira, Khulna, Bagerhat, Barisal, Patuakhali, Bhola, Noakhali, and Chittagong.

Key Drainage & Water Management Activities:

- **Drainage Improvement:** Upgrading and rehabilitating drainage channels to prevent waterlogging and reduce salinity in coastal soils.
- **Infrastructure Development:** Constructing small-scale water infrastructure, including sluice gates and embankment improvements to manage tidal flooding.
- **Climate Resilience:** Implementing sustainable, participant-driven water management systems through the Local Government Engineering Department (LGED).
- **Target Areas:** The initiative aims to improve water management over 220,000 hectares, focusing on increasing crop yields, intensifying cropping, and improving livelihoods for over 335,000 households.

(II) Drainage of Barind Drought Prone Areas (16 districts)

The CDRSSWRMP active from 2022 to 2029, is a major initiative by the Local Government Engineering Department (LGED) to improve water management in Bangladesh, specifically targeting drought-prone Barind areas, among other hotspots.

Districts Involved: The project focuses on the drought-prone **High Barind** regions (predominantly in the Rajshahi division) and other climate-vulnerable zones, focusing on key districts including: Rajshahi, Naogaon, Chapainawabganj, Bogura, Joypurhat, Pabna and Sirajganj

Drainage & Water Management Activities

To address water scarcity, high evaporation, and low groundwater recharge in the Barind tract, the project implements the following:

- **Canal Rehabilitation:** The project rehabilitates canals (e.g., 140 kilometers) to improve water retention and drainage capacity, facilitating irrigation during dry seasons.
- **Water Conservation:** Development of water retention capacity in existing Khals (canals) and Beels (wetlands) to boost irrigation availability.
- **Small-Scale Infrastructure:** Construction of sluice gates and drainage improvements to manage excess monsoon water while conserving it for dry periods.

- **Surface Water-Based Irrigation:** Promoting surface water usage to reduce pressure on the declining groundwater table, which has reached critical levels in areas like Naogaon.
- **Nature-Based Solutions:** Rehabilitating dryland forests and ecosystem-based adaptation techniques to reduce water scarcity.

The project aims to improve agricultural productivity and profitability for over 335,000 farming households, directly benefiting about 86,000 hectares of land through enhanced water management.

(III) Drainage of Haor Flash Flood Area (9 districts)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project, initiated in late 2023 and running through 2029, covers 42 districts across four major geographic hotspots identified in the Bangladesh Delta Plan 2100.

The project focuses on drainage improvement, flood management (embankments/slucice gates), and water conservation to mitigate flash floods, particularly in the Haor region.

Districts in Haor & Flash Flood Areas Hotspot

The primary districts covered under the "Haor and Flash Flood Areas" hotspot, which are specifically targeted for drainage improvement and flash flood management (such as, re-excavation of canals, protection walls, and sluice gates), include: Sunamganj (most severe), Sylhet, Netrokona, Habiganj, Kishoreganj, Moulvibazar and Brahmanbaria (adjacent area).

Key Project Components for Haor Drainage

- **Drainage Improvement:** Re-excavation of drainage canals to increase the capacity of the drainage systems.
- **Flood Management:** Rehabilitation and construction of embankments and/or sluice gates to reduce the depth and duration of farmland flooding.
- **Water Conservation:** Developing water retention capacity in existing haors, Beels, and Khals for irrigation water availability.
- **Infrastructure Protection:** Building village protection walls to safeguard against flash flood erosion.

Implementation Details

- **Executing Agency:** Local Government Engineering Department (LGED).
- **Target:** 150 new inclusive Water Management Cooperative Associations (WMCAs) and strengthening 230 existing subprojects.
- **Focus Area:** The project specifically aims to support agriculture (e.g., Boro rice) which is highly vulnerable to early flash floods in the northeast region.

4.1.6 Hydrology and Water Resources of 42 Districts

(I) Hydrology and Water Resources of Coastal Region (17 districts)

The coastal region of Bangladesh, encompassing 17 project districts (e.g., Satkhira, Khulna, Barishal, Noakhali, Chittagong), is a complex hydrological zone dominated by the Ganges-Brahmaputra-Meghna delta, characterized by high salinity, tidal surges, and vulnerability to cyclones. The CDRSSWRMP aims to manage these water resources, addressing issues like embankment erosion, saltwater intrusion, and waterlogging.

Key hydrological and water resources feature in these districts include:

- **Hydrological Characteristics:** The region features an intricate network of rivers, channels, and creeks with significant tidal influence. It is divided into three distinct zones: the western (Ganges tidal plain, high salinity), central (active delta, high sediment), and eastern (influenced by hilly rivers).
- **Water Resources:** Surface water is abundant but often saline, with fresh water mostly available during the monsoon. Groundwater, the primary source for drinking and irrigation, is increasingly affected by salinity intrusion.
- **Key Water Issues:** Major challenges include waterlogging due to improper drainage, storm surges from cyclones, erosion of coastal chars, and acute shortage of fresh water for domestic use in the dry season.
- **CDRSSWRMP Focus:** The project focuses on small-scale interventions like repairing embankments, sluice gates, and drainage canals to mitigate flooding and manage saline intrusion.

(II) Hydrology and Water Resources of Barind Drought Prone Area (16 districts)

The Barind drought-prone area in northwest Bangladesh, covering districts like Rajshahi, Naogaon, and Chapainawabganj, faces critical water scarcity due to low rainfall and declining groundwater, especially in the High Barind. Under the CDRSSWRMP (Climate and Disaster Resilient Small-Scale Water Resources Management Project), efforts focus on improving water management, diversifying crops, and developing resilient, small-scale water infrastructure to mitigate severe drought impacts.

Hydrology and Water Resources Profile

- **Location:** The Barind Tract covers parts of Rajshahi, Chapainawabganj, Naogaon, Bogura, Joypurhat, Rangpur, and Dinajpur districts.
- **Water Scarcity:** This region has the lowest rainfall in Bangladesh and is characterized by frequent, severe droughts, with intense dry seasons.
- **Groundwater Decline:** Groundwater levels are continuously falling due to over-exploitation and reduced recharge, with significant depletion occurring post-2000.
- **Surface Water:** Limited surface water is available; however, the area contains roughly 10,000 ponds and 200 canals.
- **Aquifer Characteristics:** Aquifer transmissivity is low in the central part ($< 500\text{m}^2/\text{day}$) and higher in other parts ($> 1000\text{m}^2/\text{day}$), creating varying conditions for irrigation and supply.

Key Challenges & Management (CDRSSWRMP Context)

- **Climate Risks:** Increasing, frequent droughts (e.g., predicted in 2026, 2028, 2031) threaten food security and water supply.

- **Project Focus:** The ADB-supported CDRSSWRMP aims to build climate-resilient, small-scale infrastructure to improve agricultural productivity and livelihoods.
- **Management Strategies:** Key interventions include re-excavating canals, rehabilitating ponds to boost surface water storage, and implementing sustainable groundwater management to combat over-extraction.
- **Districts Involved:** The project specifically targets 14 upazilas within Rajshahi, Chapainawabganj, and Naogaon districts.

(III) Hydrology and Water Resources of Haor Flash Flood Area (9 districts)

The Haor flash flood areas in Bangladesh are a critical ecological and agricultural hotspot, largely covered by the CDRSSWRMP, a project by the Local Government Engineering Department (LGED). The region, primarily in the northeastern part of the country, is a bowl-shaped tectonic depression that remains underwater for 5–7 months annually, with flash floods posing severe threats to livelihoods.

Districts Under the Haor Focus Area

The flash flood-prone districts under the purview of such initiatives (including CDRSSWRMP and related JICA/IFAD projects) comprise six districts in the northeastern region: Sunamganj (most affected), Sylhet, Habiganj, Moulvibazar, Netrokona and Kishoreganj

Hydrology and Water Resources Characteristics

The hydrology of this area is distinct due to its unique topographical and meteorological conditions:

- **Flash Flood Timing:** Occurs mainly in the pre-monsoon season (March–May), caused by heavy rainfall in the upstream Indian hills (Meghalaya and Barak basins).
- **Inundation Depth & Duration:** The region transforms into an "inland sea" during monsoons, with water depths ranging from 4 to 8 meters.
- **Wave Action (Afal):** Intense wave action, known locally as *Afal*, occurs during floods, causing significant erosion to villages (known as *Hati* or *Kanda*) and destroying crops.
- **Sedimentation:** High sedimentation on riverbeds restricts water flow, causing increased bank overflows.
- **Major Wetlands:** Key areas include Tanguar Haor and Hakaluki Haor, which are ecologically critical areas (ECA).

Water Resources Management and Constraints

Water management in this region involves balancing agricultural needs with high-intensity flooding:

- **Submersible Embankments:** The Bangladesh Water Development Board (BWDB) constructs these to protect the crucial *Boro* rice crop from early floods.
- **Project Focus (CDRSSWRMP/IFAD):** Initiatives focus on constructing climate-resilient, small-scale water resources infrastructure, such as improved embankment systems, flood shelters, and enhancing community-based management (WMCAs).

- **Challenges:** The area faces acute drinking water shortages during the dry season and extreme vulnerability to crop damage, with nearly 25% of the country's total annual Boro rice output produced in this risky region.

Key Risks

- **Crop Loss:** Early flash floods regularly destroy pre-harvest Boro rice.
- **Infrastructure Destruction:** High wave action damages rural road networks and homes.
- **Vulnerability:** Limited access to safe drinking water and sanitation, coupled with isolation during the monsoon.

The project aims to mitigate these risks by enhancing the resilience of small-scale water infrastructures to protect livelihoods in these vulnerable districts.

4.1.7 Weather and Climate of 42 Districts

(I) Weather and Climate of Coastal Region (17 districts)

The coastal region districts in Bangladesh, particularly those addressed by projects like the Coastal Climate Resilient Infrastructure Project (CCRIP) and Coastal Towns Climate Resilience Project (CTCRP) (which include 12–22 districts such as Satkhira, Khulna, Bagerhat, Pirojpur, Jhalokathi, Barguna, Barisal, Patuakhali, and Bhola), are defined by a high-vulnerability tropical monsoon climate.

1. General Climate and Weather Pattern

- **Monsoon Dominated:** The climate is tropical and humid, dominated by the monsoon season (June–October), which brings high rainfall.
- **Temperature:** Warm temperatures occur between May and August, with the southwestern coast (Khulna) often recording the highest average temperatures, sometimes exceeding 30°C in May. Winters (December–February) are dry and mild.
- **Rainfall:** High intensity, with over 70% of the annual rainfall occurring during the monsoon, often causing waterlogging in low-lying coastal polders.

2. Key Climate-Induced Hazards (Under CDRSSWRMP/CCRIP Context)

These districts are frequently battered by natural disasters that are increasing in intensity due to climate change:

- **Cyclones and Storm Surges:** Tropical cyclones, usually occurring in April–June and September–November, are common. The Funnel-shaped Bay of Bengal amplifies these, causing significant storm surges, especially in the central (Bhola, Patuakhali) and western (Satkhira, Khulna) zones.
- **Salinity Intrusion:** Considered a "slow poison," saltwater from the Bay of Bengal intrudes into freshwater sources and agricultural lands, particularly in the southwest (Satkhira, Khulna, Bagerhat), affecting soil fertility and drinking water.

- **Sea-Level Rise (SLR):** The sea levels are rising faster than the global average. A 1-meter rise could submerge 17% of the total land area.
- **Coastal Flooding and Erosion:** High tidal flows and, in some cases, tidal surges (reaching 6-9 meters in extreme cases) cause frequent flooding.

3. District-Specific Vulnerabilities (Example Context)

- **Satkhira, Khulna, Bagerhat:** Severe salinity intrusion in soil and water, waterlogging, and extreme vulnerability to cyclones (e.g., Aila, Amphan).
- **Bhola, Patuakhali, Barguna:** High exposure to cyclones and storm surges, rapid coastal erosion, and tidal flooding.

4. Climate Trends (Future Projections)

- **Rising Temperatures:** An upward trend in both annual maximum and minimum temperatures.
- **Increased Rainfall Intensity:** Monsoon rainfall is projected to increase by 12% to 27% by 2030-2075, while winter rainfall decreases.
- **Increased Cyclone Frequency:** Studies predict a rise in the intensity of tropical cyclones in the Bay of Bengal.

These districts are categorized as "exposed" or "interior" coast, with the western region (Ganges Tidal Plain) particularly prone to slow-onset disasters like salinity and waterlogging, and the central/eastern regions prone to rapid-onset disasters like cyclones and tidal surges.

(II) Weather and Climate of Barind Drought Prone Areas (16 districts)

The Barind drought-prone areas, often referred to as the Barind Tract or Varendra Bhumi, cover approximately 10,000 square kilometers in the northwestern region of Bangladesh. This area is characterized by a distinct, sub-tropical monsoon climate that frequently experiences high temperatures and low, erratic rainfall compared to the rest of the country. The region is a key focus for climate resilience, including initiatives like the Climate and Disaster Resilient Small-Scale Water Management Project (CDRSSWMP). The Barind Tract primarily spans parts of:

- **Rajshahi Division:** Rajshahi, Naogaon, Chapainawabganj, Bogra, Joypurhat, and Pabna districts.
- **Rangpur Division:** Parts of Dinajpur and Rangpur districts.

Climate and Weather Characteristics

- **Temperature:** The region experiences extreme temperatures, with average summer highs ranging from 35°C to 45°C, making it one of the hottest areas in Bangladesh. Winters can be cold, with temperatures sometimes dropping to 5°C in certain areas of Dinajpur and Rangpur.
- **Rainfall:** The Barind region receives significantly less annual rainfall than the national average, with an average of roughly 1,400 mm to 1,971 mm. Rainfall is erratic, with long dry spells and sometimes, in the monsoon, high-intensity showers.

- **Seasonality:** The region is distinct for its sharp contrasts, featuring a very hot and dry pre-monsoon season and a monsoon that often fails to provide sufficient, consistent moisture.
- **Soil:** The area is composed of old, dense, clayey soil, which has low porosity, hindering natural groundwater recharge.

Key Climate Challenges (Drought & Water Scarcity)

- **Groundwater Decline:** The reliance on groundwater for irrigation (especially for Boro rice) has caused water tables to fall by 1 to 3 meters in some areas.
- **Desertification Signs:** Due to climate change, the region is witnessing signs of desertification, including dust storms, severely eroded landscapes, and reduced soil moisture.
- **Agricultural Impact:** High temperatures, especially in March, exceed 35°C, which disrupts the pollination of Boro paddy, causing sterile grains and reduced yields.
- **Increased Vulnerability:** The region is facing a shift towards extreme drought conditions, exacerbated by a 0.5°C per decade increase in maximum temperature.

CDRSSWMP Focus

The Climate and Disaster Resilient Small-Scale Water Management Project (CDRSSWMP) and similar initiatives focus on this area to mitigate these risks by enhancing water management, rehabilitating water infrastructure, improving irrigation, and building resilience among farming communities.

(III) Weather and Climate of Haor Flash Flood Area (9 districts)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), supported by the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD), covers several districts in Bangladesh, including those specifically vulnerable to haor (wetland) flash floods.

The primary districts in the haor region targeted for such interventions include Sunamganj, Sylhet, Habiganj, Moulvibazar, Netrokona, and Kishoreganj.

Weather and Climate of Haor Flash Flood Areas

The haor regions are characterized by a unique, highly seasonal, and increasingly unpredictable climate that poses significant challenges to livelihoods and agriculture.

- **Pre-Monsoon Flash Floods:** Flash floods are common from **April to July**, with a major threat occurring in pre-monsoon (April-May) due to high intensity, short-duration rainfall in the upstream Meghalaya and Assam hills of India, combined with local rainfall.
- **Monsoon Inundation:** The entire haor region remains submerged for 5–7 months (typically June to October/November).
- **Climate Change Impact (Erratic Rainfall):** Rainfall patterns have become increasingly erratic. A shift in heavy rainfall from May to April has been observed, causing flash floods to occur earlier and with greater intensity, frequently damaging the mature *Boro* rice crop.
- **Rising Temperatures:** Temperatures in the region are rising, with an upward trend in both maximum and minimum annual temperatures, exceeding a 1.4°C increase over recent decades.

- **Hydrological Stress:** The Surma-Kushiyara river system, which feeds the haors, experiences rapid, high-velocity water rises, resulting in overbank discharge that floods villages.
- **Wave Erosion:** During the monsoon, wind-driven waves (up to 3 meters high) cause significant erosion, threatening the artificially constructed mounds of earth (kanda) where villages are located.

Key Characteristics of Affected Districts

- **Sunamganj:** Highly vulnerable, with Tanguar Haor frequently experiencing severe, early flash floods.
- **Sylhet:** Receives high rainfall, with over 400 mm in April often triggering severe floods.
- **Kishoreganj (Itna Upazila):** Focus area for climate-resilient livelihood support (e.g., BDRCS projects) due to prolonged, annual flooding.

Climate Change Implications

The frequency of high-intensity flash floods has increased, with devastating events occurring in 2017, 2019, and 2022. The annual flooding is projected to become more extensive due to sea-level rise exacerbating drainage congestion.

Mitigation and Resilience (CDRSSWRMP Focus)

Under the CDRSRWMP, interventions focus on:

- Improving water management infrastructure to handle rapid water level changes.
- Introducing flood-tolerant or short-duration *Boro* rice varieties.
- Strengthening, repairing, and building flood-resilient infrastructure (embankments) to protect homes and crops.
- Developing early warning systems and increasing community resilience to withstand longer periods of submersion.

4.1.8 Air and Water Quality of 42 Districts

(I) Air and Water Quality of Coastal Region (17 districts)

Coastal districts in Bangladesh, supported by the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), face severe air and water quality issues, including high salinity, arsenic, and PM_{2.5} pollution. Air quality is degrading with high SO₂, O₃ and PM_{2.5}. Water quality suffers from seawater intrusion, high, salinity and, heavy metals (Fe, Mn, As).

Air Quality in Coastal Regions

- **Particulate Matter:** PM_{2.5} levels consistently exceed Bangladesh National Ambient Air Quality Standard (BNAQS) of 65µg/m³, with average values often around 56µg/m³, particularly in Khulna, Bagerhat, Satkhira, and Narail.

- **Pollutant Trends:** Interior coastal areas are generally more polluted than exposed coastal areas, with an increasing trend in pollution.
- **Impacts:** Air pollution contributes to the vulnerability of the region.

Water Quality in Coastal Regions

- **Salinity Intrusion:** Increased salinity in groundwater and surface water is a primary concern in many districts, affecting drinking water safety.
- **Contamination:** Over 50% of the 567 unions studied in the southwestern coastal region do not have access to safe drinking water, with high levels of arsenic, iron, and manganese, along with high electrical conductivity (EC).
- **Groundwater Characteristics:** Groundwater salinity varies, often exceeding the 600 mg/L chloride standard.
- **Quality Mitigation:** The CDRSSWRMP and other projects are addressing these issues by promoting rainwater harvesting and community-based, filtered water supplies to ensure safe drinking water.

(II) Air and Water Quality of Barind Drought Prone areas (16 districts)

The Barind tract (Rajshahi, Naogaon, Chapainawabganj) faces critical water scarcity and deteriorating air quality due to severe, unpredictable droughts, low rainfall, and high temperatures. Groundwater levels are plunging, with severe depletion, while surface water dries up. Climate change drives rising temperatures, worsening agricultural conditions.

Water Quality and Availability (CDRSSWRMP Area)

- **Declining Groundwater:** The region, especially high-barind zones, suffers from a significantly falling groundwater table.
- **Contamination Risks:** Groundwater in many parts of the region is affected by arsenic contamination in shallow aquifers and pollution from agricultural runoff.
- **Surface Water Scarcity:** Surface water sources are almost nonexistent during the prolonged dry season, causing acute drinking and irrigation water crises.
- **Water Management Challenges:** The area is considered a "high water-scarcity zone," with bans on new tube wells in some areas to prevent further depletion.

Air Quality and Climate

- **Rising Temperatures:** The Barind region experiences intense heatwaves and increasing maximum/minimum temperatures.
- **Dry Conditions:** Frequent droughts and low rainfall result in arid conditions, leading to increased dust pollution.
- **Climate Change Impact:** The region is experiencing more consecutive dry days and erratic rainfall patterns, which are projected to intensify, increasing the vulnerability of the region to heat stress.

Key Drought-Prone Districts

The most affected areas within the CDRSSWRMP (Climate and Disaster Resilient Small-Scale Water Resources Management Project) scope in the Barind tract include: Rajshahi, Naogaon, Chapainawabganj, Parts of Natore, Bogura, and Dinajpur.

(III) Air and Water Quality of Haor Flash Flood Area (9 districts)

The Haor flash flood areas in northeastern Bangladesh (primarily Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, and Kishoreganj) experience severe environmental degradation during the pre-monsoon (April-May) and monsoon (June-September) seasons, driven by heavy rainfall in the Indian Meghalaya hills and rising water levels in the Surma and Kushiya rivers. The water quality drastically deteriorates during these events, while air quality, although generally better than urban areas, faces localized issues.

Water Quality in Haor Flash Flood Areas

- **Acute Contamination:** Flash floods severely impact drinking water, with a significant number of tube wells and sanitation facilities submerged, leading to an acute crisis of safe water and outbreaks of waterborne diseases like diarrhea.
- **Fish Mortality:** The sudden influx of floodwater often reduces the quality of water, causing high mortality rates among fish stocks, with reports indicating massive losses in fish, such as the 49.75 MT loss in 2017.
- **pH Levels:** Studies in areas like Hakaluki Haor show water has a tendency to become alkaline, with pH levels ranging from 7.60 in the wet season to 8.79 in the dry season.
- **Sedimentation and Pollution:** The floods carry heavy loads of sediments, including sand, gravel, and pollutants like coal and limestone, which reduce the water-carrying capacity of rivers, increase sedimentation, and cause acidification.
- **Waterlogging:** In the post-flood period, waterlogging is a common issue that keeps the water stagnant and degraded for longer periods, often causing rotten smell due to decaying crops.

Air Quality in Haor Flash Flood Areas

- **Seasonal Variations:** Air quality varies by season. While the monsoon brings cleaner air due to heavy rain and wind, the pre-monsoon and post-monsoon periods can have higher pollutants, especially in areas with high traffic.
- **Impact of Flood Management:** The destruction of standing crops and the decay of vegetation during floods can cause localized air quality issues, though not as severe as the industrial pollution in other parts of Bangladesh.
- **Humidity and Odor:** High humidity and stagnant water often lead to poor air quality, with strong odors from decomposing vegetation and submerged agricultural waste.

Environmental and Socio-Economic Impact

- **Damaged Infrastructure:** The flash floods destroy infrastructure, with 2024 seeing 6,542 km of roads and 1,066 bridges/culverts damaged.

- **Agricultural Impact:** 2017 saw over 149,000 hectares of Boro rice fields affected by early flash floods in Sunamganj alone.
- **Ecological Crisis:** The Haor basin is sinking by 4mm to 2.1cm annually, which makes it more vulnerable to extensive flooding and ecological imbalance, causing long-term damage to the unique wetland ecosystem.

4.1.9 Sound level of 42 project districts

(I) Sound level of coastal region (17 districts)

Sound levels in the coastal region of Bangladesh frequently exceed national standards, with urban coastal areas like Barisal, Bagerhat, and Cox's Bazar experiencing high noise pollution, often ranging between 70 dBA and over 100 dBA. High traffic density, hydraulic horns, and rapid urbanization are major contributors, with peak noise levels often exceeding 100 dBA.

Key noise level findings in coastal regions include:

- **Barisal City:** Noise levels are severe, ranging from 67.8 dBA in residential areas to 86.5 dBA in commercial zones (Nathullabad), and exceeding 100 dBA near, for example, the Bus Terminal (106.82 dBA).
- **Cox's Bazar:** Due to high tourism traffic, peak noise levels can reach up to 125.80 dBA, with minimums around 49.90 dBA in off-peak hours.
- **Bagerhat Sadar:** Noise levels in bus stands and busy areas range from 50 dB to 99.8 dB.
- **Patuakhali Municipality:** Rapid infrastructure development has caused elevated noise levels, particularly affecting residential and commercial zones.

These elevated noise levels often surpass the World Health Organization permissible limit of 55 decibels.

(II) Sound level of Barind drought prone areas (16 districts)

Based on studies of noise pollution in the northwestern region of Bangladesh, specifically Naogaon and Rajshahi within the Barind Tract, sound levels frequently exceed national standards. While the area is rural, sound levels in mixed (residential/commercial) areas during the day often range above 60-85 dB, significantly higher than the standard.

Key Findings on Sound Levels in the Barind Region:

- **Mixed Areas (Residential/Commercial):** In Naogaon Sadar, noise levels in mixed-use zones have been recorded at 85 dB, which is far above the permissible limit.
- **Silent Areas (Schools/Hospitals):** In these designated zones, where the standard is 45 dB, recorded levels have reached as high as 83.3 dB.
- **Source of Noise:** Noise in these areas is largely driven by traffic (three-wheeled autorickshaws and motorcycles) and, during irrigation seasons, the operation of deep tube wells.
- **Urban/Peri-urban Centers:** In urbanized parts of the Barind tract (like Rajshahi), noise levels on main roads can range from 70–76 dBA or higher, with some areas exceeding 100 dBA due to traffic density.

Factors Affecting Sound Levels:

- **Irrigation Infrastructure:** The Barind region has heavy reliance on groundwater extraction through deep tube wells, and the operation of pumps contributes to localized noise pollution.
- **Traffic:** Similar to other regions in Bangladesh, motorized vehicles, especially in peri-urban areas, are the primary contributors to high noise levels.
- **Seasonality:** While the area is rural, high-intensity agriculture (Boro rice) and transportation during peak seasons lead to elevated noise levels.

The noise pollution in these areas is considered to be in a "dangerous" state in several zones, posing health risks such as stress and, in extreme cases, hearing impairment.

(III) Sound Level of Haor Flash Flood Area (9 districts)

Based on environmental studies in Bangladesh and general characteristics of flood events, the sound level in the Haor flash flood areas (such as Sunamganj and Sylhet) during a peak event is high, likely exceeding rural ambient levels and reaching moderate noise pollution levels.

- **Estimated Sound Level:** While specific, comprehensive acoustic mapping during a flash flood event is scarce, the sound of heavy rainfall, combined with the rapid, high-velocity flow of water, often results in a "roaring sound". Heavy rainfall alone (50 dB) and turbulent water, often accompanied by strong winds in these areas, suggests noise levels in flooded areas frequently range from **60 to over 80 dB(A)**.
- **Contributing Factors:**
 - **Heavy Rainfall & Wind:** Pre-monsoon and monsoon rains in the northeastern region can reach 3,000–4,000 mm, and 3-meter high waves have been reported in the Haors, which generate significant noise.
 - **High-Velocity Flow:** Flash floods in the Haor basin are characterized by rapid onrush of water from the upstream Meghalaya hills, creating high-intensity, turbulent sound.
 - **Structural Damage/Activity:** The sound of debris, damaged homes, and intensive human activity/emergency measures in the area can further elevate sound levels.
- **Comparison to Baseline:** The typical ambient noise level in a quiet rural village area in Bangladesh is generally lower, around 67 dB(A), meaning a flash flood significantly increases the noise pollution level in these, usually tranquil, wetland ecosystems.

These conditions make the sound level hazardous to long-term hearing if exposed continuously, similar to the noise pollution levels (above 70-80 dB) reported in urban and busy parts of the surrounding Sylhet region.

4.1.10 Sources of Existing Pollutions of 42 Districts

(I) Sources of Existing Pollutions of Coastal Region (17 districts)

The project coastal districts of Bangladesh, covering 17 districts (including Satkhira, Khulna, Bagerhat, Pirozpur, Barguna, Patuakhali, Bhola, Chittagong, Cox's Bazar, etc.), face significant pollution, with major sources identified as industrial, agricultural, and urban-based. Under frameworks such as the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), key sources of existing pollution include:

1. Industrial Effluents (Land-based)

- **Textile and Dyeing:** A major contributor discharging 12.7–13.5 million m³ of waste water annually, polluting 20% of fresh water.
- **Tannery Waste:** Discharge of approximately 0.15 million tons/day of crude waste from leather industries directly into rivers.
- **Ship Breaking Yards:** Located in Chittagong (Sitakunda), these dump around 22.5 tons of polychlorinated biphenyls (PCBs) annually.
- **Other Industries:** Fertilizer, cement, pulp and paper, food processing, pharmaceuticals, and metal plants discharge heavy metals (Cd, Cr, Pb, Ni, As).
- **Heavy Metal Accumulation:** High concentrations of heavy metals are found in marine fish and sediment due to untreated effluents.

2. Sea-Based and Port Activity Pollution

- **Oil Spills:** Over 2,500 tons of operational oil spills occur annually from ships, mechanized vessels, and refinery handling losses in the Bay of Bengal and coastal waters.
- **Port Activity:** Chittagong Port and Mongla Port act as major pollution hotspots due to bilge water, sewage, and cargo-related waste dumping.
- **Destructive Fishing:** Use of motorized trawlers causes oil spills, and discarded nets (ghost fishing) destroy marine ecosystems.

3. Agriculture and Aquaculture Runoff

- **Shrimp Cultivation:** Predominant in coastal areas, aquaculture leads to eutrophication from excessive feeding and nutrient loading.
- **Agrochemical Runoff:** Fertilizer (N, P, K) and pesticide residues are washed into the Bay of Bengal, with roughly 25% of pesticide residues reaching the coast.

4. Solid Waste and Urban Sewage

- **Plastic Waste:** Approximately 3,000 tons/day of plastic waste are generated, with a significant portion entering the marine environment.
- **Urban/Domestic Sewage:** Inadequate sewage treatment in coastal towns and cities contributes to water contamination.

5. Environmental and Climate-Induced Pollution

- **Salinity Intrusion:** Climate change and reduced freshwater flow in the dry season have increased saltwater intrusion, affecting soil, agriculture, and drinking water sources.
- **Transboundary Pollution:** Wastes carried by major rivers (Ganges, Padma, Jamuna, Meghna) from neighboring countries.
- **Coastal Erosion:** Natural and man-made erosion affects habitats.

Pollution Hotspots (As identified in studies)

- **Chittagong and Cox's Bazar:** High contamination from industrial waste, ship-breaking, and port traffic.
- **Khulna and Satkhira:** Heavily affected by shrimp farming, salinity intrusion, and industrial activities.
- **Bhairab River/Noapara:** High industrial effluent impact.

(II) Sources of Existing Pollutions of Barind Drought Prone Areas (16 districts)

Existing pollution in the Barind drought-prone areas of Bangladesh—particularly in Rajshahi, Chapainawabganj, and Naogaon districts, which are central to the Climate and Disaster Resilient Small-scale Water Resources Management Project (CDRSSWRMP) area—stems from a combination of intensive agricultural practices, industrial waste, and environmental degradation.

Key sources of pollution and environmental degradation include:

- **Agricultural Runoff (Fertilizers and Pesticides):** Intensive farming, particularly the cultivation of water-intensive Boro rice, relies heavily on chemical fertilizers and pesticides. These pollutants wash into local water bodies (such as the Barnoi River) or leach into the shallow aquifers, causing chemical contamination.
- **Declining Groundwater Levels and Quality:** Over-extraction of groundwater via deep tube wells for irrigation, in conjunction with low recharge rates (due to clayey soil and low rainfall), leads to both acute water scarcity and degradation of water quality.
- **Arsenic Contamination:** Like many parts of Bangladesh, groundwater in the region often contains elevated levels of arsenic and other toxic trace metals, which pose severe risks to drinking water supplies.
- **Environmental Degradation and Dust Syndrome:** The drying up of surface water bodies and topsoil, particularly during the prolonged dry season (Falgun and Chaitra), leads to dust pollution, sometimes known as "dust syndrome".

The CDRSSWRMP seeks to address some of these issues by implementing stakeholder-driven, small-scale water resources management to reduce reliance on groundwater and enhance water quality.

(III) Sources of Existing Pollutions of Haor Flash Flood Area (9 districts)

The haor flash flood areas in northeastern Bangladesh (primarily covering Sylhet, Sunamganj, Habiganj, Moulvibazar, Netrokona, and Kishoreganj) face severe, recurring pollution, exacerbated by the rapid, heavy inflow of water from the Meghalaya hills in India.

The main sources of existing pollution in the haor regions are categorized into agricultural, industrial, domestic, and natural/geographical factors:

1. Agricultural Pollution (High-Intensity Fertilizer/Pesticide Runoff)

- **Agrochemical Runoff:** The, intensive use of chemical fertilizers (urea, TSP, MP) and pesticides (used by over 35% of farmers in some areas) on Boro rice fields causes significant pollution. During flash floods, these chemicals are washed directly into the water, degrading water quality.
- **Pesticide Residues:** Pesticides specifically applied to protect early-stage crops are flushed into the wetlands, destroying fish habitats.

2. Anthropogenic and Domestic Pollution

- **Unregulated Tourism:** In hotspots like Tanguar Haor, waste from houseboats, plastics, and sewage from unregulated tourism are major contributors to water pollution.
- **Dead Carcasses:** In the aftermath of sudden flash floods, massive amounts of rotten fish and other aquatic species, along with rotting rice stalks (rotten paddy), pollute the stagnant water.

3. Structural and Developmental Factors

- **Deforestation and Land Use Change:** The clearing of swamp forests (e.g., Hijal, Karos) and filling of canals for human settlement reduce the natural filtering capacity of the ecosystem.
- **Unplanned Embankments and Infrastructure:** Mismanagement of embankments and road construction often blocks natural flow, leading to increased water contamination and decreased water quality.

4. Contaminants Found in Water

- **Heavy Metals:** Recent studies found alarming levels of toxic heavy metals, including Lead (Pb), Nickel (Ni), Copper (Cu), and Chromium (Cr) in Tanguar Haor sediments, exceeding safe limits for aquatic life.
- **Pathogens:** The water is heavily contaminated with microbial pathogens due to flooded toilets and livestock manure, causing high rates of diarrhea and respiratory infections among inhabitants.

The combination of flash floods, which act as a carrier of pollutants, and the low-lying, enclosed nature of the haors makes this ecosystem extremely vulnerable to these pollutant sources.

4.2 Biological Environment

The biological environment, or biotic environment, refers to the sum of all living organisms—plants, animals, fungi, and microorganisms and their complex interactions within a specific habitat. It includes, and is defined by, the relationships between species, such as food webs, predation, and symbiosis, as well as their interactions with non-living (abiotic) components like sunlight and water.

4.2.1 Ecology (flora, fauna, terrestrial habitat, marine/aquatic habitat)

(I) Ecology of Coastal Region (17 districts)

The coastal region of Bangladesh, spanning 17 project districts (including Satkhira, Khulna, Bagerhat, Bhola, and Cox's Bazar), is a highly dynamic ecosystem, 32% of the country's land area, defined by mangroves, wetlands, and tidal rivers. It is severely impacted by climate change, experiencing salinity intrusion, sea-level rise, and cyclones, which threaten biodiversity, agriculture, and livelihoods.

Key Ecological and Environmental Characteristics

- **Unique Ecosystems:** The region includes the Sundarbans (mangrove forest), extensive intertidal mudflats, and tidal wetlands, which act as natural protective buffers.
- **Hydrological Dynamics:** Characterized by high water discharge, a vast network of rivers, and intense tidal surges, particularly in the central coastal region.
- **Environmental Stressors:** High salinity intrusion, sea-level rise (SLR), and frequent cyclones are major threats to the natural balance.
- **Biodiversity Hotspot:** The coastal waters house the Swatch of No Ground (a marine protected area), home to endangered marine species, including dolphins, turtles, and varied estuarine fish.

CDRSSWRMP Context

The project, aimed at improving agricultural production, focuses on mitigating the ecological risks to livelihoods:

- **Addressing Degradation:** Tackling the decline of natural resources and biodiversity caused by climate impacts and land-use changes.
- **Resilient Infrastructure:** Implementing water management infrastructure that is resilient to climate change, reducing damage to coastal habitats.
- **Sustainable Livelihoods:** Promoting practices like crab farming in 6, climate-vulnerable coastal districts, which are more suitable to high-salinity conditions than traditional rice farming, thereby supporting biodiversity-conscious economic activity.
- **Protection Measures:** In some areas, building, repairing, and protecting coastal ecosystems and agricultural land from flooding and erosion.

The coastal zone's ecological health is heavily influenced by the interaction between the land and the Bay of Bengal, requiring integrated, resilient management to protect its vulnerable environment and inhabitants.

(II) Ecology of Barind Drought Prone Areas (16 districts)

The Barind Tract in northwestern Bangladesh (Rajshahi, Naogaon, Chapainawabganj) is a drought-prone, high-terraced agro-ecological zone (AEZ-13) characterized by low rainfall, high evapotranspiration, and rapid groundwater depletion. It suffers from extreme climate variability, with severe Pre-Kharif/Rabi droughts impacting agricultural productivity and livelihoods.

Key Ecological Characteristics of the Barind Region

- **Climate & Geography:** The region experiences a subtropical monsoon climate but is often drought-stricken due to low precipitation, with up to 100% rainfall deficits in critical months (June–October). It is a slightly elevated, clay-heavy, grey terrace soil area.

- **Hydrology & Soil:** Groundwater levels are under immense pressure due to high extraction rates for irrigation. Soil moisture is scarce in the dry season, making it difficult to grow crops without sustainable water management.
- **Agricultural Impact:** The region faces low productivity, with agriculture heavily affected by dry spells. The ecology is undergoing a shift from traditional rain-fed systems to irrigated farming, which is not sustainable without interventions like those proposed by ADB.
- **Project Context (CDRSSWRMP):** The Climate and Disaster Resilient Small-scale Water Resources Management Project (CDRSSWRMP) focus on strengthening Local Government Engineering Department's (LGED) capacity, enhancing sustainable water management, and improving agricultural production.

Districts & Hotspots

- **Key Districts:** Primarily includes Rajshahi, Naogaon, and Chapainawabganj.
- **Hotspot Focus:** As identified by the Bangladesh Delta Plan 2100 (BDP2100), this area is categorized as a high-vulnerability "Barind and Drought Prone Area".

The ecology of the area necessitates drought-resilient agricultural practices and improved water management to combat the effects of climate change and sustain local communities.

(III) Ecology of Haor Flash Flood Area (9 districts)

The Haor flash flood areas, primarily addressed under initiatives like the Climate and Disaster Resilient Small-Scale Water Resources Management Project, are 9 north-eastern districts of Bangladesh, including **Sunamganj, Sylhet, Habiganj, Maulvibazar, Netrokona, Kishoreganj, and Brahmanbaria**. The ecology of these regions is characterized by a unique, bowl-shaped wetland ecosystem, known for extreme vulnerability to early, rapid, and destructive flash floods in March and April.

Key Ecological Characteristics & Flash Flood Impact

- **Hydro-ecological Structure:** The region consists of 373 major haors (wetlands) and countless *Beels* (permanent/seasonal lakes). During the monsoon, the area transforms into a vast, inland sea, where villages (*hatis*) appear as tiny, isolated islands.
- **Flash Flood Dynamics:** Unlike main-river floods, these are flash floods from Indian hilly areas that cause a rapid rise in water level, often bringing coarse sediment that damages boro rice crops and fish stocks just before harvest.
- **Unique Biodiversity:** The region is known for its aquatic biodiversity and as a sanctuary for migratory birds. Native, flood-tolerant swamp forest species like *Hijol* (*Barringtonia acutangula*) and *Koroch* (*Pongamia pinnata*) are crucial to this ecosystem.
- **Soil and Land Conditions:** The soils are predominantly acidic clay in basins (pH 3.4–3.6 in some areas), with peat soils found in deeper basins. The region faces severe phosphorus and zinc deficiencies.
- **Ecological Degradation & Threats:** Human activities like rapid siltation, unplanned infrastructure, narrowing of rivers, and excessive sand extraction have intensified the damage.

- **Adaptation Efforts (CDRSSWRMP/Similar Initiatives):** Strategies focus on ecological restoration, such as using vetiver grass and local tree species (e.g., hijal, koroch) as bio-revetments to protect villages and riverbanks, in addition to creating artificial, raised homesteads (*hatis*) to withstand increased flood depth.

Regional Variations

- **Piedmont Zone (Sylhet/Moulvibazar):** Higher elevation with rapid siltation from hilly rivers.
- **Flood Plain Zone (Netrokona/Kishoreganj/Brahmanbaria):** Gentle slopes with moderate sedimentation.
- **Deeply Flooded Zone (Sunamganj/Habiganj):** Deepest parts with extensive seasonal flooding.

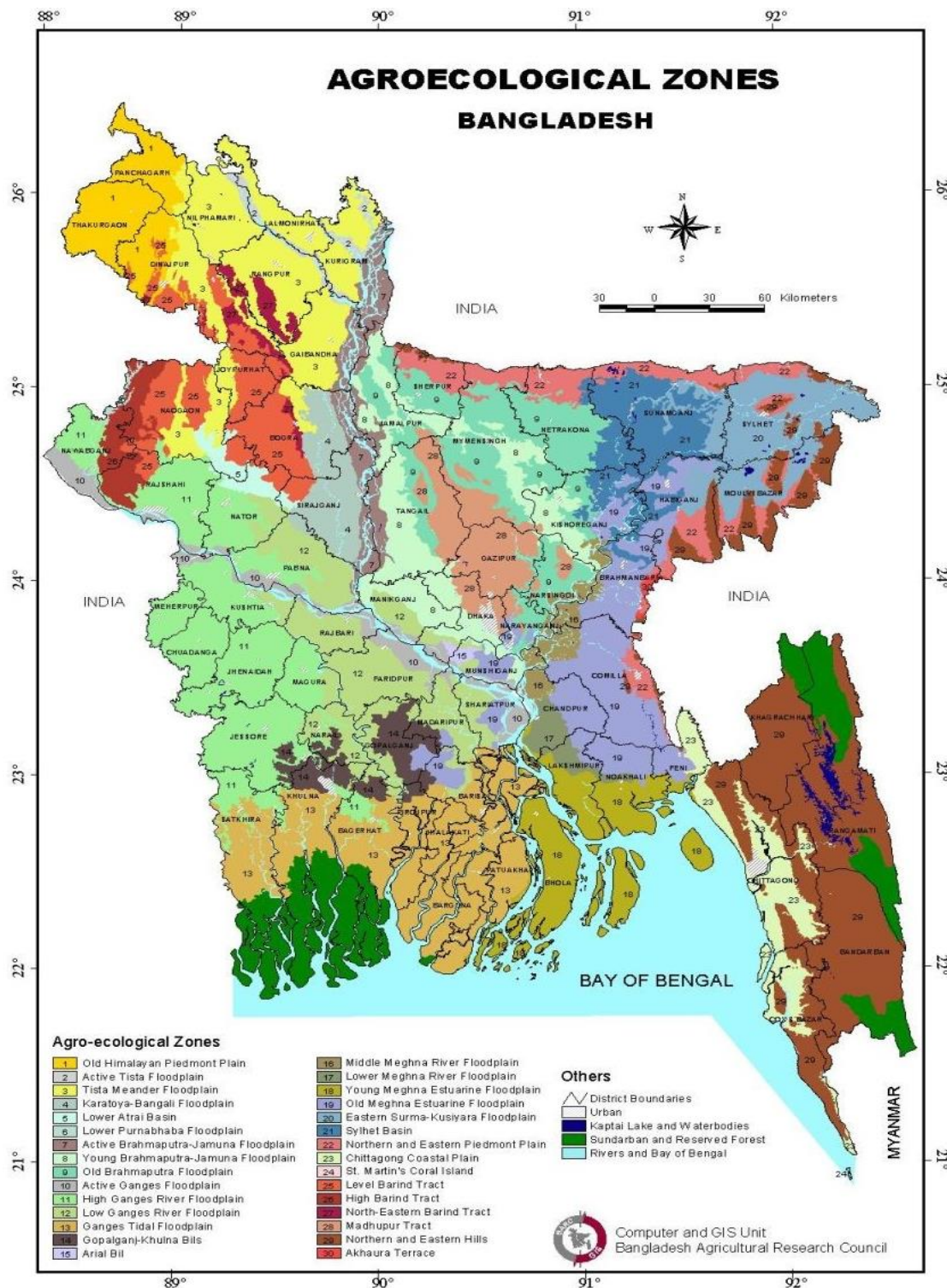
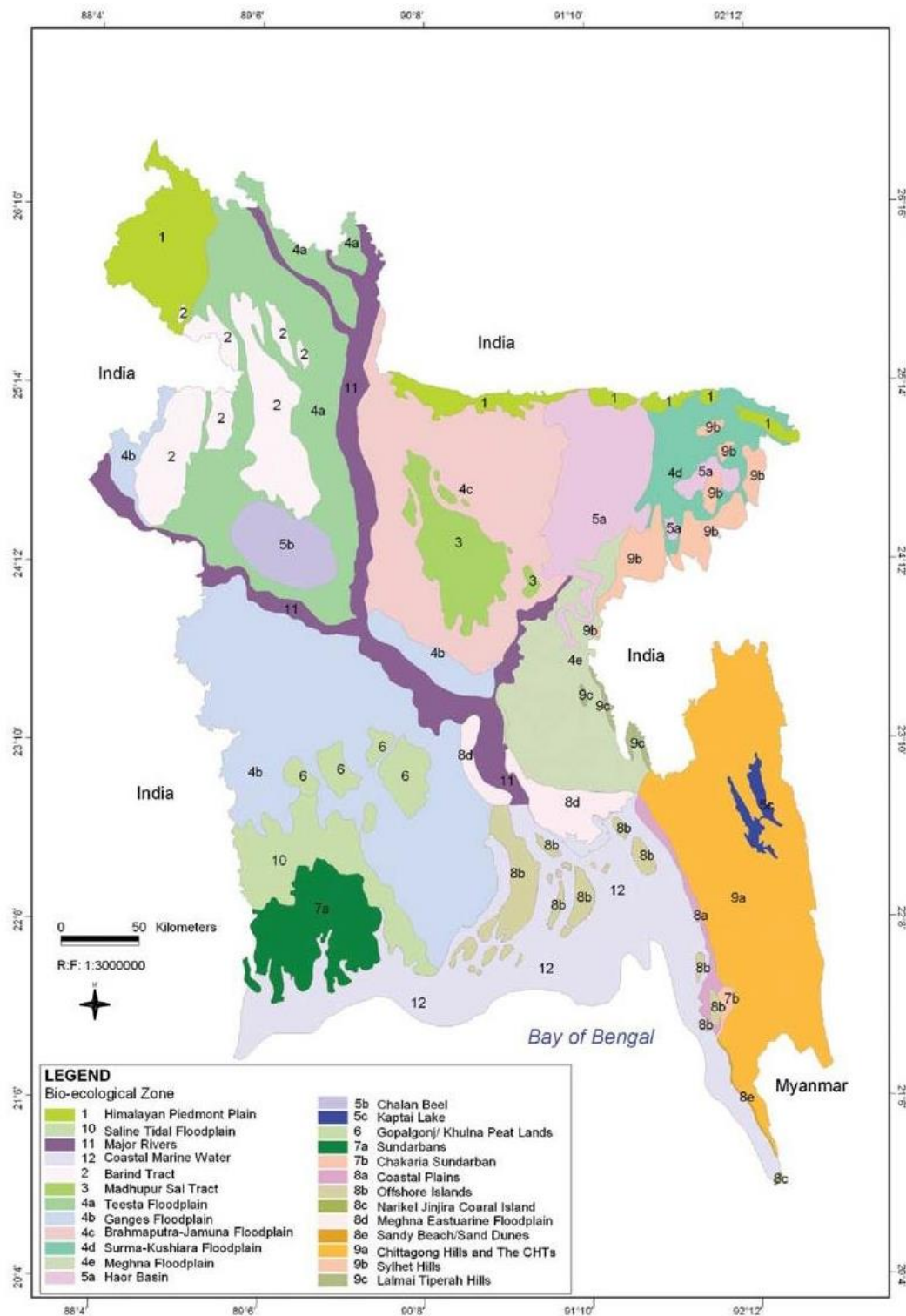


Figure 8: Agroecological Zones of Bangladesh



https://www.researchgate.net/figure/Bio-ecological-Zones-of-Bangladesh-SourceIUCN-2002_fig5_327691767

Figure 9: Bio-ecological Zoning Map of Bangladesh

4.2.2 Water Land

(I) Water Land of Coastal Region of Bangladesh (17 districts)

The CDRSSWRMP, led by LGED, focuses on improving, managing, and developing small-scale water resources across approximately 86,000 hectares of land in 17 coastal districts. The project covers coastal saline-prone zones including Satkhira, Khulna, Bagerhat, Barisal, Patuakhali, Bhola, Noakhali, and Chittagong, among others, to enhance irrigation, fisheries, and sustainable water infrastructure.

Water Resource Management Aspects:

- **Target:** Improving small-scale water resources, including canals and streams in the western region and managing coastal land erosion in the central region.
- **Infrastructure:** Building climate-resilient, beneficiary-managed infrastructure for 86,000 hectares to boost agriculture and fisheries, enhancing livelihoods against saline intrusion.
- **Components:** Establishing Water Management Cooperative Associations (WMCA) to manage water resources for sustainable development.

Key aspects of the existing water land and management under CDRSSWRMP include:

- **Targeted Regions:** The 17 coastal districts, covering roughly 20% of the country's land and 30% of cultivable land.
- **Water Resources:** Focuses on small-scale water bodies, including existing ponds, canals, and Khals, for enhancement.
- **Infrastructure Improvement:** Development of water management systems to mitigate salinity and enhance agricultural production (e.g., pond-based ultra-filtration).
- **Management Structure:** Establishment of 150 new Water Management Cooperative Associations (WMCAs) to manage these water resources.
- **Focus Areas:** Involves improving water capacity for fisheries, irrigation, and safe water supply in climate-vulnerable zones.

The project aims to improve climate-vulnerable communities by managing the diverse ecosystems and to improve agricultural productivity, aquaculture and reduce climate change risks for coastal communities particularly in the 17 coastal districts.

(II) Water land of Barind Drought Prone Areas (16 districts)

The Barind Tract in northwestern Bangladesh is a severely drought-prone, semi-arid region covering parts of Rajshahi, Rangpur, and Bogra, defined by low rainfall (approx. 1,100–1,400 mm annually). Clayey soil with low porosity and intensive groundwater irrigation for rice have led to falling water tables, creating critical water scarcity for both agriculture and consumption.

Key Aspects of the Barind Tract:

- **Location:** Covers parts of greater Rajshahi, Rangpur, Dinajpur, Bogra, Naogaon, and Joypurhat.
- **Water Crisis:** Groundwater levels have dropped by over 20 meters in some areas. The region faces high evaporation and slow groundwater recharge due to soil characteristics.

- **Drought & Climate:** It is the hottest and driest zone in Bangladesh. Climate change has intensified these conditions, with droughts affecting agriculture and leading to potential water emergencies.
- **Water Management:** The Barind Multipurpose Development Authority (BMDA) manages irrigation, relying heavily on deep tube wells. Recent efforts focus on re-excavating ponds and canals to conserve surface water.
- **Impact on Life:** The water scarcity has led to severe consequences, including reduced crop yields and increased poverty, with women in particular bearing the burden of collecting water from distant sources.

To mitigate these challenges, initiatives are focusing on switching to surface water, improving water-use efficiency, and promoting drought-resilient crops.

(III) Water Land of Haor Flash Flood Area (9 districts)

The Haor basin in northeastern Bangladesh, covering districts like Sunamganj and Sylhet, is a vast, bowl-shaped wetland that experiences annual, severe flash floods, primarily between April and June. Triggered by heavy rainfall in neighboring Indian hills, these floods submerge the region for up to six months, destroying Boro rice crops, threatening livelihoods, and isolating communities.

Key Aspects of the Haor Flash Flood Region:

- **Location & Geography:** Situated in the northeastern districts of Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrakona, and Kishoreganj. It is characterized by low-lying, swampy land surrounded by hills.
- **Flash Flood Timing & Impact:** These floods are "flashy" and often occur early in the season, causing immense damage to the standing Boro rice crop—the primary livelihood for residents. The 2017 flood, for instance, caused massive damage to over 149,000 hectares of cropland.
- **Water Cycle:** During the dry season (winter), the area is a vast, dry agricultural plain. In the monsoon, it turns into a sea-like landscape, with only villages (hilly spots) remaining above water.
- **Vulnerability:** The region is highly susceptible to climate change, leading to increased frequency and intensity of floods. Inhabitants face high risks to food security, health, and housing.
- **Key Areas:** Tanguar Haor is one of the most prominent, significant wetland areas in this region.

Common Livelihood & Adaptation Strategies:

- **Agriculture & Fishing:** Inhabitants rely heavily on Boro rice in the dry season and fishing during the monsoon.
- **Adaptation Efforts:** Key strategies include cultivating early-maturing rice varieties, strengthening embankments, and improving early warning systems.

4.2.3 Endemic/threatened/endangered species

(I) Endemic/Threatened/Endangered Species of Coastal Region (17 districts)

The coastal region of Bangladesh, including the Sundarbans and Bay of Bengal, hosts critically endangered species like the Spoon-billed Sandpiper, Northern River Terrapin, and Ganges River Dolphin. Other threatened fauna includes the Bengal Tiger, Masked Finfoot, various sharks/rays, and marine turtles. Key habitats are under threat from pollution, climate change, and habitat destruction.

Critically Endangered (CR) & Endangered (EN) Species

- **Birds:** Spoon-billed Sandpiper (CR- ~10% of global population in coastal Bangladesh), Indian Skimmer (VU/EN - ~50% of global population), Spotted Greenshank (EN), Great Knot (EN), Masked Finfoot.
- **Reptiles:** Northern River Terrapin (CR - *Batagur baska*), Saltwater Crocodile (EN), marine turtles (e.g., Olive Ridley, Green Turtle).
- **Mammals:** Bengal Tiger (EN - Sundarbans), Ganges River Dolphin (EN), Irrawaddy Dolphin (VU), Indo-Pacific Finless Porpoise.
- **Fish:** Multiple species of sharks, rays, guitarfish, and sawfish (many EN/CR).

Threatened Habitats & Conservation Issues

- **Sundarbans Mangrove:** The world's largest mangrove forest, crucial for the Bengal tiger and other wildlife.
- **Threats:** Habitat loss, illegal trade, pollution, fishing nets, and climate-induced sea-level rise.
- **Impact:** Over 300 marine species, including corals and crustaceans, are affected by coastal deterioration.

(II) Endemic/Threatened/Endangered Species of Barind Drought Prone Areas (16 districts)

The Barind Tract in northwestern Bangladesh (encompassing parts of Rajshahi, Dinajpur, Rangpur, Bogra, Joypurhat, and Naogaon) is a Pleistocene terrace characterized by low rainfall and high drought risk. This region faces severe water stress, with groundwater levels dropping significantly, making local biodiversity vulnerable.

While the Barind is heavily cultivated, its specific ecological conditions have made certain species, particularly medicinal plants and wetland hydrophytes, threatened or rare.

Threatened/Endangered Flora (Medicinal & Others)

A study on the ethno-medicinal plants in the Barind Tract identified several species as threatened due to habitat destruction:

- **Medicinal Plants:** Various species used by local Kavirajs (village doctors) have become scarce, although the search results do not explicitly name all the species from that specific study.
- **Dwarf date palm (*Phoenix acaulis*):** Listed as a critically endangered plant in Bangladesh, which is suited for drier, open, or degraded areas.

- **Invasive species (threat to natives):** The ecological balance is threatened by invasive species like *Assamgach* (*Chromolaena odorata*), *Assamlota* (*Mikania scandens*), and *Lantana* (*Lantana camara*).

Threatened/Endangered Fauna & Aquatic Species

- **Fish Species:** The Barind area, specifically through its re-excavated ponds, Dighis, and Kharies (small canals), has seen changes in aquatic biodiversity. Studies on hydrophytes (water plants) and aquatic ecosystems in the region have highlighted the need for conservation.
- **Birds:** Formerly found in various parts of Bangladesh, species such as the Bengal Florican (*Eupodotis bengalensis*) and White-rumped Vulture (*Gyps bengalensis*) have seen severe population declines due to habitat loss and environmental degradation.
- **Wetland species:** The reduction of surface water in the Barind ("drought-prone") has threatened amphibians and small aquatic reptiles, although specific "endemic" species names for the Barind are sparse in the provided results.

Key Drivers of Biodiversity Loss

- **Groundwater depletion:** Water levels have dropped over 20 meters in some parts of the Barind, killing native aquatic vegetation and reducing habitat for aquatic life.
- **Agriculture:** Intense, double- or triple-cropping practices have replaced native vegetation.
- **Deforestation:** The high Barind was historically forested but has been largely converted.

The Bangladesh Forest Department is actively working on cultivating critically endangered species like *Phoenix acaulis* to increase their population in suitable habitats.

(III) Endemic/Threatened/Endangered Species of Haor Flash Flood Area (9 districts)

The Haor flash flood areas of Bangladesh (primarily in the Sylhet and Mymensingh regions, including Tanguar and Hakaluki Haors) are rich in biodiversity but face significant threats due to climate change, overfishing, and habitat destruction. Over 50 freshwater fish species in this region are currently considered threatened, with many endemic species facing extinction.

Here is the key threatened and endangered species in the Haor areas:

Critically Endangered (CR) and Endangered (EN) Fish Species:

Many indigenous fish species, specifically from the Cypriniformes and Siluriformes orders, have become rare or nearly extinct:

- Mohashol (*Tor tor*) - Critically Endangered.
- Bhangon Bata (*Labeo ariza*) - Endangered.
- Nandi (*Nandus nandus*) - Endangered.
- Goalpara Puia (*Lepidocephalichthys annandalei*) - Endangered.
- Pipla Shol/Tila Shol (*Channa orientalis*) - Endangered.

- Kala Pabda (*Ompok pabo*) - Endangered.
- Baghair (*Bagarius bagarius*) - Endangered.
- Chenua (*Channa marulius*) - Endangered.
- Gang Magur (*Plotosus canius*) - Endangered.
- Tara Baim/Gutum (*Macrognathus aral* / *Lepidocephalichthys annandalei*).

Endemic Species of the Haor Basin:

At least 16 species, endemic to the region have been identified, particularly within the Cyprinidae family:

- Endemic Cyprinidae: *Labeo ariza*, *Aspidoparia morar*, *Barilius tileo*, *Barilius bendelisis*, *Barilius barila*, *Barilius vagra*, *Barilius dogarsinghi*.
- Endemic Balitoridae/Sisoridae: *Schistura sikmaiensis*, *Syncrossus hymenophysa*, *Gogangra viridescens*, *Gagata sexualis*.

Threatened Aquatic Flora and Fauna:

- Migratory Birds: Tanguar Haor serves as a crucial habitat for endangered migratory birds such as the Pallas's Fish-eagle (*Haliaeetus leucoryphus*) and Baer's Pochard.
- Swamp Forest Vegetation: Key threatened wetland tree species include Hijal (*Barringtonia acutangula*), Karach (*Pongamia pinnata*), Gulli, Balua, and Ban Tulsi.
- Reptiles/Mammals: The Asian small-clawed otter and various freshwater turtles are increasingly threatened.

Major Drivers of Biodiversity Loss:

- Overfishing: The use of illegal, fine-mesh, and destructive fishing gear.
- Dewatering: Draining Beels (wetland basins) for fishing destroys brood fish and juvenile stocks.
- Climate Change: Flash floods, erratic rainfall, and increased drought periods.
- Siltation: Infilling of water bodies due to deforestation in upstream hills.

Table 15: Extinct Mammalian Species of Bangladesh, 2015

Sl. No.	Scientific Name	Local Name	Place of occurrence	Tentatively lost since
1	<i>Hyaena hyaena</i>	Striped Hyena	Northwestern part of the country	20 th Century
2	<i>Canis lupus</i>	Grey Wolf	In all abundant tree covered areas	Mid-20 th Century
3	<i>Boselaphus tragocamelus</i>	Nilgal	Dinajpur, Rangpur, Forests.	1930s
4	<i>Bos javanicus</i>	Banteng	Chittangong & CHT	1940s
5	<i>Bubalus amee</i>	Wild Buffalo	Chittangong & CHT	1940s

Sl. No.	Scientific Name	Local Name	Place of occurrence	Tentatively lost since
6	<i>Dicerorhinus sumatrensis</i>	Sumatran Rhinoceros	North of existing Sundarbans	1930s
7	<i>Rhinoceros sondaicus</i>	Javan Rhinoceros	North of existing Sundarbans	1930s
8	<i>Rhinoceros unicornis</i>	Indian Rhinoceros	North of existing Sundarbans	1930s
9	<i>Rucervus duvaucelii</i>	Swamp Deer	Sundarbans	1950s
10	<i>Antelope cervicapra</i>	Blackbuck	Northern region	End of 19 th Century
11	<i>Melursus ursinus</i>	Sloth Bear	Chittagong Hill Tracts	Beginning of 21 th Century

Table 16: Extinct Wildlife Species of Bangladesh (IUCN, 2015)

Sl. No.	Class	Bangla Name	English Name	Scientific Name
1	Reptilia	Mitha Panir Kumir	Marsh Crocodile	<i>Crocodylus palustris</i>
2	Aves (Bird)	Moyur	Indian Peafowl	<i>Paro cristatus</i>
3	Aves (Bird)	Sobuj Moyur	Green Peafowl	<i>Pavo muticus</i>
4	Aves (Bird)	Golapi Shir Hans	Pink-headed Duck	<i>Rhodonessa caryophyllacea</i>
5	Aves (Bird)	Badi Hans	White-winged Duck	<i>Asarcornis scutulata</i>
6	Aves (Bird)	Saros	Sarus Crane	<i>Antigone antigone</i>
7	Aves (Bird)	Raj Shokun	King Vulture	<i>Sarcogyps calvus</i>
8	Aves (Bird)	Ispotbil Pelican	Spot-billed Pelican	<i>Pelicanus philippensis</i>
9	Aves (Bird)	Boro Madan Tak	Greater Adjutant	<i>Leptoptilos dubius</i>
10	Aves (Bird)	Bangla Florican	Greater Florican	<i>Houbaropsis bengalensis</i>
11	Aves (Bird)	Choto Florican	Lesser Florican	<i>Sypheotides indicus</i>
12	Aves (Bird)	Baro Tailed Tree Creeper	Bar-tailed Tree Creeper	<i>Certhia himalayana</i>
13	Aves (Bird)	Kalobuck Parrotbill	Black-breasted Parrotbill	<i>Paradoxornis flavirostris</i>
14	Aves (Bird)	Spot Breasted Parrotbill	Spot-breasted Parrotbill	<i>Paradoxornis guttaticollis</i>
15	Aves (Bird)	Boro Parrotbill	Greater Rufous-headed Parrotbill	<i>Paradoxornis ruficeps</i>
16	Aves (Bird)	Dhusor Titir	Grey Francolin	<i>Francolinus pondicerianus</i>
17	Aves (Bird)	Rasti fronted Barwing	Rufous-throated Barwing	<i>Actinodura egertoni</i>
18	Aves (Bird)	Rufous Throated Partridges	Rufous-throated Partridges	<i>Arborophila rufogularis</i>
19	Aves (Bird)	Swamp Titir	Swamp Francolin	<i>Francolinus gularis</i>
20	Aves (Bird)	Sada Bok	White-bellied Heron	<i>Ardea insignis</i>
21	Mammalia	Varotiyo Gondar	One-horned Rhinoceros	<i>Rhinoceros unicornis</i>
22	Mammalia	Sumatran Gondar	Sumatran Rhinoceros	<i>Rhinoceros sumatrensis</i>
23	Mammalia	Javan Gondar	Javan Rhinoceros	<i>Rhinoceros sondaicus</i>
24	Mammalia	Baroshingo	Swamp Deer	<i>Cervus duvauceli</i>
25	Mammalia	Dagi Hyena	Striped Hyena	<i>Hyaena hyaena</i>
26	Mammalia	Banteng	Banteng	<i>Bos javanicus</i>

Sl. No.	Class	Bangla Name	English Name	Scientific Name
27	Mammalia	Krishna Shar	Black Buck	<i>Antelope cervicapra</i>
28	Mammalia	Dhusor Nekra Bagh	Grey Wolf	<i>Canis lupus</i>
29	Mammalia	Nil-gai	Blue Bull	<i>Boselaphus tragocamelus</i>
30	Mammalia	Shloth Valluk	Sloth Bear	<i>Melursus ursinus</i>
31	Mammalia	Buno Mohish	Wild Buffalo	<i>Bubalus arnee</i>

4.2.4 Nearest Conserved, Sensitive or Critical Habitat

(I) Nearest Conserved, Sensitive or Critical Habitat of Coastal Region (17 districts)

The CDRSSWRMP, implemented by the Local Government Engineering Department (LGED) with Asian Development Bank (ADB) and IFAD support, focuses on coastal embankments, polders, and water management in the coastal districts of Bangladesh.

The nearest conserved, sensitive, or critical habitats to these infrastructure interventions include:

1. Protected Areas and Wildlife Sanctuaries

- The Sundarbans: The largest mangrove forest in the world, consisting of East, West, and South Wildlife Sanctuaries (Bagerhat, Satkhira, and Khulna districts).
- Char Kukri-Mukri Wildlife Sanctuary: Located in Bhola district, critical for protecting mangrove ecosystems.
- Teknaf Wildlife Sanctuary: Located in Cox's Bazar district.
- Marine Protected Areas (MPAs):
 - Swatch of No Ground: Located near the southernmost point of the Sundarbans.
 - Nijhum Dwip: Located at the mouth of the Meghna Estuary (Hatiya, Noakhali).
 - St. Martin's Island: Designated to protect marine biodiversity and coral.
- Dolphin Sanctuaries: Pankhali, Shibsha, and Vadra dolphin sanctuaries (Khulna).

2. Ecologically Critical Areas (ECAs)

- Sundarbans Reserve Forest: A 10 km landward periphery, covering parts of Bagerhat, Khulna, Barguna, Pirojpur, and Satkhira.
- Cox's Bazar-Teknaf Peninsula: Ecologically sensitive coastal zone.
- Sonadia Island: Located in Moheshkhali, Cox's Bazar.

3. Key Coastal Habitats (Within Project Areas)

- Coastal Green Belt/Mangrove Afforestation: Plantations on the outer slopes of embankments, often targeted by LGED to protect against storm surges.

- Estuarine Ecosystems: The Meghna River estuary, particularly near Hatiya and Manpura islands, is a highly dynamic area and crucial habitat.

These habitats are crucial to the project's focus on nature-based solutions and coastal resilience.

(II) Nearest Conserved, Sensitive or Critical Habitat of Barind Drought Prone Areas (16 districts)

The Barind Tract, a drought-prone region in northwestern Bangladesh (covering parts of Rajshahi, Naogaon, Chapainawabganj, Dinajpur, Rangpur, and Bogra), is primarily characterized by dry, undulating terrain with low water retention. Due to its high vulnerability, conservation efforts are focused on local, decentralized ecological sites rather than large national parks.

Key conserved, sensitive, or critical habitats/sites in and around the Barind region include:

1. Significant Conserved Water Bodies (Wetlands)

Surface water conservation is critical to reducing pressure on falling groundwater levels.

- Beel Bhatia (Chapainawabganj): Located in Bholahat upazila, this is a vast wetland (approx. 6,388 acres) currently targeted for re-excavation and surface water management.
- Rohanpur Water Bodies (Chapainawabganj): A 4-5 km long water body in Gomastapur upazila being rehabilitated for ecological and irrigation purposes.
- Sonadighi and Dibor Dighi (Naogaon): These areas are being developed into eco-tourism destinations with environmental conservation, including bank protection and tree planting.
- Re-excavated Canals and Ponds: Over 3,098 ponds, 2,011 km of canals, and 413 dugwells have been re-excavated by the Barind Multipurpose Development Authority (BMDA) to store rainwater.
- Altadighi National Park (Naogaon): A major biodiversity conservation area located in Dhamoirhat, Naogaon, designated to protect the Altadighi water body and surrounding forest.

2. Sensitive Ecological Areas and Forests

- High Barind Tract (HBT) Protection Zones: Specifically in Nachole, Godagari, and Bholahat upazilas, these are identified as high-risk areas undergoing biodiversity conservation through the "Building Climate Resilient Livelihoods" (BCRL) project.
- Regenerating Sal Forest: Enrichment plantations are underway on 20 hectares of land to restore natural Sal (*Shorea robusta*) forests in the region.
- Char Land Plantations: The forest department has established plantations on chars (river islands) within the Ganges/Atrai river basins, covering roughly 100 hectares, serving as important biodiversity niches.

3. Key Ecological & Agricultural Biodiversity Areas

- **Homestead Vegetation Zones:** The indigenous fruit-based orchards and homestead gardens act as important biodiversity refuges, protecting local plant species, medicinal plants, and bamboos.
- **Riverine Corridors:** The banks of the Atrai, Mahananda, and Little Jamuna rivers are crucial, where rehabilitation of derelict canals is creating new wetlands.

4. Endangered Species Habitat Initiative

- **Arboretums and Herbal Orchards:** New projects include the establishment of two arboretums for rare and endangered tree species and the herbal orchard containing roughly 1,250 medicinal saplings to revive native flora in the arid landscape.

(III) **Nearest Conserved, Sensitive or Critical Habitat of Haor Flash Flood Area (9 districts)**

The nearest conserved, sensitive, or critical habitats within the flash flood-prone haor districts of Bangladesh (primarily Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, and Kishoreganj) are heavily influenced by the seasonal hydrology of the region and often serve as hotspots for biodiversity.

Key critical habitats in these areas include:

- **Tanguar Haor (Sunamganj):** Designated as a **Ramsar site** (wetland of international importance) and an **Ecologically Critical Area (ECA)**, this is the most prominent, permanently protected, and sensitive habitat in the flash flood zone.
- **Hakaluki Haor (Moulvibazar/Sylhet):** One of the largest freshwater wetlands in Asia, it is an Ecologically Critical Area (ECA) and a Ramsar site, crucial for migratory birds and fisheries.
- **Rema-Kalenga Wildlife Sanctuary (Habiganj):** A protected wildlife sanctuary located in the hilly region adjacent to the haor basin.
- **Hail Haor (Moulvibazar):** Recognized for its rich biodiversity and as a critical ecological spot near Sreemangal.
- **Other Important Haors:** These include Dekar, Pagnar, Sonir, and Matian haors in Sunamganj, which are vital for fish breeding and biodiversity, although they suffer from annual flash floods.

Contextual Factors:

- **CDRSSWRMP Target Area:** The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) work within 42 districts, including the haor and flash flood areas, focusing on climate-resilient agriculture, water management, and ecological management.
- **Flash Flood Impact:** These sensitive habitats are often inundated by early flash floods (April–May) from the Meghalaya hills, severely impacting agricultural cycles (Boro rice) and local livelihoods.
- **Key Affected Districts:** Sunamganj is considered the worst-affected in terms of flash floods, with many Haor areas, such as Shalla Upazila, turning into isolated islands during peak season.

Table 17: List of Protected Areas (51) of Bangladesh

SL No.	Protected Areas	Upazila	District
1	Altadighi National Park	Dhamoirhat	Naogaon
2	Bangabandhu Safari Park Cox Bazar	Chakaria	Cox's Bazar
3	Bangabandhu Safari Park Gazipur	Gazipur Sadar	Gazipur
4	Baroiyadhala National Park	Sitakunda	Chattogram
5	Barshijora Eco-Park	Moulvibazar Sadar	Moulvibazar
6	Bhawal National Park	Gazipur Sadar	Gazipur
7	Chadpai Wildlife Sanctuary	Mongla	Bagerhat
8	Char Kukri-Mukri Wildlife Sanctuary	Char Fasson	Bhola
9	Chunati Wildlife Sanctuary	Lohagara, Chakoria and Banshkali	Chattogram
10	Dhangmari Wildlife Sanctuary	Mollahat	Bagerhat
11	Dudhmukhi Wildlife Sanctuary	Sarankhola	Bagerhat
12	Dudpukuria-Dhopachari Wildlife Sanctuary	Rangunia	Chattogram
13	Fasiakhali Wildlife Sanctuary	Chakaria	Cox's Bazar
14	Hazarikhil Wildlife Sanctuary	Sitakunda	Chattogram
15	Himchari National Park	Cox's Bazar Sadar	Cox's Bazar
16	Inani National Park	Ukhia	Cox's Bazar
17	Kadigarh National Park	Bhaluka	Mymensingh
18	Kaptai National Park	Kaptai	Rangamati
19	Khadim Nagar National Park	Sylhet Sadar	Sylhet
20	Kuakata Eco- Park	Kalapara	Patuakhali
21	Lawachara National Park	Kamalganj	Moulvibazar
22	Madhupur National Park	Mathupur	Tangail
23	Madhutila Eco Park	Nalitabari	Sherpur
24	Aquatic Reserve	Hatiya, Rangabali	Bay of Bengal
25	Medhakachhapia National Park	Chakaria	Cox's Bazar
26	Mirpur Botanic Garden	Dhaka Mirpur	Dhaka
27	Nagarbari-Mohanganj Dolphin Sanctuary	Bera	Pabna
28	Nawabganj National Park	Nawabganj	Dinajpur
29	Nazirganj Dolphin Sanctuary	Sujanagar	Pabna
30	Nijhum Dweep National Park	Hatiya	Noakhali
31	Pablakhali Wildlife Sanctuary	Baghaichhari	Rangamati
32	Rajeshpur Eco-Park	Cumilla Sadar	Cumilla
33	Ramsagar National Park	Dinajpur Sadar	Dinajpur
34	Rema-Kalenga Wildlife Sanctuary	Chunarughat	Habiganj
35	Sangu Matamuhari	Thanchi	Bandarban
36	Satchari National Park	Chunarughat	Habiganj
37	Shilanda-Nagdemra Dolphin Sanctuary	Santhia	Pabna
38	Singra National Park	Birgonj	Dinajpur
39	Sitakunda Eco-Park	Sitakunda	Chattogram
40	Sonarchar Wildlife Sanctuary	Rangabali	Patuakhali
41	The Sundarbans	Several Upazila	Khulna
42	St. Martin's Island Aquatic Protected Area	Teknaf	Cox's Bazar
43	Sundarbans East Wildlife Sanctuary	Sharankhola	Bagerhat
44	Sundarbans South Wildlife Sanctuary	Dacope and Koyra	Khulna
45	Sundarbans West Wildlife Sanctuary	Koyra and Dacope Shymnagar	Khulna Satkhira
46	Sundarbans Reserved Forest	Several Upazila	Khulna

SL No.	Protected Areas	Upazila	District
47	Swatch of No Ground Aquatic Protected Area	Several Upazila	Bagerhat & another district
48	Tanguar Haor	Dharmapasha & Tahirpur	Sunamganj
49	Teknaf Game Reserve	Teknaf	Cox's Bazar
50	Tengragiri Wildlife Sanctuary	Taltali	Barguna
51	Tilagor Eco Park	Sylhet Sadar	Sylhet

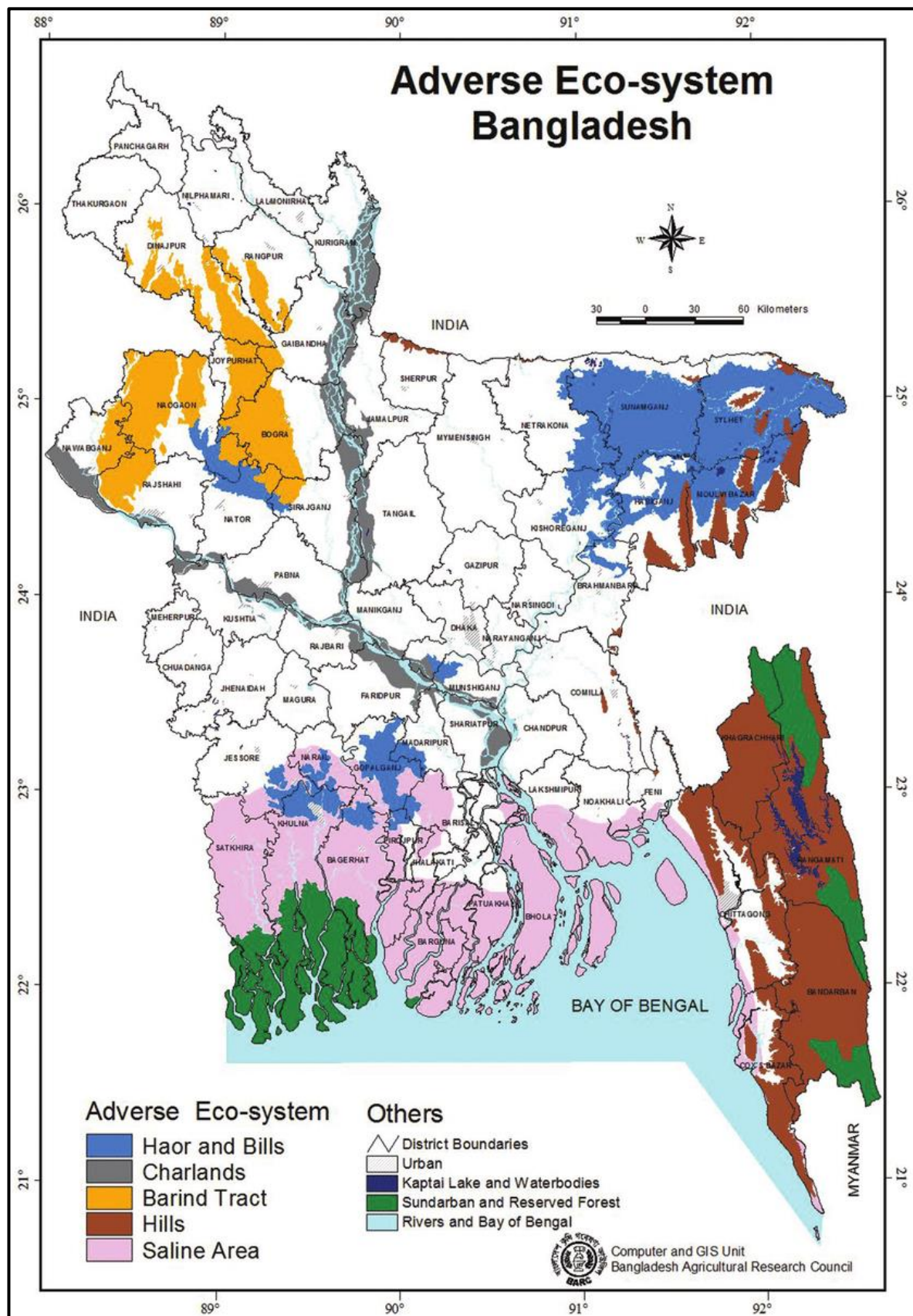


Figure 10: Adverse Eco-system of Bangladesh

4.3 Land Use of 42 Districts

(I) Land Use of Coastal Region (17 districts)

The Climate and Disaster Resilient Small-scale Water Resources Management Project focus on 17 coastal districts to manage land use, primarily upgrading agricultural and fisheries infrastructure. Key land uses include saline-prone agricultural land, coastal mangrove forests, shrimp farms, and rural settlements, with the project targeting 86,000 hectares for improved, resilient water management.

Key land use patterns and initiatives within the 17 coastal project districts include:

- **Agricultural Land Use:** The region contains over 30% of Bangladesh's total cultivable land, often suffering from low productivity due to salinity.
- **Shrimp and Aquaculture:** Significant portions of single-crop land have converted into shrimp farms, a major land-use change.
- **Infrastructure & Development:** The project focuses on improving small-scale water resources, including embankments and drainage, to support rural livelihoods.
- **Land Use Trends:** The coastal belt experiences rapid changes, including increased settlement areas and conversion of mudflats into cropland, alongside a decrease in mangrove coverage in some areas.
- **Climate Resilience:** The project addresses water and soil salinity, aiming to protect 86,000 hectares through enhanced, climate-resilient, and beneficiary-managed infrastructure.

(II) Land use of Barind Drought Prone Areas (16 districts)

The Barind drought-prone area, specifically targeted by initiatives like the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) and similar, covers several districts in northwestern Bangladesh, primarily Rajshahi, Chapainawabganj, Naogaon, Dinajpur, Rangpur, Bogura, and Joypurhat. Land use in these regions has shifted from traditional single-cropping to intensive agriculture, though this is now being adapted to combat climate-induced water scarcity.

Key land use aspects in the Barind area include:

- **Agricultural Dominance:** Primarily used for intensive rice cultivation (especially Boro and drought-tolerant varieties), wheat, and Mango orchards.
- **Cropping Pattern Shift:** The area is transitioning from single-cropping to double or triple cropping, heavily dependent on Groundwater-fed irrigation, which has led to high groundwater depletion.
- **Land Type Distribution:** The region consists of 56% medium-high land and 36% high land.
- **Water Management Challenges:** Increasing reliance on surface water, with projects aiming to use rivers like the Padma, Mohananda, and Punarbhaba to reduce groundwater pressure.

- **Adaptive Land Use:** Farmers are adopting climate-resilient practices, including mulching, cultivating drought-resistant crops, and using indigenous methods to retain soil moisture.
- **Land Degradation:** Intense cultivation and environmental changes have degraded land quality.

Key Trends:

1. **Surface Water Expansion:** Barind Multipurpose Development Authority (BMDA) is shifting irrigation from groundwater to surface water (rivers/canals) to sustain agriculture.
2. **Drought-Resilient Crops:** Promotion of drought-tolerant rice varieties like Binadhan-17, Binadhan-19, BRRI dhan56, BRRI dhan57, BRRI dhan66, BRRI dhan71, and BRRI dhan83.
3. **Eco-friendly Agriculture:** Increased use of organic fertilizers and reduced water-intensive, low-water-demanding crops (like cotton) to improve soil health and water conservation.

The region faces chronic water shortages, making sustainable water management crucial for continued agricultural production.

(III) Land Use of Haor Flash Flood Area (9 districts)

The Haor flash flood area districts, which are a key focus area under the CDRSSWRMP, are primarily located in the northeastern region of Bangladesh. These districts, covering the Meghna basin, include Sunamganj, Sylhet, Habiganj, Moulvibazar, Netrokona, Kishoreganj, and Brahmanbaria.

The land use in these seven districts is dominated by a unique wetland ecosystem where around 53% of the land area is classified as "haor" (depression). The land use patterns are deeply influenced by seasonal changes, characterized by a one-crop agricultural cycle.

Key Land Use Characteristics

- **Wetland Ecosystems (Haor/Beel):** A large portion of the area consists of bowl-shaped depressions that become vast water bodies during the monsoon (June–November).
- **Agricultural Land:** The area is primarily utilized for **Boro rice cultivation** during the dry season (Rabi season, November–April), producing roughly 25% of the country's total annual Boro rice.
- **Fallow Land:** During the monsoon, the majority of the land remains submerged and uncultivated.
- **Settlements (Hati/Kanda):** Homesteads are typically located on elevated land known as *kanda* or *haiti*, which appear as islands during the wet season.
- **Fisheries:** Ponds and deeper haor basins are used for both capture and culture fisheries.

Agricultural Land Use (Cropping Patterns)

- **Boro–Fallow–Fallow:** The dominant cropping pattern in the haor basin (upwards of 80% in some districts).

- **Intensity:** The average cropping intensity is very low (approx. 104%–169%) compared to the national average (195%) due to long-term submergence, though it has slightly increased with improved drainage.
- **Crop Diversification:** Limited to higher lands, including vegetables, potatoes, and spices.

Land Use Changes and Flash Flood Impacts

- **Pre-Monsoon Flooding:** Flash floods in April/May often damage the maturing Boro rice crops, which are the main agricultural activity.
- **Land Degradation:** Erosion of hilly areas in the north, causes sedimentation of sand in rivers and canals, reducing water-carrying capacity and turning agricultural land into wetlands.
- **Development of "Kanda" Land:** Increased pressure on land has led to the cultivation of slightly elevated *kanda* land.

Project Focus (CDRSSWRMP)

The project aims to improve climate resilience in this hotspot by focusing on:

- Rehabilitating and constructing flood management infrastructure.
- Protecting, or increasing, agricultural land through better drainage.
- Promoting alternative, short-duration, and flood-tolerant rice varieties.
- Enhancing fisheries management in the depressed *Beels*.

4.3.1 Existing and Proposed Land Use

(I) Existing and Proposed Land Use of Coastal Region (17 districts)

The CDRSSWRMP targets 17 coastal districts, focusing on enhancing climate-resilient agriculture and livelihoods, managing saline intrusion, and reducing disaster risks (flooding, cyclones). Proposed land use aims to transition from intensive, single-crop systems to diversified, salinity-tolerant, and sustainable, community-managed water resources, integrating aquaculture with agriculture.

Key Existing Land Use Patterns (Coastal Region)

- **Intensive Agriculture:** Predominantly rice cultivation, but threatened by salinity, leading to low productivity in areas like Satkhira, Khulna, and Bagerhat.
- **Shrimp/Salt Farming:** Increasing, often replacing traditional agriculture, particularly in Chittagong, Satkhira, and Khulna.
- **Natural Habitats:** Mangrove forests (Sundarbans), coastal wetlands, and tidal mudflats, which are crucial for ecological balance.
- **Infrastructure:** Dense, vulnerable, and poorly connected rural roads and settlements.

Proposed Land Use under CDRSSWRMP/Similar Projects

- **Climate-Resilient Agriculture:** Transition to saline-tolerant rice varieties and crop diversification to ensure food security despite increased salinity.

- **Optimized Water Management:** Development of Small-scale Water Resources (SSWR) infrastructure, including dredging canals, enhancing drainage, and controlling water flow to reduce flood risks.
- **Integrated Aquaculture-Agriculture:** Promotion of sustainable, managed shrimp farming within integrated systems, often designated via coastal land zoning, to reduce environmental degradation.
- **Protected Infrastructure:** Investment in improved, flood-resilient roads, village protection walls, and community spaces to reduce disaster vulnerability.
- **Conservation Zones:** Protecting mangroves and coastal wetlands to act as natural buffers against cyclones and tidal surges.

(II) Existing and Proposed Land Use of Barind Drought Prone Areas (16 districts)

The Barind Tract in northwestern Bangladesh, covering parts of Rajshahi, Rangpur, and Dinajpur divisions, is a distinct Pleistocene-era unit characterized by high, drought-prone, and compacted clay soil. Historically reliant on rain-fed, single-crop agriculture, the region has transformed over the last few decades into an intensive, multi-crop agricultural zone, leading to severe groundwater depletion.

Existing Land Use (Current Situation)

- **Intensive Agriculture (Boro Rice):** Following initiatives by the Barind Multipurpose Development Authority (BMDA), the region has shifted from single-cropping to triple-cropping, particularly heavily relying on groundwater-intensive Boro rice during the dry season.
- **Groundwater Dependence:** Agriculture is 75-77% reliant on groundwater, with water tables in the High Barind (areas like Porsha, Nachole) dropping significantly.
- **Declining Wetlands:** Due to, agricultural expansion, canal construction, and irrigation, natural wetlands and water bodies have shrunk, causing a severe drop in surface water.
- **Fruit/Homestead Farming:** Areas with Mango orchards, guava, and other fruits are common, along with homestead vegetation which acts as a primary source of biodiversity.
- **Land Degradation:** Over-exploitation of resources, deforestation, and high drought intensity (45% of the region is considered highly vulnerable to drought/desertification) have caused significant land degradation.

Proposed/Ongoing Changes in Land Use (Sustainable Management)

The Bangladesh Delta Plan (BDP) 2100 and BMDA initiatives focus on creating a "Resilient Barind" through the following transformations:

- **Surface Water Utilization:** Shifting from underground water dependence to surface water by re-excavating 312+ ponds and canals to store water for irrigation.
- **Crop Diversification:** Reducing the area under water-intensive Boro rice, and promoting high-value, low-water-consuming crops (wheat, maize, pulses, oilseeds, spices).

- **Afforestation & Environmental Protection:** Expanding, social forestry and planting, trees along, water bodies to combat drought, improve soil moisture, and increase ecological balance.
- **Integrated Land Management (ILM):** Utilizing, a "30% reduction" strategy for groundwater, (reducing, current, abstraction, by 30%) and promoting, agro-forestry, and, orchard management in, arid zones.
- **Indigenous Adaptation Practices:** Increasing use of, traditional, methods like mulching (covering, soil with leaves/straw) to retain soil moisture.

The overall aim is to transition from a purely intensive, water-draining system to a sustainable, diversified model that addresses the high risk of desertification in the region.

(III) Existing and Proposed Land Use of Haor Flash Flood Area (9 districts)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), supported by the Asian Development Bank (ADB) and implemented by the Local Government Engineering Department (LGED), focuses on seven districts in the Haor region (Sunamganj, Sylhet, Habiganj, Maulvibazar, Netrokona, Kishoreganj, and Brahmanbaria).

This project, along with similar initiatives like the Haor Infrastructure and Livelihood Improvement Project (HILIP), aims to transition the land use from high-risk, single-crop agriculture to more resilient, multi-purpose, and climate-adaptive systems.

Existing Land Use (Pre-Project Scenario)

The Haor area is a bowl-shaped depression (around 1.99 million hectares) that remains deeply inundated during the monsoon.

- **Mono-cropping Agriculture:** Primarily Boro rice cultivation during the dry season (December–April). The land is highly vulnerable to early flash floods in April/May, often resulting in total crop failure.
- **Capture Fisheries:** Seasonal fishing in Beels (small lakes) and rivers during the monsoon.
- **Low-lying Settlement:** Villages are mostly situated on low mounds (kandas) that are prone to erosion and submersion during high floods.
- **Natural Vegetation:** Limited wetland forests (Hijal, Karach) and reeds.

Proposed Land Use (CDRSSWRMP & Allied Projects)

The project aims for an Integrated Water Resources Management (IWRM) approach to transform land-use, focusing on four key areas:

- **Flood Management & Improved Agriculture:** Rehabilitation of existing embankments and construction of new flood-proof, submersible, and wave-resistant floodwalls to protect Boro crops.
- **Water Conservation & Fisheries Development:** Re-excavation of drainage canals and Khals (canals) to increase water retention for irrigation, while enhancing habitats for fish nursing to promote aquaculture and boost fish production.

- **Resilient Infrastructure & Settlement Raising:** Raising the elevation of homesteads, rural roads, and market infrastructure (bazaar) above flood levels to provide safety during the monsoon.
- **Diversified Livelihoods & Afforestation:** Promotion of flood-tolerant, indigenous tree planting (e.g., Hijal, Karach) in buffer zones to act as windbreaks and reduce wave action. Promotion of alternative, high-value livelihood options like crab farming or duck rearing.

Key Target Areas (Districts)

The interventions specifically target the most vulnerable areas within the seven Haor districts: Sunamganj, Habiganj, Netrakona, Kishoreganj, Brahmanbaria, Sylhet and Maulvibazar

4.3.2 Ecologically Important Areas for Conservation

(I) Ecologically Important Areas of Conservation of Coastal Area (17 districts)

Key ecologically critical areas (ECAs) in Bangladesh's coastal districts—primarily under the 1999 Environment Act-focus on protecting biodiversity in the Sundarbans (Bagerhat, Khulna, Satkhira, Pirojpur, Barguna), Cox's Bazar-Teknaf Sea beach, Sonadia Island, and Saint Martin's Island. These areas face threats from climate change, industrial development, and salinity intrusion.

- **Sundarbans Reserved Forest (Bagerhat, Khulna, Satkhira, Pirojpur, Barguna):** The largest contiguous mangrove forest, with a 10 km, non-forest periphery also declared an ECA to protect against salinity and natural hazards.
- **Cox's Bazar – Teknaf Sea Beach:** A crucial biodiversity hotspot including sandy beaches, hills, and forests, which are threatened by rapid infrastructure development.
- **St. Martin's Island (Teknaf, Cox's Bazar):** The only coral-bearing island in Bangladesh, requiring strict conservation of its unique coral-algal community.
- **Sonadia Island (Moheshkhali, Cox's Bazar):** Contains vital mangrove forests and serves as a nest ground for sea turtles and migratory birds.
- **Coastal Greenbelts:** Conservation initiatives focus on mangrove afforestation and preserving natural vegetation to act as barriers against cyclones and storm surges.
- **Wetland Ecosystems:** Other sensitive areas include the Naf River and various tidal mudflats, which are crucial for mangrove regeneration and marine, fishery, and avian habitats.

These areas are designated to restrict development that threatens biodiversity, though enforcement remains challenging.

(II) Ecologically Important Areas of Conservation of Barind Drought Prone Areas (16 districts)

The Barind Tract in northwestern Bangladesh, covering parts of Rajshahi, Chapainawabganj, Naogaon, Bogura, Joypurhat, Rangpur, and Dinajpur, is a major drought-prone ecological zone facing severe water scarcity. Key ecologically important areas of conservation focus on protecting wetlands, restoring forests, and managing water resources to counter the effects of climate change and over-extraction of groundwater.

Key Conservation Areas & Initiatives in the Barind Tract

- **Wetlands and Water Bodies (Beels and Dighis):**

- **Sonadighi and Dibor Dighi:** Targeted for ecological restoration, including infrastructure development (footpaths, benches) to promote eco-tourism and protect local aquatic ecosystems.
- **Byde Land (Valleys):** The High Barind is cut by narrow valleys known as *bydes*, which act as natural channels for water runoff and require protection to enhance surface water retention.
- **Rivers:** The Little Jamuna, Atrai, and Lower Punarbhaba rivers are crucial, with initiatives focusing on restoring surface water availability to reduce reliance on groundwater.
- **Restoration of Natural Forests (Shal Forest):**
 - Enrichment plantations are underway on 20 hectares to regenerate the natural Shal forest (Shorearobusta), which is essential for stabilizing the soil and maintaining local biodiversity.
 - Development of a 600-kilometre strip forest and a 100-hectare woodlot garden to enhance green cover.
- **Botanical and Biodiversity Areas:**
 - Arboretums: Two new arboretums are being established to conserve rare, endangered, and long-lifespan tree species.
 - Herbal Orchards: Establishment of herbal gardens with approximately 1,250 medicinal plant saplings.
- **Agricultural and Homestead Ecosystems:**
 - Homestead Vegetation: Recognized as a key area for conserving local plant diversity and genetic resources.
 - Char Land: Significant efforts in planting along char lands to stabilize soil and increase agricultural productivity through community participation.

Focus Areas for Ecological Protection

- High Barind Tract (Rajshahi, Chapainawabganj, Naogaon): The most severely drought-prone area, specifically Tanore and Nachol upazilas, requiring urgent attention for water management.
- Surface Water Harvesting: Focus on re-excavating canals and ponds to store rainwater for irrigation to reduce pressure on the water table.

Key Conservation Strategies

- Managed Aquifer Recharge (MAR): Techniques such as rainwater harvesting are being promoted to reverse the decline in the water table, particularly through initiatives like the one at the Amtoli-1 deep tubewell.
- Ecosystem-based Adaptation (EbA): Promoting sustainable, low-water-consuming crops, plantation of three lakh palm trees for lightning protection and ecological balance, and protecting indigenous species.

(III) Ecologically Important Areas of Conservation of Haor Flash Flood Area (9 districts)

The Haor basin in northeastern Bangladesh, covering parts of Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, Kishoreganj, and Brahmanbaria districts, is a unique, fragile wetland ecosystem that faces annual flash floods. These areas are critical for biodiversity (migratory birds, endemic fish) and livelihood, requiring specific conservation initiatives, particularly as they are increasingly threatened by climate change and flash floods (**Table 18**).

Key Ecologically Important Areas of Conservation

- **Tanguar Haor (Sunamganj):** Designated as a Ramsar site (2000) and an Ecologically Critical Area (ECA, 1999). It is a 9,727-hectare wetland supporting over 135 fish species, 208 bird species (including migratory), and freshwater swamp forests.
- **Hakaluki Haor (Moulvibazar/Sylhet):** One of Asia's largest freshwater wetlands, it is an ECA and a key habitat for migratory birds, freshwater turtles, and endangered species. It comprises over 238 interconnected beels (wetland basins).
- **Hail Haor (Moulvibazar):** Famous for its biodiversity, this area has a community-maintained sanctuary (Baikka Beel) that has become a refuge for fish, birds, and aquatic plants.
- **Gurmar Haor (Sunamganj):** Known for its Pashua Beel site, which acts as a safe habitat for cormorants, herons, and rare migratory birds.
- **Bara Haor (Sunamganj):** Important for its floodplain grasslands, reed bogs, and as a breeding ground for birds.
- **Balai Haor (Netrokona/Sylhet):** A significant area for migratory birds and rare species like the Pallas's fish eagle and Lesser adjutant.
- **Piyain River (Sylhet):** A river ecosystem crucial for aquatic biodiversity and fish breeding, frequently impacted by sedimentation.

Conservation Priorities and Strategies

Conservation efforts in these flash flood-prone districts focus on nature-based solutions and community-led management:

- **Restoring Swamp Forests:** Replanting indigenous trees like Hijol (*Barringtonia acutangula*) and Karach (*Pongamia pinnata*) to act as natural bio-shields against wave erosion and provide habitats.
- **Beel Re-excavation:** Re-excavating canals and deepening beels to improve connectivity, enhance fish breeding, and manage water flow.
- **Community-Based Management (ECA):** Establishing Village Conservation Groups (VCGs) to manage wetlands, prevent illegal fishing, and protect the ecosystem in designated ECAs like Tanguar and Hakaluki.
- **"Mujib Killa" and Homestead Protection:** Building elevated, concrete flood shelters (Killa) and reinforcing homesteads with sandbags and local flora to protect against flash floods.
- **Fisheries Sanctuaries:** Creating dedicated fish sanctuaries in Beels to ensure the sustainability of fish stocks, a major source of income.

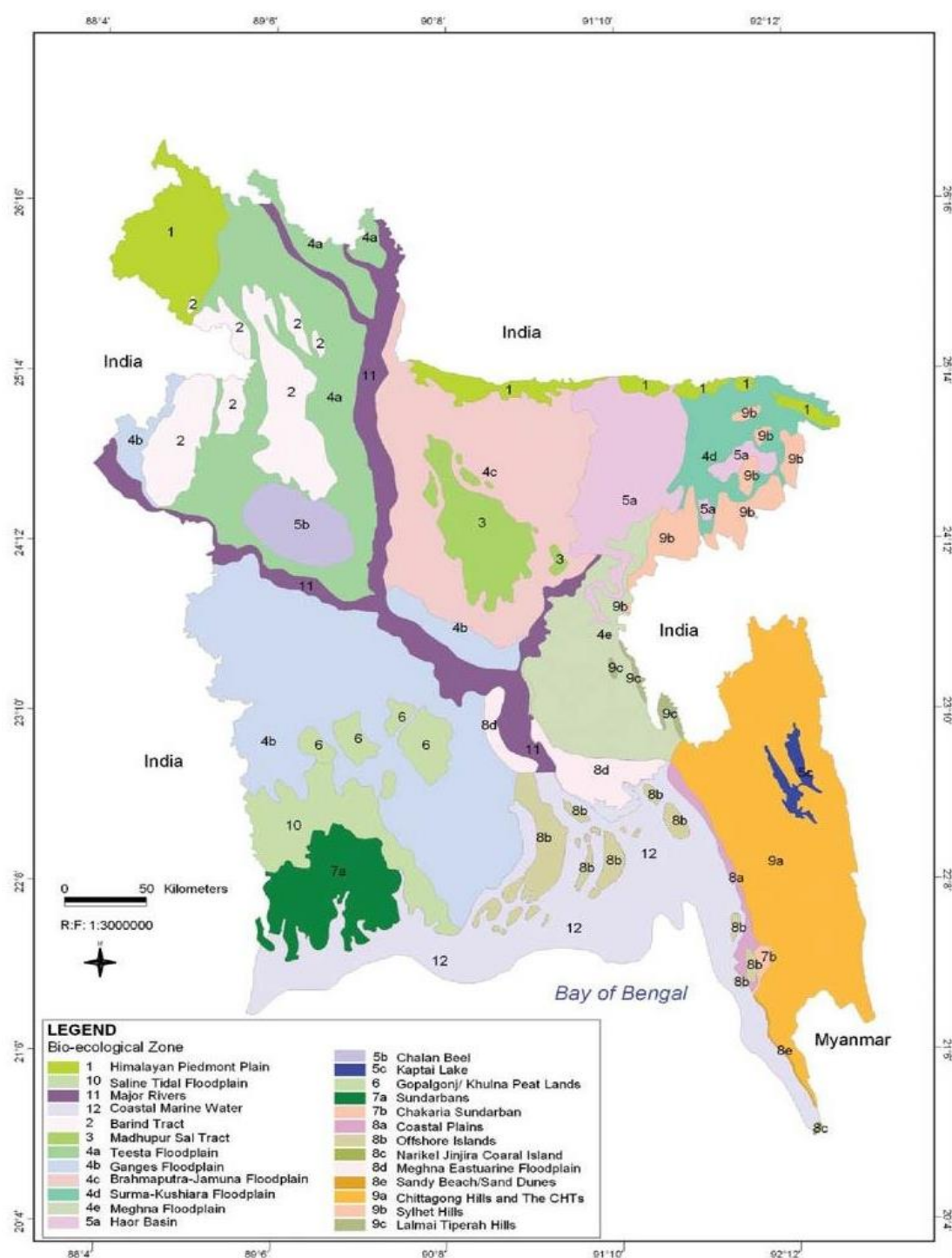


Figure 11: Bangladesh Bioecological Zones Map

Table 18: Declared Ecologically Critical Areas (ECAs) of Bangladesh

Name of the ECA	Category of Ecosystem	Location (Zilla)
Sundarbans	The outside of Sundarbans Reserved Forest at 10 km extent	Bagerhat, Khulna, Saatkhira, Pirojpur, Borguna
Cox's Bazar–Teknaf Sea beach	Village, Agricultural Land, Hills, Forest	Cox's Bazar

Name of the ECA	Category of Ecosystem	Location (Zilla)
Saint Martin's Island	Coastal Waterways, Oceanic Island with Corals	Cox's Bazar
Sonadia Island	Mangrove forests	Cox's Bazar
Hakaluki Haor	Haor (Watershed)	Sylhet, Moulvibazar
Tanguar Haor	Haor (Watershed)	Sunamganj
Marjat Baor	Oxbow Lake	Jhenaidah
Gulshan-Baridhara Lake	Urban Lake	Dhaka
Buriganga River	River	Beside Dhaka Metropolitan
Turag River	River	Beside Dhaka Metropolitan
Balu River	River	Beside Dhaka Metropolitan
Sitalakshya River	River	Beside Dhaka Metropolitan and Narayanganj
Jaflang-Dauki River	River and the surrounding area of 500 metres	Sylhet
Halda River	River and the surrounding area of 500 metres	Chattogram, Khagrachhari

The legal requirements under BECA compel the concerned authorities to ban certain activities within the ECAs, which are: - felling or collecting trees, hunting, catching or killing wildlife, industrial establishment, fishing, and other activities that might affect fish or aquatic life. In general, any activity that could destroy the natural characteristics of soil or water in these areas are to be prevented under this law.

To address the extreme events of extinction, the Government of Bangladesh has also taken some institutional steps which include area-based observation, project implementations and awareness-raising programme. The Department of Environment, which is the technical arm of the Ministry, reports quite a few engaging activities that have been undertaken to protect and conserve the ECAs of Bangladesh (**Table 19**).

Table 19: Bangladesh Ecologically Critical Areas with Their Ecosystem Type

No	Name of the ECA	Type of Ecosystem	Location	Areas(ha)	Year of Declaration
1.	Cox's Bazar- Teknaf Peninsula	Coastal-Marine	Cox's Bazar	20,373	1999
2.	Sundarbans (10 km landward periphery)	Coastal-Marine	Bagerhat, Khulna Barguna, Pirojpur and Satkhira	292,926	1999
3.	St. Martin's Island	Marine Island with coral reefs	Teknaf Upazila, Cox's Bazar	1,214	1999
4.	Hakaluki Haor	Inland Freshwater Wetland	Sylhet and Moulvibazar	40,466	1999
5.	Sonadia Island	Marine Island	MoheshKhali, Cox's Bazar	10,298	1999
6.	Tanguar Haor	Inland Freshwater Wetland	Tahirpur, Sunamganj	9,727	1999
7.	Marjat Baor	Oxbow Lake	Kaliganj Upazila of Jhenaidah and Chaugacha Upazila of Jashore	325	1999
8.	Gulshan-Baridhara Lake	Urban Wetland	Dhaka city	101	2021
9.	Buriganga	River	Around Dhaka	1336	1009
10.	Turag	River	Around Dhaka	1184	2009
11.	Sitalakhya	River	Around Dhaka	3771	2009

No	Name of the ECA	Type of Ecosystem	Location	Areas(ha)	Year of Declaration
12.	Balu including Tongi canal	River	Around Dhaka	1315	2009
13.	Jaflong-Dawki	River	Jaflong, Sylhet	1493	2015
Source: Department of Environment (2015)					

4.3.3 Protected Areas of Bangladesh

Protected areas – also known as designated sites – help to ensure that their natural features of special interest remain in good health for all to enjoy, now and in the future. International directives and treaties, domestic legislation and policy, or local needs and interests may call for the designation of sites.

Wildlife sanctuaries, National parks, and Biosphere are the three types of protected areas that have been earmarked for the conservation of forest and wildlife.

Effectively managed protected areas are a critical tool for safeguarding biodiversity, maintaining ecosystem balance, preserving important habitats, building resilience to climate change, providing global food security, maintaining water quality, conserving natural resources, driving economic success, curbing the spread of diseases and pests, and providing many other benefits to wildlife and human health. Map of protected area of Bangladesh is given in **Figure 12**.

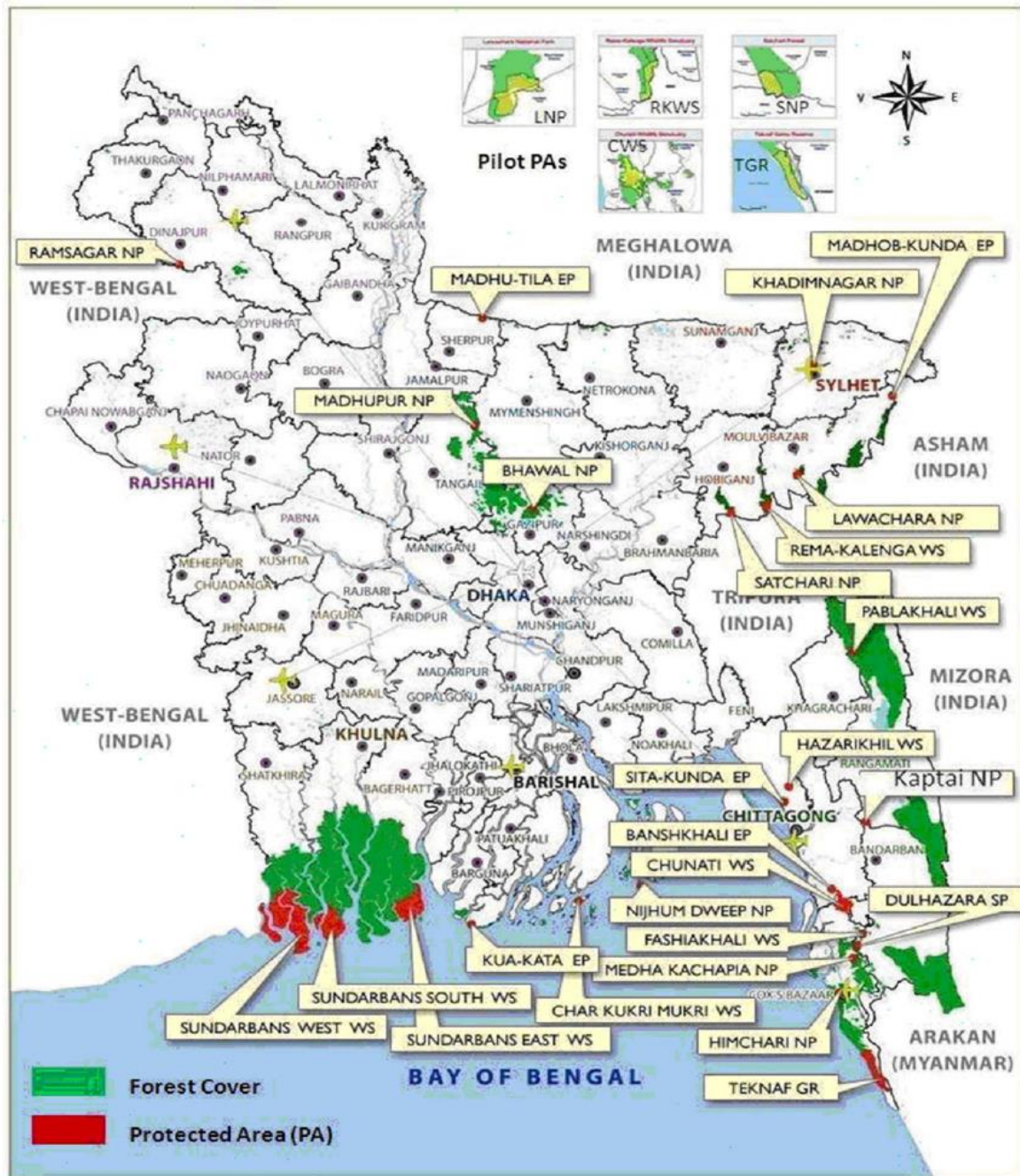


Figure 12: Map of Bangladesh Showing the Protected Areas (PAs)

As of 2022, the World Database of Protected Areas list of 51 protected areas in Bangladesh (Table 17).

4.4 Social Environment of 42 Districts

(I) Social Environment of Coastal Area (17 districts)

The social environment of Bangladesh's 17 coastal districts is defined by high climate vulnerability, significant poverty (14 districts below national average), and reliance on shrinking natural resources. Over 37 million people face frequent cyclones, tidal surges, salinity intrusion, and erosion, causing chronic food insecurity, health issues from saline water, and high migration rates.

Key Aspects of the Social Environment:

- **High Vulnerability & Poverty:** Coastal communities, particularly in the southwest, are among the most vulnerable to climate change. Poverty is widespread, with over 56% in some areas facing food deficiency.
- **Natural Disasters & Displacement:** Frequent, intense cyclones (e.g., Aila, Sidr, Amphan) and riverbank erosion have forced many, particularly in the Meghna estuary, to become landless and homeless, altering community structures.
- **Health and Water Crisis:** Salinity in drinking water causes severe health problems, including high blood pressure, eclampsia in pregnant women, and menstrual issues in teenage girls. Access to healthcare is inadequate, especially for marginalized and disabled populations.
- **Livelihood Shifts & Inequality:** Traditional agriculture is declining due to salinity, forcing a shift to shrimp farming, which creates social conflicts over land use and resources. There is an undue influence of local, powerful individuals in some areas.
- **Gender and Social Dynamics:** Women face severe hardships due to the water crisis. However, they are also drivers of resilience through, for example, rainwater harvesting and community-led initiatives.
- **Migration and Demographic Changes:** Due to environmental hazards and economic hardship, many young people migrate to cities, leading to an aging, often isolated, population left behind.

Infrastructure and Services:

- **Limited Access:** Many areas, particularly in parts of Noakhali, Bhola, and Cox's Bazar, have low literacy rates and poor access to electricity.
- **Infrastructure Gaps:** Coastal towns (Pourashavas) struggle with inadequate basic services, lacking proper drainage and waste management, which compounds flood risks.
- **Resilience Efforts:** Despite these challenges, communities are adapting through improved, localized early warning systems, storm shelters, and, in some cases, shifting to alternative livelihoods like crab farming.

(II) Social Environment of Barind Drought Prone Areas (16 districts)

The social environment in the Barind drought-prone districts of Bangladesh (Rajshahi, Naogaon, Chapainawabganj) is defined by high vulnerability to water scarcity, impacting livelihoods and promoting male out-migration. The community is predominantly agrarian, facing significant financial limitations and low educational rates among vulnerable groups like the Santal women.

Key Aspects of the Social Environment:

- **Vulnerability and Livelihood:** The, ICIMOD has identified that drought causes severe economic strain due to water shortages for irrigation and household use.
- **Gendered Impact:** Women and girls are disproportionately affected, often walking long distances to collect water and facing increased household burdens while men migrate for work.

- **Socio-economic Status:** The population, including many minority communities, is largely poor with limited access to resources, and often depends on informal, non-institutional credit.
- **Community Structure:** The society is characterized by strong social bonding and traditional practices, but faces challenges with low formal education.
- **Adaptation Strategies:** Residents rely on local knowledge for coping, such as changing crop patterns, and switching to less water-intensive plants (e.g., mango, jujube).
- **Emerging Issues:** There is increasing demand for a dedicated drought policy and social protection mechanisms to manage future risks.

(III) Social Environment of Haor Flash Flood Area (9 districts)

The social environment of the Haor flash flood districts in northeastern Bangladesh (primarily Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrakona, and Kishoreganj) is characterized by a "vicious cycle of poverty," high vulnerability to recurrent natural disasters, and strong dependency on subsistence agriculture and fishing. The inhabitants, often termed "haor people," live in a unique, bowl-shaped landscape that is frequently submerged, shaping a culture of endurance, marginalization, and high mental stress.

Key Aspects of the Social Environment:

- **Poverty and Economic Vulnerability:** Over 28% of the population lives below the Lower Poverty Line (LPL). The economy is heavily dependent on a single annual crop (Boro rice), which is frequently destroyed by early, unexpected flash floods in April-May.
- **Marginalization and Indebtedness:** Due to limited income opportunities during the monsoon, many farmers are forced to borrow money from local moneylenders (Mohajon) or NGOs at high interest rates, creating a cycle of debt.
- **Education and Infrastructure Constraints:** The area lacks adequate educational facilities, resulting in high rates of illiteracy (over 80% of farmers have no formal education). Many children drop out of school to help their families earn money.
- **Impact on Women and Children:** Women are particularly vulnerable, suffering from malnutrition, sanitation problems, and limited access to health services during floods. Women reported high levels of anxiety (88%), depression (89%), and increased family violence during flood events.
- **Migration and Labor:** A high rate of temporary migration occurs during the lean season, as people seek jobs as rickshaw pullers or labourers in other parts of the country.
- **Coping Mechanisms and Resilience:** Despite their vulnerability, communities have developed traditional coping strategies, such as building homes on raised platforms (Uthan), fishing, and using boats for transportation.
- **Social Cohesion and Support:** While traditional support networks exist, the severity of modern flash floods often overwhelms local solidarity, making external government or NGO aid essential.

Geographical and Social Isolation:

The Haor region is physically isolated during the monsoon, making communication difficult.

This isolation, combined with the lack of access to basic services, exacerbates the social and economic challenges faced by the residents.

4.4.1 Population Distribution

(I) Population Distribution of Coastal Area (17 districts)

The coastal zone of Bangladesh, often defined by the 19 coastal districts (including 17 project districts), is one of the most densely populated areas in the country, home to approximately 43.8 to 44.8 million people. This region covers roughly 32% of the total landmass of Bangladesh.

Under initiatives similar to the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) and related Coastal Embankment Improvement Projects (CEIP), the focus is primarily on the vulnerable southern districts.

Population Distribution of Coastal Districts

The project 17 coastal districts are divided into exposed (most vulnerable) and interior coasts, with the majority of the population residing in rural areas.

- Total Coastal Population: ~44.8 million (Approx. 28-30% of the total population).
- Key Coastal Districts (17): Jessore, Narail, Gopalganj, Chandpur, Satkhira, Khulna, Bagerhat, Pirojpur, Jhalokathi, Barguna, Barisal, Patuakhali, Bhola, Lakshmipur, Noakhali, Chittagong, and Cox's Bazar.
- High-Density Areas: Chittagong and Khulna are among the most densely populated coastal cities, with densities approaching 20,000 people per square kilometer in certain areas.

Focus Areas of Coastal Projects (CDRSSWRMP/CEIP)

Projects focusing on strengthening resilience (like the World Bank's CEIP and ADB's CDRSSWRMP) often concentrate on districts with the highest exposure to tidal flooding and saline intrusion:

- Exposed Coast Districts: Bagerhat, Khulna, Satkhira, Barguna, Patuakhali, Pirojpur, Bhola, Noakhali, Lakshmipur, Feni, Chittagong, and Cox's Bazar.
- Recent Project Focus: Specifically, 6 coastal districts (Bagerhat, Khulna, Satkhira, Barguna, Patuakhali, and Pirojpur) have been highlighted in major resilience projects, protecting around 760,000 people within designated polders.

Demographic Trends

- Urban vs. Rural: While currently heavily rural, the coastal urban population is rising rapidly. The coastal urban population is expected to grow from 8.5 million (2001) to 30.2 million by 2050.
- Vulnerability: A higher percentage of the population in these districts lives below the poverty line compared to the national average.
- Density: The region is characterized by high population density within a relatively small area, with many households located in tidal-prone zones.

(II) Population Distribution of Barind Drought Prone Areas (16 districts)

The Barind Tract, located in the northwestern region of Bangladesh, is a major drought-prone area covering roughly 34,359 sq. km. It encompasses major parts of Rajshahi, Rangpur, Dinajpur, Bogra, Naogaon, Pabna, and Joypurhat districts.

Population and Demographic Characteristics

- **Total Population:** The Barind region is inhabited by approximately 34 million people.
- **Density:** The region is densely populated, with an average density of around 980 people per sq. km.
- **Livelihood Dependence:** The majority of the population relies heavily on agriculture for their livelihood.
- **Demographic Composition (Sampled Study):** A study on the drought-prone Barind area showed a high concentration of working-age individuals (57% aged 40–60, 41% aged 20–40).
- **Gender Distribution:** The same study indicated a male-dominated workforce in the agricultural sector (73% male vs. 27% female).
- **Household Status:** Over 70% of the rural population consists of landless, marginal, and small households, with 34% possessing only homestead land.

Drought Impact and Migration

- **Vulnerability:** The region is characterized by severe water stress, with groundwater levels dropping by more than 20 meters in some areas, affecting both agricultural and domestic water use.
- **Seasonal Migration:** Due to the "Monga" (seasonal food insecurity) caused by droughts, people are often forced to migrate to other regions to find work during the agricultural off-season.
- **Impact on Household Roles:** Women and girls in the region are disproportionately affected by the water scarcity, often walking long distances to collect water.

Key Districts Affected

The Barind tract mainly covers the following districts, with varying levels of drought intensity:

- **Rajshahi (including Godagari, Tanore):** Highly vulnerable, with 95.62% of the area considered high-potential for drought.
- **Naogaon:** Highly vulnerable (92.51% of the area).
- **Pabna:** Highly vulnerable (90.84% of the area).
- **Dinajpur & Rangpur:** Known for severe water scarcity in certain, with colder winters.
- **Joypurhat & Bogra:** Part of the older alluvium region experiencing water crises.

The region is characterized by high, variable temperatures (up to 40°C in summer) and low annual rainfall compared to the rest of the country.

(III) Population Distribution of Haor Flash Flood Area (9 districts)

The Haor region in northeastern Bangladesh, prone to annual pre-monsoon flash floods (typically between March and May), spans seven districts and is home to approximately **19.37**

million people. The core districts heavily affected by these flash floods are Sunamganj, Sylhet, Netrokona, Kishoreganj, Habiganj, Moulvibazar, and Brahmanbaria.

Key Population and Affected Area Data (Based on 2017-2024 Trends)

- Sunamganj: Consistently the worst-hit, with over 60–65% of its population affected by floods. It has the highest number of affected people (over 2 million during the 2022 flood).
- Sylhet: High density, with over 1.5 million people (35% of the district's population) affected in major events.
- Netrokona & Others: Together with Habiganj, Kishoreganj, and Moulvibazar, these areas regularly experience, on average, 20–35% of their population affected during severe flash floods.
- General Vulnerability: The region is almost entirely single-cropped (Boro rice), making the population highly vulnerable to food insecurity and poverty, with over 90% of households in some study areas living below 2.15 USD per day.

Population Vulnerability Factors

- Density: While not as dense as other parts of Bangladesh, the population is spread across bowl-shaped depressions.
- Impacted Occupations: Agriculture (specifically Boro rice) and fishing are the main livelihoods, leaving fishermen and farmers extremely vulnerable to income loss.
- 2022 Impact: The 2022 flood was exceptionally severe, impacting over 7.2 million people across these districts.
- 2024 Impact: In June 2024, flash floods from heavy rains again inundated the Haor region, with over 3 million people affected in the northeastern districts of Sylhet and Sunamganj.

Commonly Affected Upazilas (Sub-districts)

The most vulnerable areas often include Chhatak, Sunamganj Sadar, Jagannathpur, Baniachong, and Kalmakanda, where over 80% of cropland is often submerged.

4.4.2 Economic activities

(I) Economic Activities of Coastal Area (17 districts)

Economic activities in Bangladesh's coastal districts are dominated by a "Blue Economy" approach, heavily relying on fishing, shrimp aquaculture, salt production, and coastal agriculture. Major industries include shipbreaking in Chittagong, mangrove forestry, marine logistics, and tourism, while supporting livelihoods through small-scale trade, handicrafts, and agro-processing.

Primary Economic Activities:

- Fisheries and Aquaculture: This is the main livelihood, involving capture fisheries, processing, and shrimp/crab farming, particularly in Satkhira, Khulna, and Bagerhat.
- Salt Production: A major industry, particularly concentrated in the Cox's Bazar district.

- Agriculture: Cultivation of salinity-tolerant crops, rice, and vegetables in coastal belts.
- Forestry: The Sundarbans provide livelihood through fishing, honey collection, and wood resources.

Secondary and Industrial Activities:

- Shipping and Maritime Logistics: Ship building, repairing, and port services are major economic drivers in areas like Chittagong, Mongla, and Payra.
- Shipbreaking: A significant industry located near Chittagong.
- Marine Tourism: Popular in Cox's Bazar and the Sundarbans, involving hotels, restaurants, and transport services.
- Manufacturing: Boat manufacturing, net making, and fish processing plants.

Key Economic Drivers and Challenges:

- Blue Economy Potential: Focus on ocean-based resources, including potential oil/gas exploration, marine biotechnology, and renewable energy (wind/tidal).
- Micro, Small, and Medium Enterprises (MSMEs): Active in handicrafts, tailoring, and agro-processing.
- Challenges: Economic activities are highly vulnerable to climate change, including cyclones, floods, and sea-level rise causing salinity intrusion.

(II) Economic Activities of Barind Drought Prone Areas (16 districts)

The Barind Tract, covering parts of Rajshahi, Naogaon, and Chapainawabganj districts in northwestern Bangladesh, is a severely drought-prone, high-terrace region defined by low rainfall and high temperatures. Its economy is primarily agrarian, transitioning from subsistence farming to intensive irrigated agriculture, supplemented by fruit cultivation, agro-forestry, and, increasingly, non-farm activities to cope with water shortages.

Key Economic Activities

- Intensive Crop Agriculture: Despite water scarcity, the region is a significant producer of crops, largely supported by deep tubewell (DTW) irrigation managed by the Barind Multipurpose Development Authority (BMDA).
 - Rice Production: Transplanted Aman (T-Aman) is grown in the monsoon, while Boro rice is cultivated in the dry season, although it is heavily criticized for draining groundwater.
 - Drought-Resilient Crops: Farmers are shifting to less water-intensive crops, including wheat, maize, lentils, oilseeds (mustard), and pulses (e.g., mung bean).
 - High-Value Crops: Cultivation of potatoes and vegetables is popular for higher economic returns.
- Fruit Farming (Horticulture): The region is famous for mango and jujube (boroi) cultivation, which are more drought-tolerant than rice. Mango orchards often allow for intercropping of other seasonal crops.
- Agro-forestry and Homestead Gardening: Homesteads are crucial for diversifying income and nutrition. They provide fruits, vegetables, timber, and bamboo.

- **Livestock and Poultry Rearing:** Rearing cattle, goats, chickens, and ducks is a major secondary source of income, often supported by NGOs, especially when crops fail.
- **Fish Culturing:** While water is scarce, the re-excavation of old ponds (miniponds) has allowed for increased fish farming.
- **Agricultural Labor and Services:** Many landless or smallholder farmers work as agricultural laborers.
- **Non-Farm Activities:** To cope with drought-induced income losses, residents engage in petty business, construction work, and rickshaw-pulling.

Adaptation and Changing Economic Strategies

- **Organic Farming:** Due to the high cost of chemical fertilizers and degraded soil, there is an increase in the production and marketing of organic manure (vermicompost).
- **Water Management Economy:** A new economic sector includes managing and selling irrigation water via "water lords" or "deep tubewell operators" using smart cards.
- **Switching Crops:** Farmers are moving away from water-intensive crops to drought-resistant, short-duration varieties (e.g., BRRI Dhan-56, BRRI 62, BARI Gom-24) to reduce irrigation costs.
- **Seasonal Migration:** In extreme droughts, some residents migrate seasonally to other areas for work.
- **Use of Technology:** The use of solar-powered pumps and surface water harvesting (re-excavated canals/ponds) is being encouraged to reduce dependence on groundwater.

(III) Economic Activities of Haor Flash Flood Area (9 districts)

The economic activities of the Haor flash flood districts in Bangladesh (primarily Sunamganj, Sylhet, Habiganj, Netrokona, Kishoreganj, Brahmanbaria, and Moulvibazar) are predominantly based on a single-crop agricultural system, specifically Boro rice, complemented by fishing, livestock rearing, and, to a lesser extent, non-farm activities. These areas, characterized by deep freshwater wetlands, suffer from severe, premature flash floods (usually in April/May) that often damage the single annual rice crop just before harvest, significantly affecting the livelihoods of local residents.

Core Economic Activities

- **Boro Rice Cultivation (Single Crop):** Agriculture is the primary livelihood, with Boro rice cultivation covering nearly 80% of the land and providing about 20% of the country's total staple food. This single crop sustains households for the entire year.
- **Fisheries:** Due to the extensive wetland, fishing is a crucial economic activity, particularly in the wet season (June to November).
- **Livestock and Poultry Rearing:** Duck rearing and, to a lesser extent, cattle farming are significant, providing a source of income, especially after agricultural losses.
- **Wage Labour:** Many landless or smallholder farmers work as wage labourers in agricultural, fishing, or transport sectors.
- **Small Businesses & Others:** Activities include trading aquatic resources, boat piloting, and, in some areas, extracting stone and sand.

Impact of Flash Floods on Economic Activities

- **Crop Destruction:** Pre-monsoon flash floods cause immense damage to the standing Boro rice, often causing 80-100% loss in low-lying areas.
- **Occupational Shifts:** Due to the devastation of agriculture, farmers are often forced to shift temporarily to other, less profitable occupations, such as day labor or fishing.
- **Asset Loss:** Floods destroy homes, infrastructure, and lead to the loss of livestock and poultry.
- **Increased Vulnerability:** The loss of the primary crop forces households to rely on loans, government aid, or sell livestock for survival, leading to widespread debt.

Adaptation and Mitigation Strategies

- **Early Harvesting & Short Duration Crops:** Farmers are increasingly adopting short-duration, high-yield rice varieties that can be harvested before the flash floods arrive.
- **Diversification:** Shifting from absolute reliance on rice to farming fish, rearing ducks, and growing winter (Rabi) vegetables.
- **Constructing Submergible Embankments:** Building and strengthening ring embankments to protect crops from early floodwaters.
- **Safe Keeping of Assets:** Relocating livestock to higher ground and protecting seeds.
- **Seasonal Migration:** In severely affected years, residents may temporarily migrate to cities like Dhaka or Sylhet for construction work.

Key Challenges

- **Lack of Infrastructure:** Poor communication networks limit market access for goods and services.
- **Insecure Land Tenancy:** Complications with "khas land" (government-owned) and control by local elites affect the poor's access to fishing.
- **Poor Access to Services:** Limited access to education, health, and financial services, which aggravates poverty.

The economy of these areas is highly vulnerable, but potential exists for improvement through better infrastructure, improved flood forecasting, and the adoption of more resilient, diverse, and sustainable agricultural practices.

4.4.3 Physical Infrastructure and Services

(I) Physical Infrastructure and Services of Coastal Area (17 districts)

The coastal districts of Bangladesh (17 districts) rely on an extensive, yet vulnerable, network of physical infrastructure, including over 4,000 km of embankments, polders with sluice gates for flood/saline water protection, and cyclone shelters. Key services include agriculture, aquaculture, and coastal management, but infrastructure suffers from poor maintenance, waterlogging, and climate-induced damage (cyclones, tidal floods).

Physical Infrastructure & Services

- **Coastal Protection (Polders/Embankments):** The Coastal Embankment Project (CEP) built over 4,000 km of embankments and 1,039 drainage sluices to protect from salinity

and surge. These polders are vital for agriculture, but face challenges from siltation and breaches.

- **Emergency Infrastructure:** Many existing cyclone shelters are unsafe due to lack of maintenance, requiring new, high-capacity, multi-use shelters.
- **Transportation:** Emergency access roads in coastal towns are in poor condition, hindering disaster response.
- **Water & Sanitation:** While household sanitation coverage is high (up to 94%), there is a critical lack of septage management, leading to water pollution.
- **Urban Services:** Coastal towns (Pourashavas) struggle with weak infrastructure, including limited waste management, inadequate drainage, and low-efficiency tax collection.

Key Challenges & Vulnerabilities

- **Climate Change:** Increased intensity of storms and sea-level rise threaten the integrity of embankments.
- **Waterlogging:** Siltation of channels causes internal drainage congestion, destroying livelihoods.
- **Limited Maintenance:** Poor maintenance of infrastructure reduces the effectiveness of protection measures.
- **Environmental Degradation:** Coastal ecosystems (mangroves, coral) face pressure from rapid, often unplanned, development.

Development Efforts

- **Coastal Climate Resilient Infrastructure Project (CCRIP)** is improving union/village roads, bridges, and markets to better withstand climate conditions.
- **Coastal Embankment Improvement Project** focuses on strengthening protection systems against tidal floods.
- **Coastal Towns Environmental Infrastructure Project** works on improving sanitation, roads, and drainage.

(II) Physical Infrastructure of Barind Drought prone Areas (16 districts)

The physical infrastructure of the Barind drought-prone districts in Bangladesh—primarily covering parts of Rajshahi, Rangpur, Dinajpur, Bogra, and Naogaon—is heavily characterized by specialized water management systems designed to counter severe water scarcity. The Barind Multipurpose Development Authority (BMDA) has led the development of this infrastructure, shifting the region from a barren landscape to a hub of intensive agriculture, though this has created significant pressure on groundwater resources.

Key components of the physical infrastructure include:

1. Irrigation and Water Management Infrastructure

- **Deep Tubewells (DTWs):** The backbone of Barind's agriculture, with thousands of BMDA-installed DTWs extracting water from deep aquifers. These are increasingly operated by smart cards.
- **Surface Water Re-excavation:** To reduce reliance on groundwater, extensive efforts have been made to re-excavate canals (Kharies) and natural water bodies (Beels) to conserve rainwater and manage runoff.

- **Small-Scale Water Control Structures:** Construction of cross-dams on canals and, in some areas, small-scale irrigation schemes using surface water to irrigate thousands of hectares.
- **Water Distribution Networks:** Pipelines from DTWs and re-excavated channels to distribute irrigation water, with a shift toward underground pipes to reduce water loss.

2. Agricultural and Rural Infrastructure

- **Irrigation-Intensive Agriculture:** Infrastructure supports a high cropping intensity, often exceeding 200%, with a heavy reliance on Boro rice, though this is shifting toward less water-intensive crops.
- **Storage Facilities:** While not detailed extensively, traditional and modern agricultural storage, including small-scale storage for agricultural inputs, exists to support farmers.
- **Re-excavated Ponds/Dighis:** Traditional and restored water bodies, used for irrigation in Rabi seasons and, in some cases, for fish farming.

3. Infrastructure Challenges and Environmental Impact

- **Groundwater Depletion:** The rapid expansion of irrigation infrastructure has caused the water table to drop, in some areas by over 20 meters, limiting the efficacy of shallow tubewells.
- **Infrastructure Sustainability:** The reliance on, and over-exploitation of, groundwater has led to a potential "water emergency," forcing a shift toward surface water harvesting.
- **Lack of Proper Drainage in High Barind:** In higher, undulating areas, the lack of developed, proper drainage systems, combined with clayey soil, makes the land susceptible to both drought (in the dry season) and waterlogging (during heavy monsoons).

In summary, the physical infrastructure is highly engineered to manage water, yet it faces sustainability challenges due to over-reliance on groundwater, prompting a pivot toward infrastructure for rainwater harvesting and surface water storage.

(III) Physical Infrastructure of Haor Flash Flood Area (9 districts)

The physical infrastructure of the haor region in Bangladesh—primarily covering Sunamganj, Sylhet, Moulvibazar, Habiganj, Netrokona, Kishoreganj, and Brahmanbaria—is characterized by its extreme vulnerability to flash floods, which inundate the area for 3 to 6 months annually. The infrastructure is largely designed for adaptation, combining traditional, submersible structures with emerging climate-resilient engineering to withstand high-velocity water flows and wave erosion.

Key Components of Haor Physical Infrastructure

- **Submersible Embankments (Flood Control):** The most critical infrastructure consists of submersible embankments and dykes designed to protect "Boro" rice crops from early-monsoon flash floods (March–April). These are designed to be submerged during the full monsoon, rather than holding back all water, allowing for controlled, seasonal inundation.
- **Elevated Homes and 'Hatis' (Village-Islands):** Settlements, known as 'hatis', are located on elevated land mounds (khanda) to stay above normal flood levels. Recent initiatives involve elevating residential plinths further to create safe, dry spaces during, and after, peak flood, which often protects against "Afal" (high-velocity wave erosion).

- **Submersible Road Network and Connectivity:** Infrastructure improvement projects, such as the HILIP/CALIP funded by IFAD, focus on constructing durable, elevated, and submersible roads (RCC or Brick) to maintain communication during wet seasons.
- **Boat Landing Ghats (Landing Stages):** Due to the six-month, water-locked season, concrete boat landing stages (ghats) are vital infrastructure for transportation and commerce.
- **Water Management Facilities:** This includes the re-excavation of canals, rivers, and *beels* (natural depressions) to improve drainage, alongside the construction of regulators to manage water levels in the wetlands.
- **Community Infrastructure (Shelters):** To improve safety, new projects involve creating multi-purpose community centers and schoolyards that are raised above, or protected from, flood levels to act as safe havens.

Vulnerability and Impact on Infrastructure

- **Wave Erosion (Afal):** During heavy rainfall, strong, wind-driven waves erode the homestead lands of the *hati*.
- **Damaged Roads:** High-velocity flash floods frequently breach sub-marginal roads and embankments.
- **Water Supply Contamination:** A significant portion of shallow tube wells and sanitation facilities become submerged, causing contamination and destroying WASH infrastructure.

Recent Infrastructure Upgrades (2020–2025)

- **Concrete Protection Walls:** New projects, often led by PKSf and GIZ, have implemented 1.5+ km of concrete retention walls around highly vulnerable *hatis* to combat erosion.
- **Green Buffer Zones:** Planting native, flood-tolerant tree species around villages acts as a natural barrier to wave action.
- **Projected Growth:** The Haor Master Plan (up to 2031-32) aims to significantly improve, manage, and protect the infrastructure through integrated water resource management (IWRM).

4.4.4 Socio-Cultural Amenities

(I) Socio-Cultural Amenities of Coastal Area (17 districts)

Socio-cultural amenities in Bangladesh's 17 coastal districts are deeply intertwined with maritime livelihoods, centered around fishing, mangrove-based resources (honey/leaf collecting), and salt farming. Key elements include vibrant community-based festivals, traditional boating, and a reliance on local, natural resources for survival. However, these are heavily impacted by climate-related vulnerabilities like salinity.

- **Key Livelihoods & Culture:** Coastal life relies on fishing, agriculture, and gathering resources from the Sundarbans. Culturally, these communities are closely tied to the sea, using traditional, locally produced, and often vulnerable assets like fishing nets and small boats.

- **Social Structure & Challenges:** The communities are often patriarchal, with social hierarchies limiting the decision-making power of women and poorer residents. Educational levels are low, with many engaging in fishing-related activities.
- **Amenities & Infrastructure:** Key amenities include cyclone shelters, local markets (hats) for selling produce, and community spaces for disaster preparedness. However, these communities face significant threats from cyclones, tidal surges, and increased salinity, impacting their homes, assets, and agricultural land.
- **Tourism Impact:** In areas like Kuakata and Cox's Bazar, coastal tourism is emerging as a major economic activity, although it often suffers from poor community participation, limited infrastructure, and a lack of regulation.
- **Adaptation Mechanisms:** In response to environmental threats, people often rely on local knowledge, such as using cyclone shelters and, in some cases, forming temporary shelters on embankments.

(II) Socio-Cultural Amenities of Barind Drought Prone Areas (16 districts)

Socio-cultural amenities in Bangladesh's drought-prone Barind Tract (Rajshahi, Bogra, Dinajpur, Naogaon) are heavily constrained by water scarcity, affecting daily life, education, and social structures. Key amenities include community-based water harvesting, small-scale livestock rearing (cattle/sheep) as economic assets, and increasing reliance on agricultural diversification like mango farming.

Key Socio-Cultural Features and Amenities

- **Water Management Adaptation:** Due to severe water shortages, community-managed water resources, such as rehabilitated ponds and deep tube wells installed by the BMDA (Barind Multipurpose Development Authority), are essential amenities.
- **Small Ruminant Farming:** Cattle and goats are critical socio-economic assets, especially for indigenous (Santal) communities, used as a safety net during dry seasons.
- **Alternative Livelihoods:** Social amenities are shifting to include drought-resistant agriculture, such as mango and jujube cultivation, and small-scale cottage industries.
- **Social Forestry and Green Infrastructure:** Efforts like the Altadighi National Park development include public amenities such as seating, toilets, and improved pathways, promoting biodiversity and community spaces.
- **Educational Challenges:** Drought impacts education, with many families struggling with school expenses; however, some schools incorporate local and Bengali language learning.
- **Role of Women:** Women are central to managing water scarcity, often walking long distances, and they play a key role in raising small livestock (63% of sheep owners are women).

Social Vulnerabilities

- **Water Crisis Impact:** Women bear the brunt of water scarcity.
- **Economic Inequality:** Many farmers are landless, reducing their capacity to adapt to drought-related crop losses.
- **Resource Depletion:** Over-extraction of groundwater has strained community resources.

These areas rely heavily on local knowledge and, increasingly, on government-backed adaptation projects to sustain their social and cultural fabric.

(III) Socio-Cultural Amenities of Haor Flash Flood Area (9 districts)

Socio-cultural amenities in Bangladesh's flash-flood-prone Haor districts (Sunamganj, Sylhet, Netrokona, etc.) are deeply shaped by the seasonal "wetland" life, with resilience centered on community-based adaptation, localized education, and traditional water-based lifestyles. Key amenities include flood-resilient "killa" (embankments) used as communal space, school-cum-shelters, traditional boat-based transportation, local baul music, and community-managed fisheries (Beels).

Key Socio-Cultural Amenities and Infrastructure

- **Adaptive Infrastructure & Housing:** Due to extreme flash floods (March–May), communities build on raised, earthen, or bamboo-fenced platforms (homesteads). New, climate-resilient, 2-3 storied schools/centers act as temporary, multipurpose flood shelters and communication hubs, often including water-purification, solar-powered units, and livestock shelter.
- **Transport and Connectivity:** Boat-based transportation is the primary amenity during the prolonged monsoon, essential for accessing markets, education, and health services.
- **Social Cohesion and Cultural Events:** Despite frequent hardships, traditional cultural life thrives through boat races (Naichkhela), religious festivals (Boishakhi Mela), and local Baul (folk) music, which serve as crucial social support mechanisms.
- **Healthcare and Sanitation:** Access is limited, with reliance on community-managed health services, NGO initiatives, and mobile health services during crises.
- **Education:** Seasonal education initiatives, including "boat schools," are adapted to the six-month-long submerged conditions to ensure schooling continuity.
- **Local Governance and Disaster Risk Reduction (DRR):** Community-based organizations and village committees are crucial for managing shared natural resources (beels) and operating community-led early warning systems (EWSS) and flood-resilient infrastructure.

These areas, particularly in districts like Sunamganj, frequently experience severe infrastructure damage, making these localized, resilient, and, and adaptive services vital for daily life.

4.4.5 Public health

(I) Public Health of coastal area (17 districts)

Public health in the coastal districts of Bangladesh (Khulna, Barisal, Chittagong) is under severe stress due to climate change-induced salinity intrusion, frequent cyclones, and inadequate water, sanitation, and hygiene (WASH) infrastructure. Key issues include chronic waterborne diseases, hypertension from high salt intake, reproductive health problems, and significant mental health disorders.

Key Public Health Challenges

- **Salinity and Waterborne Diseases:** Shortage of freshwater forces residents to use saline water for drinking, cleaning, and bathing, leading to increased rates of skin diseases, dysentery, and cholera.

- **Hypertension and Reproductive Health:** Long-term consumption of saline water has caused widespread hypertension, particularly in the elderly. Women in coastal areas suffer from irregular periods, severe cramping, and pregnancy-related complications like pre-eclampsia and eclampsia.
- **Climate-Induced Mental Health Issues:** A study in the coastal region indicated high rates of anxiety (25%), depression (22%), and PTSD (20%), often driven by the loss of livelihoods and property due to natural disasters.
- **Nutritional Insecurity:** Coastal areas show high seasonality in food insecurity, with up to 39% of households affected during the monsoon season.
- **Infrastructure Vulnerability:** Frequent cyclones destroy sanitation and water infrastructure, compounding health crises and limiting access to healthcare facilities.

Vulnerable Populations

Children under 5 and individuals over 70 are the most susceptible to waterborne illnesses and nutritional deficiencies, while coastal women bear a disproportionate burden of health issues arising from water scarcity.

Impact on Health Services

While local awareness of health impacts is increasing, resources for health protection and mitigation against environmental risks are limited. Continued reliance on saline-heavy water sources, particularly during the dry season, continues to exacerbate these issues.

(II) Public health of Barind Drought Prone Areas (16 districts)

The Barind region in northwestern Bangladesh (primarily covering parts of Rajshahi, Naogaon, and Chapainawabganj districts) is a high-risk, drought-prone area facing severe public health challenges driven by climate change, extreme water scarcity, and dropping groundwater levels. The region is characterized by a semi-arid climate, low rainfall (often below 1,500 mm), and temperatures frequently exceeding 40°C in the summer.

Key Public Health Impacts

- **Water-Borne Diseases:** Due to the depletion of shallow aquifers, people often rely on unsafe or contaminated water sources, leading to a high prevalence of diseases like dysentery, diarrhea, and cholera, especially among children.
- **Malnutrition:** Droughts reduce agricultural production (specifically rice), causing food insecurity and increased rates of malnutrition and stunted development.
- **Hygiene & Sanitation Crises:** The extreme scarcity of water forces residents, particularly women, to travel long distances for water, affecting household hygiene and menstrual hygiene management.
- **Health Hazards from Heat & Dust:** Rising temperatures and increased dust during prolonged dry spells cause respiratory issues and other health hazards.
- **Contamination:** Lower water tables often lead to increased arsenic concentration in drinking water, posing long-term chronic health risks.

Vulnerable Populations and Contributing Factors

- **Women and Children:** Women and girls bear the brunt of water collection, while children are more susceptible to the diseases and malnutrition caused by the drought conditions.

- **Marginalized Communities:** Poor, landless people in rural areas face the most significant challenges due to the cost of accessing deep tube wells and lack of alternative water sources.
- **Environmental Factors:** The clay soil of the Barind restricts natural groundwater recharge, while the reliance on shallow hand-pumped tube wells makes the population highly vulnerable to drought.

Mitigation and Adaptation Measures

- **Improved Water Infrastructure:** Projects by the Department of Public Health Engineering (DPHE) and Barind Multipurpose Development Authority (BMDA) have installed thousands of deep, subsidized, or solar-powered tube wells and overhead tanks to provide safe drinking water.
- **Agricultural Diversification:** To combat food insecurity, there is a shift from water-intensive rice (Boro) to drought-tolerant crops (wheat, maize, lentils, fruits) and the adoption of water-efficient irrigation methods.
- **Community-Based Management:** Initiatives such as rainwater harvesting and the promotion of Integrated Water Resource Management (IWRM) are being implemented to increase water availability.

Despite these interventions, the region remains a high-vulnerability area where climate change is intensifying drought risks, requiring continuous improvements in water governance and public health infrastructure.

(III) Public Health of Haor Flash Flood Area (9 districts)

The public health situation in the haor (wetland) flash flood districts of Bangladesh—primarily Sunamganj, Sylhet, Netrokona, Habiganj, and Moulvibazar—is critical, characterized by recurrent, severe impacts on community health, sanitation, and nutrition. Flash floods, which frequently occur in March-April, often destroy the only annual Boro rice crop, leading to severe food insecurity, waterborne disease outbreaks, and high levels of psychological distress.

Key Public Health Challenges

- **Waterborne Diseases & Sanitation:** Due to the submergence of tube wells and lack of proper sanitation, the contaminated water supply leads to rampant diseases such as diarrhoea, dysentery, and typhoid. Skin diseases and eye infections are also common among residents forced to live in floodwater.
- **Nutrition and Food Insecurity:** The loss of the Boro crop leaves farmers with no income or food stock, leading to chronic malnutrition, stunting, and wasting in children. Pregnant and lactating women, as well as children under two, are disproportionately affected, with feeding difficulties reported widely.
- **Mental Health Impact:** Flash floods cause high levels of stress, anxiety, and depression. A study on the 2022 flood found that over 85% of respondents in affected areas suffered from moderate to severe psychological distress, with women experiencing higher levels of depression and anxiety.
- **Healthcare Access & Injury:** Infrastructure damage, including the submergence of community clinics, restricts access to health services. Physical injuries and risks of snakebites increase significantly during these events.

Vulnerability and Affected Areas

- **Highest Risk Areas:** Sunamganj is the most severely affected district, with up to 90% of its land submerged in major events, followed closely by Sylhet.
- **Vulnerable Populations:** Poor households, those in remote, hard-to-reach areas, women, adolescent girls, and people with disabilities suffer the most.
- **Key Health Indicators:** Data suggests that in some areas, 100% of residents reported the flash flood as a major, serious health problem.

Mitigation and Response

- **Emergency Needs:** The immediate needs during floods include safe drinking water, water purification tablets, hygiene kits, and emergency food assistance.
- **Coping Mechanisms:** Residents often rely on using sandbags, raising house levels, and consuming stored food, although these measures are often overwhelmed by the scale of the floods.
- **Infrastructure Improvements:** There is an urgent need to improve flood-resilient sanitation facilities, raise tubewells above flood levels, and strengthen community clinics to manage future events.

The 2022, 2024, and 2025 (as of June) floods have highlighted that these regions are facing more frequent and severe, with a direct correlation between excessive rainfall in India's Meghalaya and the intensity of the disasters in the Bangladeshi haor basin.

4.5 Update Scenarios of the Environment of Project and Surrounding Areas

(I) Update Sceneries of the Environment of Project and Surrounding Areas of Coastal Area (17 districts)

The coastal area of Bangladesh is currently undergoing intense environmental and structural shifts as of early 2026, driven by rapid climate change, sea-level rise, and major infrastructure development projects. Key visual elements include the expansion of climate-resilient agriculture, strengthening of coastal embankments, and the impacts of salinity intrusion.

Environmental and Project Updates (2025-2026)

- **Infrastructure & Embankments:** Recent images show significant, ongoing construction to strengthen coastal embankments (e.g., using geo-textile bags) to combat erosion, particularly in the Cox's Bazar and Khulna regions.
- **Mangrove Protection:** Focus is on the Sundarbans, with new initiatives announced in early 2026 to strengthen the conservation of this natural shield against cyclones.
- **Climate-Resilient Agriculture:** New projects are transforming saline-affected land into productive assets, with photos showcasing modern seabass farming and increased shrimp farming in Khulna.
- **Salinity Crisis:** Visual evidence highlights the ongoing drinking water crisis, with women collecting fresh water and elevated structures used for shops to avoid tidal surges.
- **Urban Resilience:** Coastal cities are witnessing projects aimed at mitigating extreme heat and managing waterlogging.

Key Areas Under Development

- **Cox's Bazar:** Development of coastal tourism infrastructure alongside efforts to combat severe sea beach erosion.

- Khulna/Satkhira: Focus on repairing damaged embankments and adapting to saltwater intrusion.
- Hatiya/Moheshkhali: Expansion of mangrove forests and stilt houses for protection.

These areas are frequently impacted by cyclones, with ongoing monitoring of the coastline, which is facing rapid erosion and land loss.

(II) Update Scenarios of the Environment of Project and Surrounding Areas of Barind Drought Prone Areas (16 districts)

Based on reports from late 2025 and early 2026, the Barind Tract in northwestern Bangladesh is facing an intensifying environmental crisis characterized by severe water scarcity, dropping groundwater levels (falling by more than 20 meters in some areas), and increased drought duration.

Below are the updated environmental conditions and project efforts:

1. Environmental Conditions and Landscapes (2025-2026)

- Parched Landscapes: Prolonged dry spells during Falgun and Chaitra (February-April) have left large areas of soil cracked.
- Declining Groundwater: Groundwater, which previously was accessible at shallow depths, is now only available at depths of 40–80 feet in many parts of the Barind tract, with some areas hitting solid, dry red clay.
- Surface Water Scarcity: Natural ponds and streams are drying up, creating water crises for both irrigation and daily domestic use.
- Degraded Soil: The region's dense, hard clay soil makes it difficult for rain to seep into the ground, reducing natural recharge.
- Impacted Agriculture: Due to water shortages, many traditional paddy fields are facing failure, prompting a shift toward drought-tolerant crops.

2. Ongoing Environmental Projects (2025-2026)

To counteract these conditions, several projects (e.g., PKSF's ECCCP-Drought, BMDA initiatives) are actively modifying the environment:

- Re-excavation of Canals & Ponds: In the 2024-25 fiscal year, 122 km of canals and 56 ponds, were re-excavated to create surface water reservoirs, with 22 cross-dams constructed.
- Greening and Afforestation: A 600-kilometre strip forest, a 100-hectare woodlot, and a 50-hectare endangered species garden are being developed, including the planting of 3 lakh palm trees to reduce lightning strikes.
- Irrigation Infrastructure: Installation of 450 deep tube wells, 1,305 km of underground pipelines, and solar-powered irrigation machines.
- Water Management Focus: 140 kilometers of canals are being rehabilitated to increase capacity to store water for irrigation.
- New Agriculture Techniques: Promotion of conservation agriculture, including reduced tillage, crop rotation, and keeping crop residue on fields to retain soil moisture.

3. Surrounding Areas and Villages

- **Water-Stressed Designation:** Nearly 5,000 villages across 25 upazilas in Rajshahi, Naogaon, and Chapainawabganj are severely impacted, with strict government bans on using groundwater for non-drinking purposes.
- **Widespread Inconvenience:** The acute water shortage has forced rural residents, particularly women, to travel long distances for water as local, shallow, and hand-tube wells have dried up.

(III) Update Scenerio of the Environment of Project and Surrounding Areas of Haor flash Flood Area (9 districts)

The Haor region in northeastern Bangladesh—primarily Sunamganj, Sylhet, Habiganj, Netrokona, and Kishoreganj districts—is a unique, ecologically sensitive, bowl-shaped wetland basin that acts as a natural reservoir. It is characterized by severe annual flash floods during the pre-monsoon (April–May) and monsoon (June–September) seasons, driven by heavy rainfall in the adjacent Meghalaya and Assam hills of India.

1. Environmental Characteristics

- **Geological Structure:** The area is a tectonic depression (subsiding at 4 mm to 2.1 cm annually) containing over 400 *haors* (wetlands) and *beels* (permanent water bodies), which form an inland sea during the monsoon.
- **Hydrology:** The region is drained by major rivers like the Surma and Kushiara, and tributaries like the Jadukhata, Manu, and Khowai.
- **Unique Ecosystems:** The landscape includes fresh water swamp forests, reed swamps, and wetlands that are home to immense biodiversity, including migratory birds and specialized fish species.
- **Ecologically Critical Areas (ECA):** Sites like Tanguar Haor are recognized for their environmental importance, although they are heavily threatened.

2. Environmental Impact of Flash Floods

- **"Afal" (Wave Erosion):** Intense flash flood waves, locally called *Afal*, destroy the banks of homestead mounds (*hati*) and cause severe soil erosion.
- **Untimely Flooding:** Early flash floods (March–April) often submerge the standing *Boro* rice crop just before harvest, causing massive economic losses.
- **Siltation:** Increased runoff from deforestation in upstream hilly areas has accelerated riverbed siltation, reduced the water-carrying capacity of rivers and caused them to overflow more frequently.
- **Water Pollution:** Floodwaters often bring in debris, sewage, and agricultural chemicals, impacting water quality in the surrounding, formerly clean, waterbodies.

3. Surrounding Areas and Land Use

- **Settlement Pattern:** Villages (locally called *Hati*) are built on raised earthen mounds that turn into isolated islands during the monsoon.
- **Agriculture:** The economy is heavily dependent on single-crop *Boro* rice cultivation (November–May). The land remains largely fallow during the monsoon.

- Degradation: Unplanned infrastructure development, such as roads and embankment construction, often disrupts natural water flows, exacerbating waterlogging and habitat destruction.

4. Recent Environmental Trends (2024–2025)

- Increased Frequency: The region has experienced unprecedented, record-breaking floods (e.g., 2022 and 2024) that have caused prolonged waterlogging.
- Climate Change Effects: Erratic, high-intensity rainfall in a short period is becoming more common, making flash floods more unpredictable.
- Biodiversity Loss: Swamp forests and fish populations are declining due to overexploitation, pollution, and the loss of natural habitats, with the number of migratory birds plummeting in recent years.

5. Ongoing Protection Measures

- Resilient Infrastructure: Projects (e.g., PKSF, GIZ) are implementing nature-based solutions, such as planting native trees (Hijal, Koroch) to act as bio-shields against wave erosion and building reinforced bank protection.
- Community Management: Initiatives are focusing on community-based, eco-friendly management of wetlands and, in some cases, the creation of fish sanctuaries.

4.6 Project Location

4.6.1 Project Location (with longitude and latitude)

The CDRSSWRMP in Bangladesh, is implemented by the Local Government Engineering Department (LGED).

- Project Area: The project covers 42 districts across Bangladesh.
- Geographical Focus: It is targeted at 4 specific "hotspots" defined by the Bangladesh Delta Plan 2100:
 1. Barind and drought-prone areas (Northwest)
 2. Coastal zone (South)
 3. Haor and flash flood areas (Northeast)
 4. River systems and estuaries.
- Central Office Location: The Project Management Unit (PMU) is located at the LGED Headquarters, Agargaon, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.
- Key Site/Structure: The project includes the modernization of the Bakkhali Rubber Dam (BRD).
- Duration: 2022–2029.

The project focuses on rural, disaster-prone areas and does not have a single coordinate, but operates in 42 districts nationwide (**Table 20**).

Table 20: Project districts (42) with GPS coordinates and area & population

Sl. No.	Project Districts (42 number)	Geographical Coordinates		*Area, km ²	*Population (as of 2022)
		Latitude (N ⁰)	Longitude (E ⁰)		
1	Barguna	22° 9' 2.88" N	90° 7' 35.04" E	1,831.31	1,010,531
2	Barishal	22° 48' 0" N	90° 22' 12" E	2,784.52	2,570,446
3	Bhola	22° 41' 24" N	90° 39' 9" E	3,403.48	1,932,518
4	Patuakhali	22° 21' 15.12" N	90° 19' 5.16" E	3,221.3	7,27,254
5	Chandpur	23° 12' 50.04" N	90° 38' 9.96" E	1,645.32	2,635,748
6	Laksmipur	22° 57' 0" N	90° 49' 30" E	1,440.39	1,937,948
7	Noakhali	22° 42' 0" N	91° 6' 0" E	4,202.0	3,625,442
8	Gopalganj	23° 12' 0" N	89° 48' 0" E	1,468.74	1,295,057
9	Khulna	22° 21' 0" N	89° 18' 0" E	4,394.45	2,613,385
10	Jhalokathi	22° 34' 0" N	90° 9' 0" E	706.76	661,160
11	Pirojpur	22° 34' 48" N	89° 58' 12" E	1,277.80	1,198,195
12	Chattogram	22° 20' 15" N	91° 50' 20.04" E	5,282.92	9,169,464
13	Cox's Bazar	21° 15' 0" N	92° 6' 0" E	2,491.85	2,823,268
14	Bagerhat	22° 40' 0" N	89° 48' 0" E	3,959.11	1,613,076
15	Jashore	23° 10' 1.2" N	89° 12' 32.4" E	2,606.94	3,076,144
16	Narail	23° 7' 48" N	89° 30' 0" E	967.99	788,671
17	Satkhira	22° 21' 0" N	89° 4' 48" E	3,817.29	2,196,582
18	Bogura	24° 46' 48" N	89° 21' 0" E	2,898.68	3,734,297
19	Chapainawabganj	24° 43' 48" N	88° 12' 0" E	1,702.55	1,835,528
20	Natore	24° 24' 36" N	88° 55' 48" E	1,900.19	1,859,922
21	Pabna	24° 0' 28" N	89° 14' 20" E	2,376.13	2,909,624
22	Rajshahi	24° 24' 0" N	88° 30' 0" E	2,407.01	29,13,867
23	Sirajganj	24° 19' 48" N	89° 37' 12" E	2,402.02	3,357,706
24	Gaibandha	25° 15' 0" N	89° 30' 0" E	2,114.77	2,562,233
25	Chuadanga	23° 36' 0" N	88° 42' 0" E	1,174.10	1,234,054
26	Meherpur	23° 45' 0" N	88° 42' 0" E	741.62	705,356
27	Joypurhat	25° 6' 0" N	89° 1' 48" E	965.44	956,431
28	Naogaon	24° 54' 0" N	88° 45' 0" E	38.36	178,635
29	Dinajpur	25° 37' 48" N	88° 39' 0" E	3,444.30	3,315,236
30	Nilphamary	25° 57' 0" N	88° 57' 0" E	1,580.59	2,092,568
31	Panchagar	26° 12' 0" N	88° 20' 24" E	1,404.63	1,179,843
32	Rangpur	25° 44' 0" N	89° 15' 0" E	2,400.56	3,169,614
33	Thakurgaon	25° 57' 0" N	88° 15' 0" E	1,809.52	1,533,276
34	Kishoreganj	24° 26' 0" N	90° 47' 0" E	2,688.53	3,267,626
35	Netrokona	24° 52' 48" N	90° 43' 48" E	2,794.28	2,324,853
36	Habiganj	24° 22' 30" N	91° 25' 0" E	2,636.58	2,358,886
37	Moulvibazar	24° 30' 0" N	91° 50' 0" E	2,799.38	2,123,447
38	Sunamganj	25° 1' 51.13" N	91° 24' 13.54" E	3,747.18	2,695,496
39	Sylhet	24° 53' 0" N	91° 52' 0" E	3,452.07	3,857,123
40	Cumilla	23° 16' 12" N	91° 7' 12" E	3,146.30	6,212,216
41	Kurigram	25° 45' 0" N	89° 39' 36" E	2,245.04	2,329,160
42	Lalmonirhat	26° 0' 0" N	89° 15' 0" E	1,247.37	1,428,406

* Population and Housing Census 2022

4.6.2 Geographical Boundary of the Project Area and Survey Area

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a six-year, IFAD/ADB-funded initiative aimed at increasing climate-resilient agricultural productivity. It covers 42 districts across all eight divisions of Bangladesh.

Geographical Boundary and Scope

The project's geographical coverage is focused on 341 upazilas within 42 districts, targeting four major "hotspots" defined in the Bangladesh Delta Plan 2100:

- Barind and Drought-Prone Areas: Primarily in the northwestern region.
- Coastal Zone: Affected by cyclones and salinity.
- Haor and Flash Flood Areas: Mainly in the northeastern region.
- River Systems and Estuaries: Areas prone to erosion and flood.

Key Project Areas (Districts):

Based on the project's targeting of disaster-prone regions, the 42 districts include:

- **Coastal/Southern:** Satkhira, Khulna, Jashore, Narail, Chuadanga, Meherpur, Bagerhat, Pirojpur, Barguna, Patuakhali, Bhola, Barishal, Jhalokathi, Noakhali, Laxmipur, Chattogram, Cox's Bazar.
- **Barind/Drought/Northern:** Rajshahi, Chapai Nawabganj, Naogaon, Natore, Pabna, Sirajganj, Bogura, Joypurhat, Rangpur, Kurigram, Gaibandha, Nilphamari, Dinajpur, Panchagarh, Thakurgaon, Lalmonirhat.
- **Haor/Flash Flood Regions:** Sylhet, Sunamganj, Moulvibazar, Habiganj, Netrokona, Kishoreganj, Gopalganj, Chandpur, Cumilla.

Survey Area and Focus

The project surveys and targets areas with high vulnerability, particularly:

- 42 Project Implementation Units (PIUs): Headed by LGED executive engineers across the 42 districts.
- Subproject Focus: The project focuses on rehabilitating existing Water Management Co-operative Associations (WMCAs) and developing new ones, including the Bakkhali Rubber Dam subproject.
- Technical Survey: The survey area involves topographic surveys to map water bodies, channels, and infrastructure (e.g., in the Haor region) to build climate-resilient infrastructure.

The project aims to improve 220,000 hectares of land through, for example, enhanced water control, supporting 380,000 households.

4.6.3 Location Indicated Macro Scale Map of Proposed Project, Plan, Photo or Satellite Image

Based on the search results, CDRSSWRMP, is an initiative in Bangladesh, implemented by the Local Government Engineering Department (LGED) with Asian Development Bank (ADB) and IFAD support.

Project Location and Scale

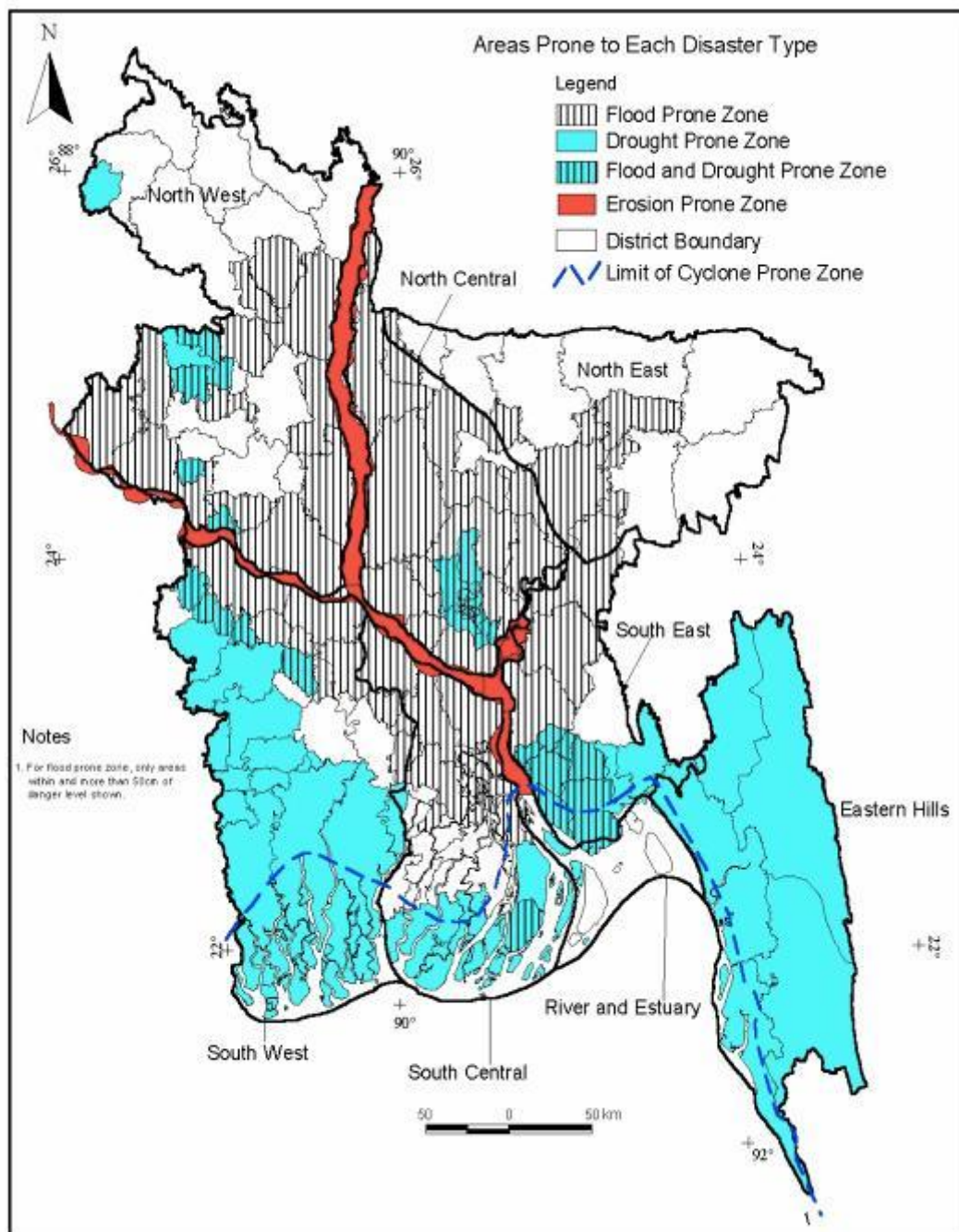
- Target Area: The project operates across 42 of the 64 districts in Bangladesh.

- **Geographical Focus:** It covers four main "hotspots" identified in the Bangladesh Delta Plan 2100: (i) Barind and drought-prone areas, (ii) the coastal zone, (iii) the haor and flash flood areas, and (iv) river systems and estuaries.
- **Key Site:** The project includes the urgent rehabilitation of the Bakkhali Rubber Dam.
- **Project Scope:** The project aims to establish 150 new, and improve 230 existing, water management subprojects, covering over 220,000 hectares.

Macro Scale Map and Target Regions

The project operates in specific zones vulnerable to climate change, spanning most of the country.

- **Figure 13:** Map of Disaster-Prone Areas (Reference for Project Areas): The project focuses on areas in the Northwest (drought-prone/Barind), Northeast (haor/flash flood areas), and Coastal zones (salinity-prone).
- **Figure 14:** Saline Zone Map (Reference for Coastal Subprojects): A significant portion of the project targets the saline-affected coastal districts of Khulna, Barisal, Patuakhali, Noakhali, and Chittagong.



Source: South Asian Disaster Knowledge Network

Figure 13: Map of Disaster-Prone Areas

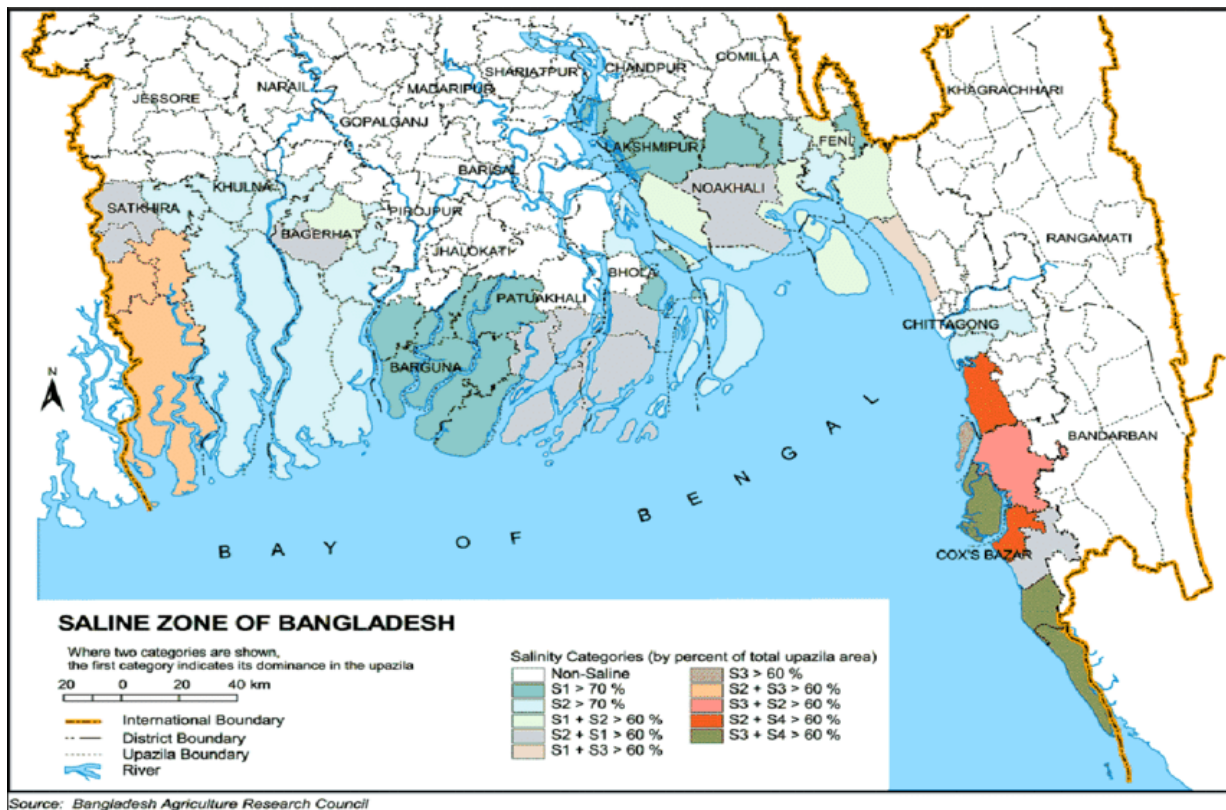


Figure 14: Saline Zone of Bangladesh

Project Plan and Infrastructure Components

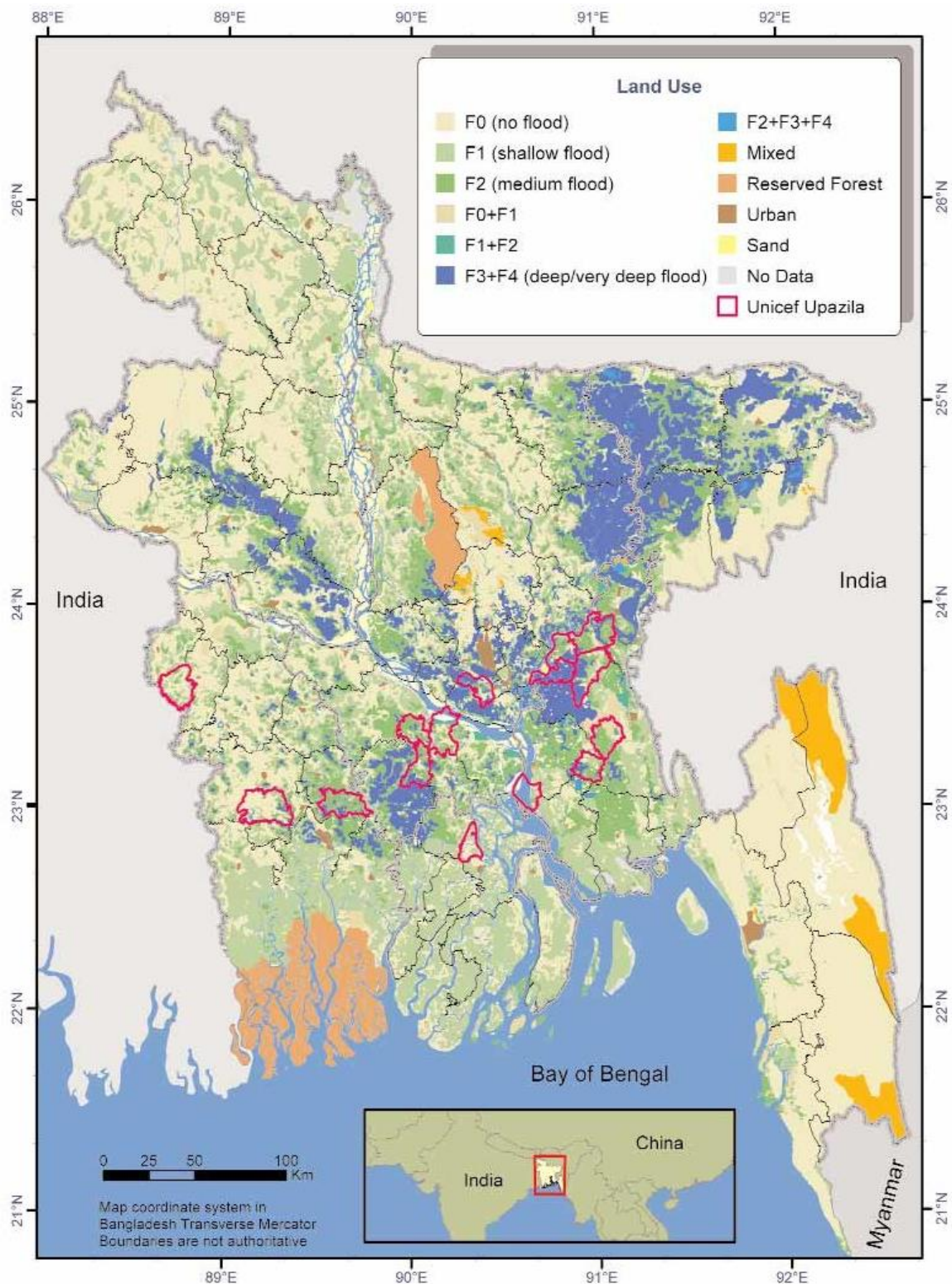
The project focuses on creating climate-resilient water infrastructures, including:

- Canal Excavation/Re-excavation: To improve drainage and water conservation.
- Small-scale Water Resources (SSWR) Infrastructure: Construction of regulators, sluice gates, and embankments.
- Agricultural Support: Rehabilitation of the Bakkhali Rubber Dam and construction of 110 kilometers of farm access roads.
- Water Management Cooperative Associations (WMCAs): Strengthening community-based management (150 new WMCAs).

For detailed, high-resolution satellite imagery or specific site plans for individual subprojects, it is recommended to refer to the LGED Integrated Water Resources Management Unit (IWRMU) project documents.

4.6.4 Colored readable land use map

The image can be used to realize the existing environmental condition

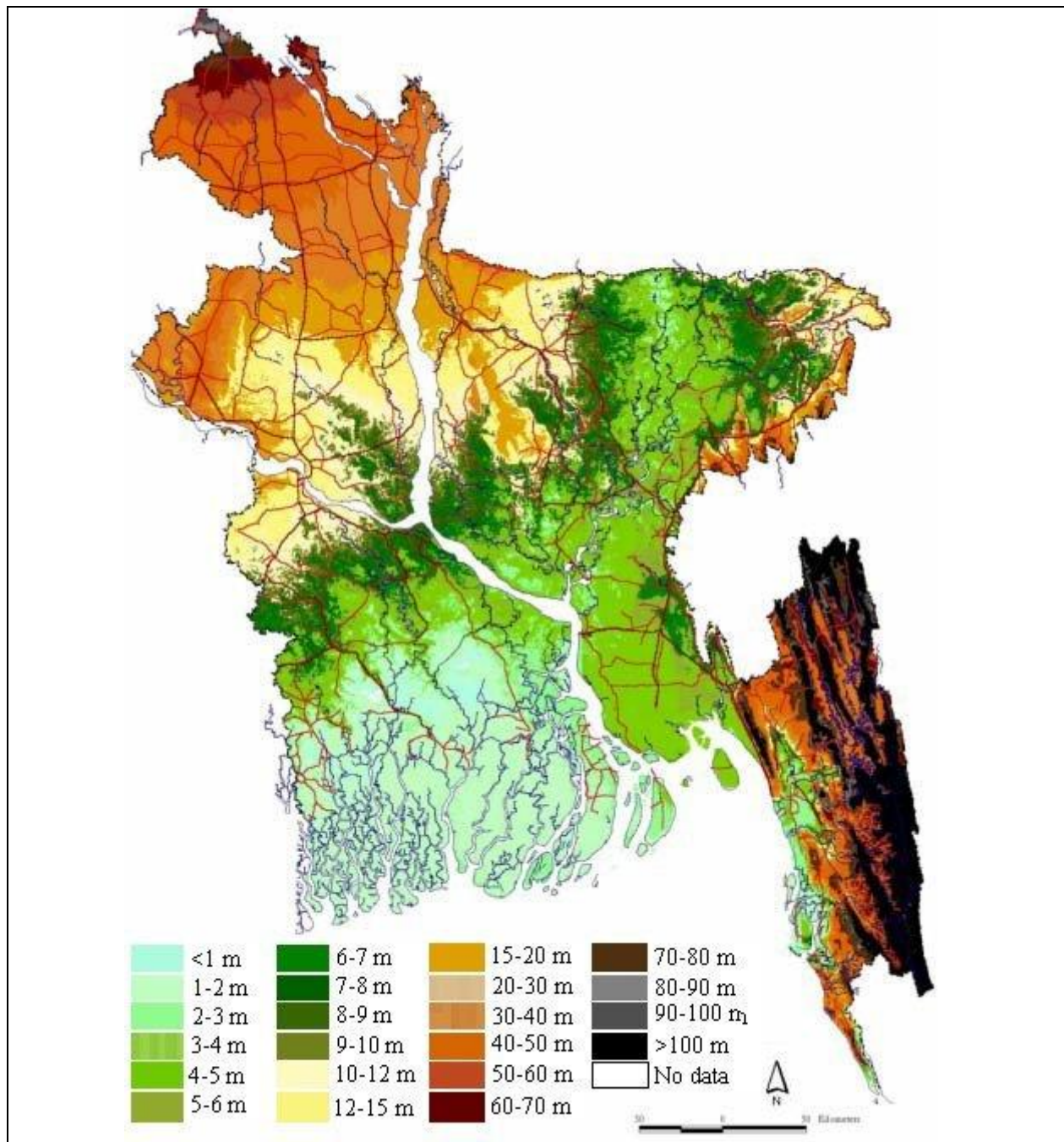


Source: ResearchGate, uploaded by Jan Willem Rosenboom

Figure 15: land use map of Bangladesh

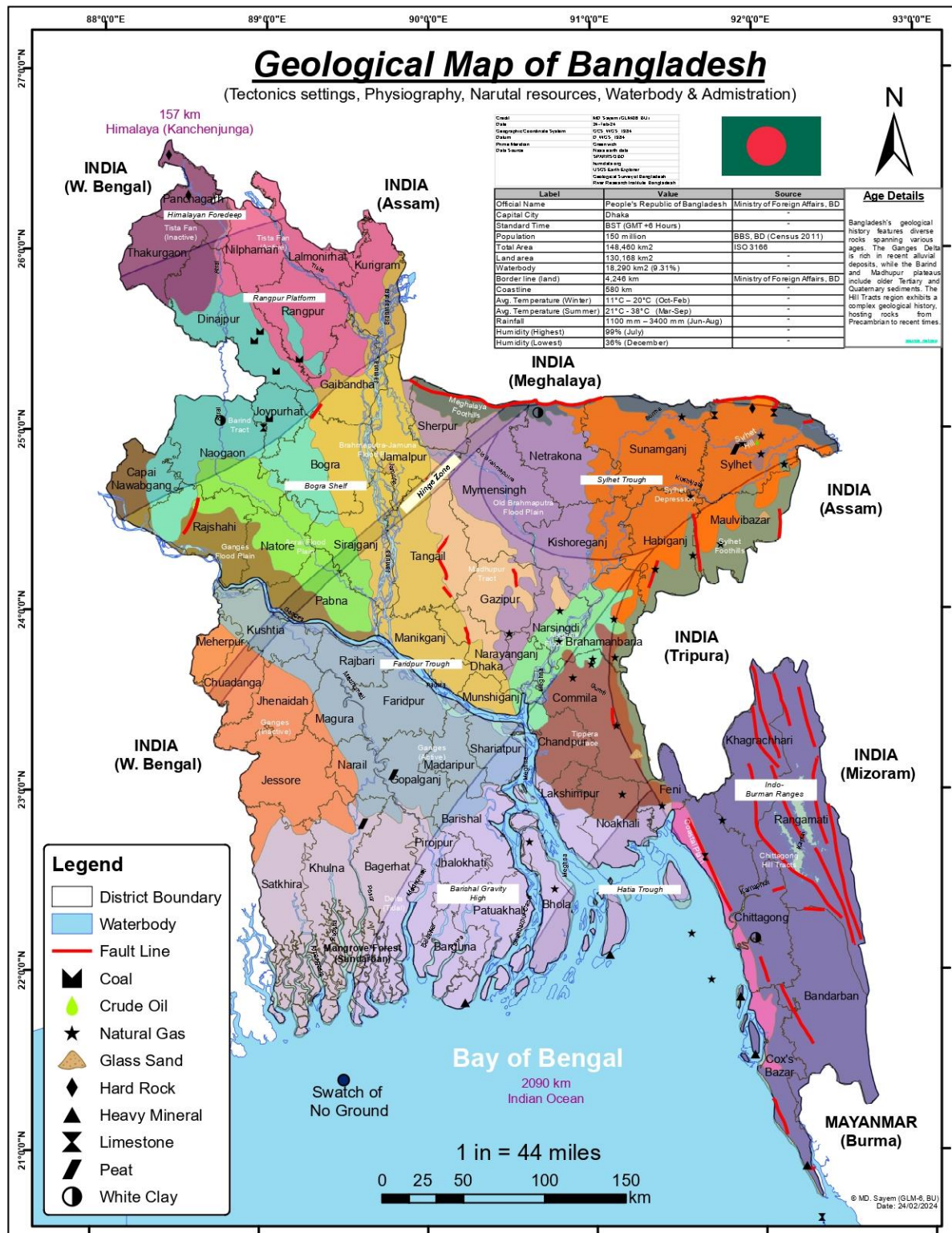
4.7 Other any Map Like Topography, Geological and Hydrological

Other any map like topography map, geological map, hydrological map etc. has been used to make understanding the existing environmental condition based on the nature of the proposed project.



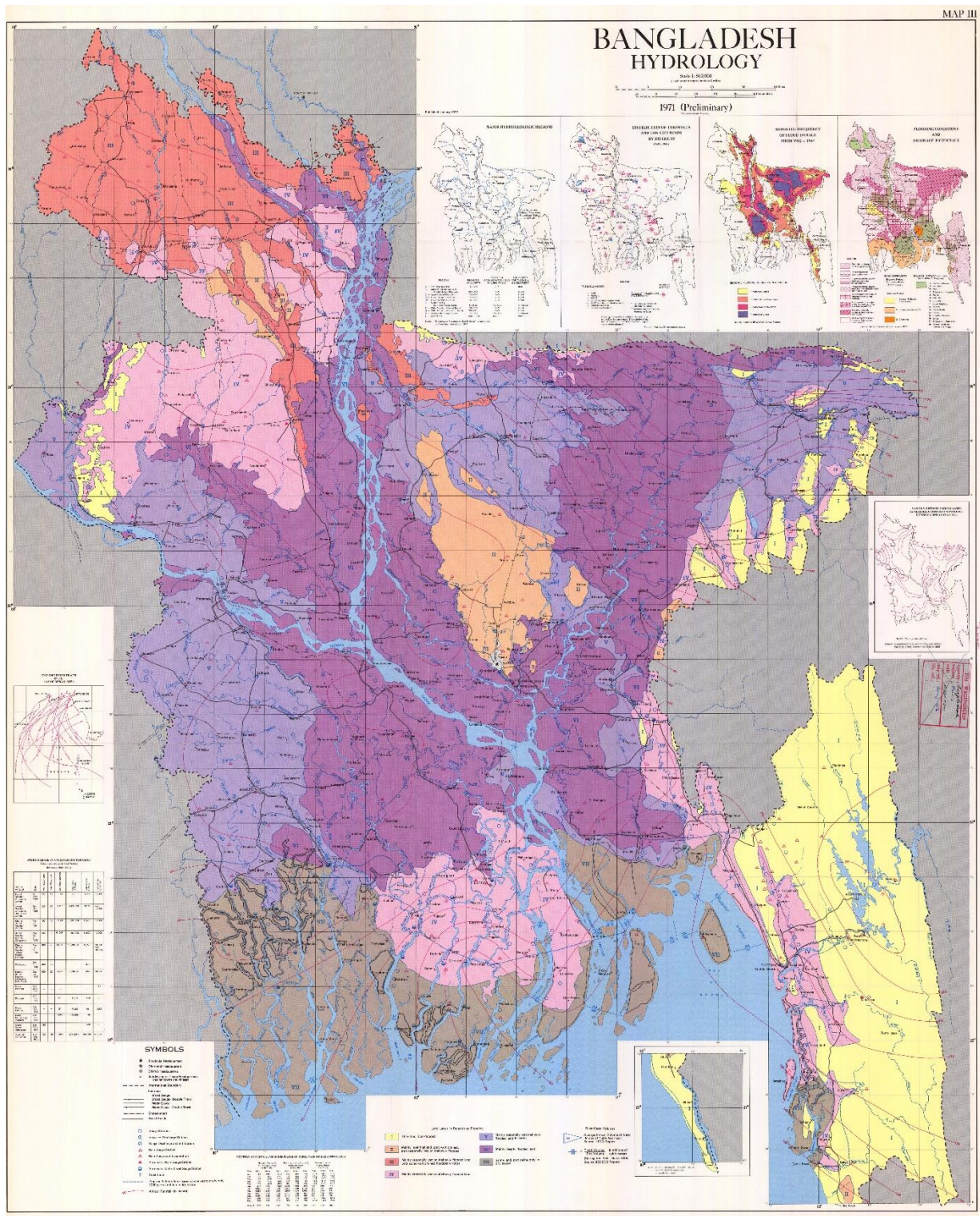
Source: ResearchGate, uploaded by Md. Abdul Awal

Figure 16: Topographic Map of Bangladesh



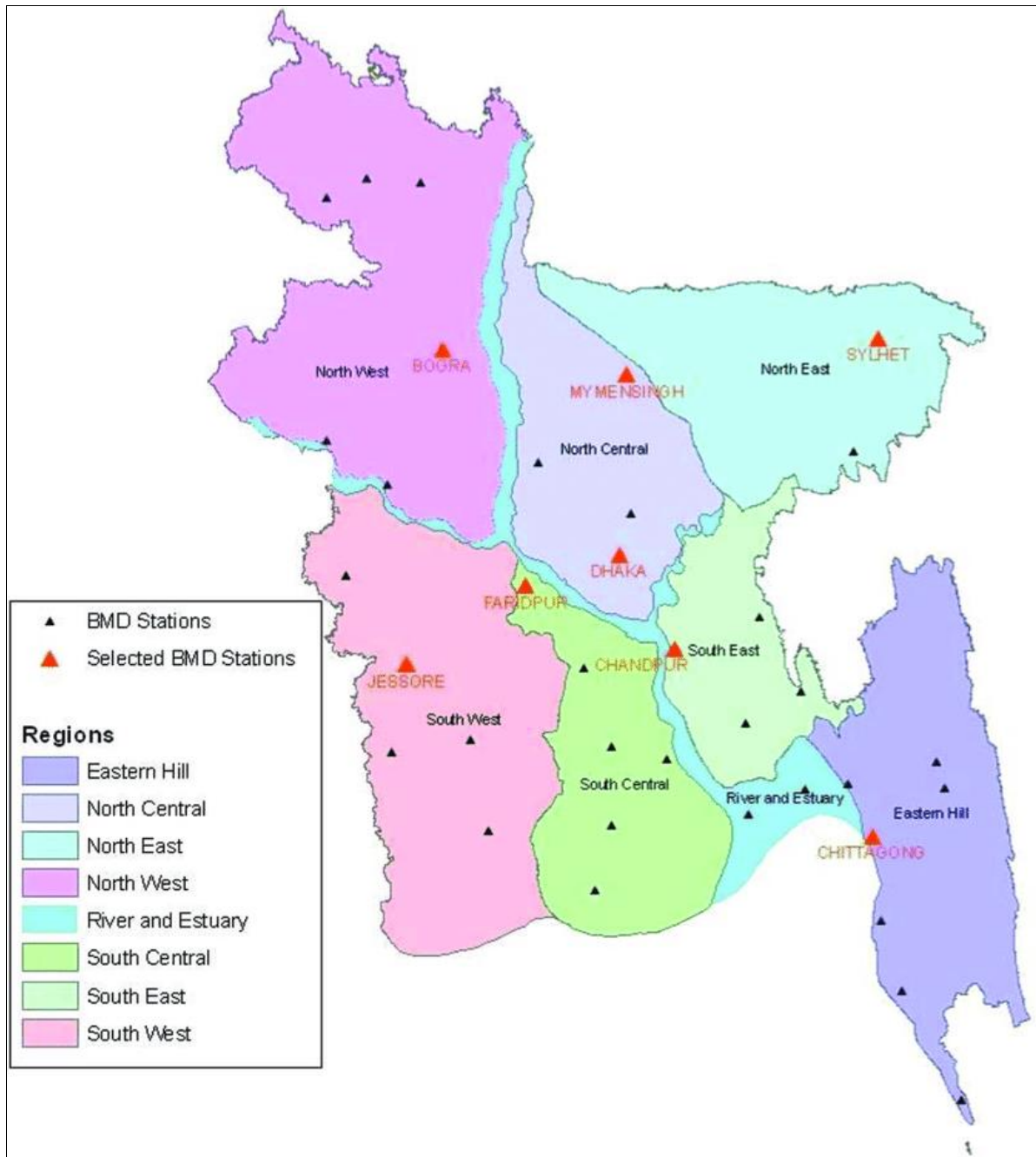
Source: <https://drive.google.com/.../1ltKLCRQNX7qTkeTY5uNRV.../view>

Figure 17: Geological Map of Bangladesh



Source: European Soil Data Centre (ESDAC)

Figure 18: Hydrological Map of Bangladesh



Source: ResearchGate, uploaded by Ashild Kolas

Figure 19:Hydrological Regions of Bangladesh

5 ENVIRONMENTAL IMPACT PREDICTION AND EVALUATION

5.1 Impact Identification:

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is designed to strengthen community resilience and enhance livelihoods against climate-induced hazards. Key impacts, primarily supported by

IFAD and ADB, include enhancing food security, promoting climate-resilient agriculture, and improving institutional capacity for water management across 42 districts.

Key Impacts and Identification Areas:

- **Livelihood Improvement and Economic Growth:** The project focuses on increasing income for approximately 380,000 households, including 45,000 landless or vulnerable households, by enhancing agricultural and fishery agribusinesses. Impact studies from similar projects (like CCRIP) indicate that such interventions can lead to over 100% increases in crop sales and over 50% in fish sales for participants.
- **Climate-Resilient Infrastructure:** The project supports the construction of infrastructure to combat hazards like flooding and salinity intrusion, benefiting over 220,000 hectares. This includes rehabilitating or building new water management infrastructure, such as small-scale embankments, water control structures, and re-excavated canals.
- **Institutional Capacity Building:** A core impact is the establishment and strengthening of 150 new Water Management Cooperative Associations (WMCAs) and the bolstering of 230 existing ones to ensure sustainable operation and maintenance of local water resources.
- **Agricultural Adaptation:** The project promotes climate-smart agricultural practices to address issues like waterlogging, drought, and salinity, which have previously caused significant agricultural losses. This includes introducing new, resilient crop varieties and diversifying farming systems.
- **Social Inclusion and Women Empowerment:** The project targets the inclusion of women, youth, and small ethnic communities, with targets for women in leadership positions within WMCAs and increased income through Labour Contracting Societies (LCS).
- **Risk Management and Reduction:** The project directly addresses high risks in four major "hotspots"—the Barind region (drought-prone), the coastal zone, the haor (flash flood) areas, and river systems—to reduce the vulnerability of rural communities to climate change.

The project is aligned with the Bangladesh Delta Plan 2100 and the Eighth Five-Year Plan, focusing on transforming vulnerable coastal and rural communities into resilient ones.

Table 21: Environmental Impacts of Proposed New Subproject Type

Environmental Impacts and Mitigation Measures of Subproject Types	
Subproject Type-1	Drainage & water conservation in Barind hot spot
Environmental Impacts	Impacts of Drainage Positive: • Improved Soil: Better aeration, bacterial activity, and tilth; reduced compaction and erosion. • Increased Productivity: Better field access for machinery, enabling higher yields and more profitable crops. • Reduced Runoff: Less surface runoff, sediment, and associated contaminants (pesticides, phosphorus). Negative (Traditional Drainage):

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Nutrient Loss: Increased loss of nitrogen (N) to surface waters, contributing to algal blooms (e.g., Lake Erie). • Water Quality: Can exacerbate water quality issues downstream due to nutrient leaching. Impacts of Water Conservation Positive: • Reduced Demand: Significant reduction in overall water use and wastewater generation. • Lower Stress: Alleviates water stress on municipal systems and water supplies. Challenges: • Concentrated Pollutants: Lower water volumes mean higher concentrations of pollutants (COD, nitrogen, phosphorus) in remaining wastewater, stressing treatment plants. System Adaptation: Requires changes in wastewater treatment and infrastructure to handle altered flow patterns and pollutant loads.
Mitigation Measures	Drainage Impact Mitigation Measures • Structural/Nature-Based Solutions: ○ Constructed Wetlands/Buffer Zones: Create natural filtration areas to slow runoff and remove pollutants. ○ Sedimentation Ponds/Traps: Capture sediment and pollutants before they enter waterways. ○ Two-Stage Channels: Design ditches with flatter sides to reduce erosion and improve habitat. ○ Green Infrastructure: Incorporate green roofs, permeable pavements, and rain gardens to absorb stormwater. • Infrastructure & Management: ○ Dredging & Upgrades: Clean out main canals and improve irrigation infrastructure to enhance flow. ○ Leak Detection: Use advanced technology (acoustic sensors, smart meters) to find and fix leaks in distribution systems. ○ Pressure Management: Control water pressure to prevent pipe bursts. ○ Floodplain Management: Restore natural floodplains and overland flow areas. • Policy & Planning: ○ Integrated Urban Planning: Coordinate with local governments and planners to implement drainage solutions. ○ Community Engagement: Involve the public in planning and maintenance. Water Conservation Mitigation Measures • Household/Individual Actions:

Environmental Impacts and Mitigation Measures of Subproject Types	
	○ Behavioral Changes: Shorter showers, turning off taps while brushing, full dishwasher/washing machine loads. ○ Water-Saving Devices: Install low-flow showerheads, toilets, and faucet aerators. ○ Rainwater Harvesting: Use rain barrels (water butts) to collect water for gardens. • Agricultural Practices: ○ Efficient Irrigation: Switch to drip or sprinkler systems, optimize irrigation schedules, and select drought-resistant crops. ○ Soil Management: Improve soil health to increase water retention. • Systemic/Technical Solutions: ○ Leak Reduction: Repair leaks in distribution systems, which can account for significant water loss. ○ Water Reuse: Treat and reuse greywater or treated wastewater where appropriate. ○ Smart Metering & Tariffs: Implement policies to monitor usage and price water appropriately. Overlapping Mitigation Strategies • Integrated Water Management: Combine drainage and conservation for holistic benefits, such as reducing deep percolation to save water and minimize drainage. • Pollution Control: Prevent pollutants (fats, chemicals, medicines) from entering drains and sewers through education and better disposal practices. • Source Reduction: Focus on reducing water demand and pollution at the source through efficiency and responsible usage.
Subproject Type-2	Flood management and drainage and water conservation in Barind
Environmental Impacts	Positive Impacts • Flood Prevention and Risk Reduction: The primary benefit is the reduction of risk to human life, property, and infrastructure by controlling water flow through methods like dams, embankments, and improved drainage systems. • Increased Agricultural Productivity: Controlled irrigation and improved drainage prevent waterlogging and allow farmers to plant high-yield variety crops, expanding cropping areas and increasing food production. Seasonal floods, when managed, can also deposit nutrient-rich silt, improving soil fertility. • Water Supply and Availability: Water conservation through dams and reservoirs ensures a stable water supply for drinking, agriculture, and industry, especially during drought periods. • Groundwater Recharge: Natural flood management techniques, such as wetland preservation and reconnecting rivers with floodplains, can enhance water retention capacity and aid in recharging groundwater aquifers. • Improved Public Health and Sanitation: Effective drainage systems remove wastewater and sewage, reducing the risk of water-borne diseases

Environmental Impacts and Mitigation Measures of Subproject Types	
	that often spread during flood events caused by contaminated water sources. • Economic and Developmental Benefits: Flood-free land is available for settlement, industry, and infrastructure development, which can lead to significant economic growth and increased food security. • Ecosystem Services: Well-managed wetlands and other natural features can purify water by removing pollutants like nitrogen, supporting healthy aquatic ecosystems. Negative Impacts and Challenges • Environmental and Ecosystem Damage: Large-scale flood control projects like embankments can disrupt natural hydrology, alter river geomorphology, and damage habitats, leading to a decline in fish populations and biodiversity. • Pollution Runoff: Rapid water runoff from artificial drainage systems in urban or agricultural areas can carry pollutants, chemicals, and debris into natural water bodies, contaminating both surface water and groundwater. • Over-drainage: Improperly managed systems can excessively dewater soil, lowering local water tables, impacting plant growth, and compromising wetland ecosystems. • High Cost and Maintenance: The construction and ongoing maintenance of complex drainage and flood management infrastructure require significant financial investment and technical expertise. • Social and Economic Disruption: While the goal is protection, some projects can displace communities, and poorly planned interventions can lead to conflicts over resource use, such as between farmers and fisherfolk. • Infrastructure Limitations: Drainage systems can be overwhelmed by extreme weather events, such as heavy, intense rainfall or flash floods, when the volume of water exceeds their capacity.
Mitigation Measures	Structural and Green Infrastructure Measures These physical measures focus on altering water flow and quantity, incorporating environmentally sensitive design. • Retention and Detention Basins: Developing basins and small reservoirs to temporarily store excess rainwater and release it gradually, lowering peak discharge rates and allowing groundwater recharge. • Floodplain and Wetland Restoration: Restoring natural floodplains and wetlands to act as natural buffers, absorbing excess water, filtering runoff, reducing erosion, and creating wildlife habitats. • Green Infrastructure/Low Impact Development (LID): Utilizing techniques in urban areas that mimic natural hydrology, such as permeable pavements, rain gardens, green roofs, and bioswales, to increase water infiltration and reduce surface runoff. • River Channel and Embankment Management: Regularly dredging and desilting river channels to maintain water-carrying capacity, and installing proper, often vegetated, bank protection to reduce erosion. • Modernized Drainage Systems: Upgrading and ensuring regular maintenance of urban drainage and sewage treatment systems to prevent

Environmental Impacts and Mitigation Measures of Subproject Types	
	blockages and handle increased capacity, incorporating smart drainage where feasible. • Water Conservation Infrastructure: Implementing rainwater harvesting systems at community and household levels to reduce surface runoff and supplement water supply. Non-Structural and Policy Measures These measures focus on planning, policy, and community behavior to reduce vulnerability and enhance resilience. • Land-Use Planning and Zoning: Enforcing strict regulations to limit or prevent new development in high-risk floodplains and low-lying areas, preserving land for natural flood management. • Early Warning Systems: Implementing and improving real-time monitoring and early warning systems to provide timely information to communities, allowing for prompt emergency response and evacuation planning. • Building Codes and Floodproofing: Mandating flood-resilient building standards for new constructions (e.g., elevating critical utilities and the lowest habitable floor) and encouraging property-level protection measures like backflow valves and barriers. • Public Awareness and Education: Conducting campaigns to inform the public about flood risks, evacuation routes, and personal preparedness measures (e.g., creating emergency plans, obtaining flood insurance). • Integrated Water Resources Management: Adopting a holistic planning approach across the entire river basin that coordinates policies across sectors (e.g., urban development, agriculture, environmental protection) and considers both water quantity and quality issues. • Ecosystem Restoration: Protecting and restoring upstream forests and promoting sustainable land management to enhance natural water retention and prevent soil erosion and sedimentation downstream.
Subproject Type-3	Drainage and Tidal irrigation in southern coast hot spot
Environmental Impacts	Flood Management and Drainage Impacts Flood control and drainage (FCD) projects, such as those involving the construction of embankments and sluice gates, aim to control water levels and reduce flood risk. Positive Impacts: • Protection of Life and Property: The primary benefit is reducing hazards from extreme floods and tidal surges, saving lives, homes, and infrastructure. • Increased Agricultural Production: A controlled water environment enables farmers to plant high-yield variety (HYV) crops and allows for the expansion of cropping areas and periods, significantly increasing food yields and cropping intensity. • Enhanced Land Use: Secure, flood-free land becomes available for settlement, livestock, industry, and infrastructure development. • Groundwater Recharge: Normal, managed flooding can contribute to the recharge of groundwater aquifers.

Environmental Impacts and Mitigation Measures of Subproject Types	
	Negative Impacts: • Environmental Degradation and Siltation: Embankments impede natural water flow and the deposition of nutrient-rich sediments on floodplains, leading to soil degradation, increased dependence on chemical fertilizers, and heavy siltation in riverbeds, which reduces natural drainage capacity. • Fisheries Decline: Obstruction of fish migration by sluice gates and changes in hydrological regimes lead to a significant decline in open-water fisheries, impacting a key protein source and the livelihoods of fishing communities. • Waterlogging and Salinity Intrusion: Poorly designed or maintained drainage systems can cause severe waterlogging and, in coastal areas, increased soil salinity, which damages crops and alters the local social structure. • Disease and Health Issues: Stagnant, polluted water sources resulting from poor drainage can increase the incidence of waterborne diseases like cholera and malaria.
	Tidal Irrigation Impacts Tidal irrigation involves managing water flow using the natural rhythm of tides, often within polder systems, to bring in fresh water or drain excess water. Positive Impacts: • Natural Sedimentation: Tidal river management (TRM), a form of tidal irrigation, can intentionally use sediment-laden tidal water to raise the land elevation in low-lying areas, alleviating land subsidence and improving long-term flood protection and agricultural potential. • Soil Management: Tidal flows can help flush soils of accumulated salts in coastal areas, which can be detrimental to plant growth if not removed. • Water Management Efficiency: When properly managed, it helps in regulating irrigation water, removing excess water, and preventing saltwater intrusion into agricultural land. Negative Impacts: • Disruption During Implementation: The implementation of TRM requires agricultural activities to cease for a few years in the designated area, causing short-term economic hardship for farmers. • Salinity Increase and Inundation Risk: Unplanned or poorly managed tidal systems can lead to increased salinity intrusion, riverbank erosion, and the inundation of built-up areas if dykes or sluice gates are compromised or inadequately designed. • Infrastructure Damage: The dynamic nature of tidal flows can place stress on diversion structures, requiring regular maintenance and increasing the risk of structural failure.
Mitigation Measures	For Flood Management and Drainage Impacts Impacts such as altered flow regimes, habitat loss, and community displacement can be mitigated using the following measures:

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Integrated planning and design: Adopt a holistic approach to water management that considers the entire river basin and incorporates environmental flows in project design and operation. • Use of natural infrastructure (Green Infrastructure): Preserve and restore natural flood buffers like wetlands, floodplains, and forested areas (afforestation) to absorb excess water, slow runoff, and improve biodiversity. • River restoration: Re-meander straightened rivers to increase their length and delay flood flow downstream, which also helps restore natural habitats. • Improved infrastructure maintenance: Conduct regular maintenance (e.g., de-silting, clearing debris) of existing drainage systems and channels to ensure they perform efficiently and prevent blockages. • Land-use planning and zoning: Implement strict zoning regulations to restrict new construction in high-risk floodplains and encourage flood-resilient building codes (e.g., elevating structures above flood levels). • Early warning and preparedness systems: Enhance flood forecasting and warning systems to provide timely alerts, allowing communities to implement personal emergency plans and minimize loss of life and property. • Community engagement and social action plans: Engage local communities in the planning and decision-making processes. Develop social impact assessments and provide adequate compensation or alternative livelihood opportunities (e.g., promoting culture fisheries) for those affected by land-use changes or displacement.
	For Tidal Irrigation Impacts Tidal irrigation schemes can lead to issues like soil salinity, changes in inter-tidal areas, and impacts on aquatic life. Mitigation measures include: • Tidal River Management (TRM): Utilize TRM techniques, where tidal water is intentionally allowed into a designated basin (beel) to deposit sediment, which helps to raise the land and reduce waterlogging in the long run. • Water quality management: Monitor and treat runoff and seepage to prevent contamination of receiving water environments. • Soil management: Implement strategies to mitigate soil erosion, such as minimizing ground clearance during construction and replanting disturbed areas with appropriate vegetation. In areas prone to saline water intrusion, manage irrigation to minimize negative impacts on agricultural land. • Biodiversity protection: Design schemes to minimize the impact on fish, invertebrate, and bird populations by maintaining environmental flows downstream of control structures. • Optimized water use: Employ water-efficient irrigation technologies like drip or micro-irrigation systems to decrease water usage and reduce the risk of waterlogging.
Subproject Type-4	Drainage & Tidal irrigation (DR& TIRR) in south coastal hot spot
Environmental Impacts	Positive Impacts (Benefits) • Agricultural Productivity: Protects crops, enables year-round farming, and expands cultivable land.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Reduced Flood Hazards: Decreases property damage, infrastructure loss, and loss of life during floods. • Economic Stability: Protects businesses and reduces post-flood recovery costs, ensuring more consistent economic activity. • Improved Accessibility: Ensures all-year access to land and transport routes. Negative Impacts (Drawbacks) • Ecological Damage: ○ Habitat Loss: Embankments block wetlands, reducing fish migration and dispersal routes, harming fisheries. ○ Nutrient Loss: Prevents floodwaters from depositing fertile silt, reducing natural soil fertility. ○ Ecosystem Changes: Leads to monoculture, loss of natural pest control, and increased agrochemical runoff. ○ Hydrological Alterations: Changes natural water flow and soil moisture. • Socioeconomic Consequences: ○ Livelihood Loss: Harms fishers and water transport workers, often pushing poor communities further into poverty. ○ Land Market Shifts: High market prices encourage poor farmers to sell land, making them laborers. ○ Cultural Impact: Loss of traditional water-based festivals and heritage. • Agricultural Issues: ○ Increased Input Costs: Higher dependence on chemical fertilizers and pesticides. ○ Reduced Diversity: Decreased production of supplementary crops and increased waterlogging. • Drainage System Failures: Malfunctioning urban drainage can cause sewer and surface flooding, even in well-designed systems. Sustainable Solutions (Integrated Flood Management) • Ecosystem Approach: Integrates land, water, and living resource management, considering ecosystem health alongside flood control. • Natural Flood Management (NFM): Uses natural solutions like slowing water flow upstream to reduce downstream flood risk and improve drainage performance. • Public Awareness: Educating communities on flood risk and behavior adaptation is crucial for effective management.
Mitigation Measures	Key Strategies 1. Structural Measures:

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Drainage Improvement: Regular dredging, desilting, and upgrading stormwater systems (canals, pipes) to handle larger volumes of water, incorporating future climate projections. • Water Diversion & Storage: Creating reservoirs, detention ponds, and channels to divert floodwaters away from populated areas. • Barriers: Building floodwalls, levees, and embankments to physically contain river flows. • Flood-Proofing Buildings: Raising structures, sealing entry points (stop-boards), and installing backflow valves in homes. 2. Non-Structural Measures & Green Infrastructure: • Floodplain Management: Restricting development in floodplains and restoring natural floodplains/wetlands to absorb water. • Green Infrastructure (GI): Using permeable pavements, rain gardens, and vegetated swales to manage stormwater where it falls (Low Impact Development - LID). • Ecosystem Restoration: Protecting forests, mangroves, and wetlands that naturally regulate water flow and reduce erosion. • Flood Warning Systems: Implementing early warning systems for timely evacuation and preparedness. 3. Planning & Design: • Advanced Modeling: Using GIS and hydrological models to predict risks and design resilient infrastructure. • Climate Adaptation: Designing systems to withstand future extreme weather events. • Maintenance: Consistent upkeep of drainage systems and natural watercourses to maintain performance.
Subproject Type-5	Drainage & water conservation (DR & WC) in sought coastal hot spot
Environmental Impacts	Positive Impacts of Drainage (When managed) • Improved Soil Health: Reduces waterlogging, improves soil structure (tilth), and aeration for roots. • Increased Productivity: Allows for timely fieldwork, longer growing seasons, better nutrient uptake, and higher crop yields. • Reduced Erosion: Can decrease surface runoff and associated sediment loss, especially with subsurface drainage. Negative Impacts of Drainage (Especially Uncontrolled/Excessive) • Water Pollution: Rapid water movement bypasses natural filtration, carrying excess nutrients (nitrogen, phosphorus), pesticides, and sediment into rivers, leading to eutrophication (algal blooms, oxygen depletion).

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Habitat Loss: Increased sediment smothers stream beds, harming aquatic insects and fish. Diverting water can dry out wetlands, destroying habitats. • Greenhouse Gases: Drained soils can release more greenhouse gases and potentially impact soil organic carbon storage. • Salinization: In irrigated areas, poor drainage can lead to salt buildup in soils, making land unusable.
Mitigation Measures	Water Conservation Drainage (Mitigation & Benefits) • Controlled Drainage: Uses automated structures to hold water in fields during dry periods and release it slowly, reducing nutrient and sediment loss. • Buffer Strips: Vegetated areas alongside water bodies filter pollutants from runoff. • Reduced Nutrient Load: Significantly lowers nitrogen and phosphorus leaching, preventing harmful algal blooms. • Climate Change Adaptation: Helps manage water variability, making systems more resilient.
Subproject Type-6	Water Conservation (WC) in east coastal hot spot
Environmental Impacts	Key Environmental Impacts • Ecosystem Protection: ○ Maintains water levels in rivers, lakes, and wetlands, preserving habitats for fish, otters, and other wildlife. ○ Protects biodiversity by keeping natural water bodies healthy and supporting aquatic food chains. • Energy & Climate Benefits: ○ Less water use means less energy for pumping, heating, and treating water, reducing carbon footprints and greenhouse gas emissions. ○ Can mitigate climate change by protecting carbon-storing ecosystems like peatlands and forests. • Improved Water Quality: ○ Reduces the volume of wastewater, lessening the burden on treatment plants and preventing pollutants from entering waterways. ○ Helps keep natural water sources cleaner for all users. • Sustainable Agriculture & Land Use: ○ Ensures water availability for crops and livestock, preventing food shortages and supporting farmer resilience. ○ Discourages harmful practices like deforestation, which is often driven by water scarcity.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Reduced Infrastructure Strain: ○ Lowers the need for expanding energy-intensive water infrastructure (dams, pipelines), preventing environmental disruption. • Drought Mitigation: ○ Increases water supply resilience, helping communities and ecosystems cope with water shortages and drought.
Mitigation Measures	Key Strategies for Mitigation • Energy & Emissions Reduction: ○ Conserve energy: Using less water means less energy for pumping, heating, and treatment, cutting carbon footprints. ○ Smart Infrastructure: Fixing leaky pipes and installing smart meters reduces water loss and energy needed for supply. • Pollution Prevention: ○ Reduce chemical runoff: Minimize fertilizers, pesticides, and harsh cleaners from homes and agriculture. ○ Proper disposal: Don't pour fats, oils, grease, chemicals, or medications down drains or toilets. ○ Wastewater management: Reuse treated wastewater and reduce polluted discharges into waterways. • Ecosystem Protection: ○ Protect natural sinks: Conserving wetlands and forests (which need consistent water) preserves their ability to absorb CO₂. ○ Habitat preservation: Maintaining natural water levels in rivers, lakes, and aquifers supports aquatic life and ecosystems. • Sustainable Water Use Practices: ○ Smart Irrigation: Drip irrigation, soil moisture sensors, and watering at dawn/dusk minimizes evaporation. ○ Water-Wise Landscaping (Xeriscaping): Choose native, drought-resistant plants and use mulch to retain soil moisture. ○ Rainwater Harvesting: Collect rainwater for non-potable uses like irrigation or toilet flushing. • Technology & Policy: ○ Water-Saving Devices: Install low-flow showerheads, toilets, and faucet aerators. ○ Water Reuse & Recycling: Treat and reuse wastewater for irrigation or industrial processes.

Environmental Impacts and Mitigation Measures of Subproject Types	
	○ Green Infrastructure: Use green roofs, permeable pavements, and rain gardens to manage stormwater and recharge groundwater.
Subproject Type-7	Flood Control and Drainage (FCD) in west coastal hot spot
Environmental Impacts	Negative Environmental Impacts • Loss of Biodiversity & Habitat: Embankments block fish migration and reduce floodplain habitats, causing significant declines in fish populations and disrupting food chains. • Reduced Nutrient Cycling: Floodwaters naturally deposit nutrient-rich silt; FCD stops this, increasing the need for chemical fertilizers, which further pollute water bodies. • Water Pollution: Draining land flushes fertilizers, pesticides, and organic waste into streams, degrading water quality for aquatic life and downstream users. • Soil & Hydrological Changes: Drainage can lead to soil deterioration, loss of soil moisture, and changes in water tables, creating waterlogging problems in some areas, as discussed in The Journal of Transdisciplinary Environmental Studies. • Increased Agrochemical Dependency: With reduced natural pest control from floods, farmers rely more on pesticides, contaminating water and harming ecosystems, note Bangladesh Institute of Planners and The Journal of Transdisciplinary Environmental Studies. Socio-Economic & Health Impacts • Shift to Monoculture: FCD encourages monoculture (e.g., High-Yielding Varieties of rice), reducing agricultural diversity and ecosystem resilience, according to ResearchGate. • Health Risks: Poor drainage creates stagnant water, breeding mosquitoes and spreading diseases like malaria, dysentery, and cholera, report The Journal of Transdisciplinary Environmental Studies and Facebook. • Cultural & Livelihood Shifts: Changes in occupation (e.g., less fishing) and loss of traditional festivals linked to flood cycles occur, noted The Journal of Transdisciplinary Environmental Studies https
Mitigation Measures	The CDRSSWRMP, implemented by LGED in Bangladesh, focuses on mitigating the negative environmental and social impacts of flood control and drainage (FCD) infrastructure through participatory, sustainable, and climate-resilient approaches. Key mitigation measures adopted by the project include: 1. Structural Mitigation Measures

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Climate-Resilient Design: Designing embankments and sluice gates to withstand climate change, including enhanced heights and improved, sustainable slopes to handle increased intensity of floods. • Fish-Friendly Infrastructure: Operating sluice gates to allow migratory fish access to floodplains and implementing guidelines to minimize impacts on fish spawning and habitat, thereby addressing the loss of biodiversity often caused by traditional FCD structures. • Canal Re-excavation: Re-excavating drainage canals to increase capacity, which reduces water logging and improves water retention for irrigation, rather than simply draining all wetlands. • Rubber Dams: Modernizing and reconstructing structures like the Bakkhali Rubber Dam to manage water flow and provide irrigation without creating permanent, damaging water barriers. 2. Institutional and Participatory Measures • Water Management Cooperative Associations (WMCAs): Establishing and strengthening 150 new and 230 existing WMCAs to ensure that operations and maintenance of infrastructure are participatory and locally driven, ensuring that the needs of local farmers and fishermen are considered. • Participatory Environmental Management: Involving local communities in the planning and management of subprojects to identify risks to common resources and, where necessary, implementing compensatory measures for loss of grazing areas or livelihoods. 3. Environmental and Social Safeguards • Resettlement Framework: Applying a Resettlement Framework (RF) that adheres to ADB Safeguard Policy Statement (2009) to ensure that any affected persons, particularly those losing land or livelihoods, are compensated through a negotiated settlement process. • Grievance Redress Mechanisms (GRM): Using GRCs at Upazila and district levels to promptly address complaints regarding construction and environmental impacts. • Green Infrastructure: Incorporating eco-friendly practices, such as planting native vegetation on embankments to prevent erosion, rather than relying solely on concrete. 4. Agricultural Mitigation • Promoting Diverse Agriculture: Encouraging climate-smart agriculture and the use of salt-resistant crops to reduce reliance on intensive, high-risk monoculture, which can be a negative side effect of flood-controlled lands. These measures aim to shift from traditional "flood protection" to "living with floods" by creating resilient, multi-functional infrastructure.

Table 22: Environmental Impacts of Proposed PE Subproject Types of 42 Districts

Environmental Impacts and Mitigation Measures of Subproject Types	
Subproject Type-1	Water Conservation (WC) in Barind hot spot
Environmental Impacts	Key Environmental Benefits: • Energy & Climate: Less water usage means less energy for pumping, treating, and heating, reducing the carbon footprint and greenhouse gas emissions. • Ecosystem Health: Conserving water keeps more water in rivers, lakes, and aquifers, preserving habitats for fish, wildlife, and supporting natural processes like flood prevention and soil regeneration. • Pollution Reduction: Less water flowing to treatment plants reduces the energy and chemical load for processing, leading to fewer pollutants entering the environment. • Water Supply Protection: Reduces strain on finite freshwater resources, ensuring availability for human consumption, agriculture, and ecological needs, especially during droughts. • Sustainable Infrastructure: Decreases the need to build costly, environmentally impactful new water supply and treatment facilities. Impacts on Wastewater: • Concentrated Pollutants: While overall flow decreases, pollutant concentrations (like phosphorus, nitrogen, and organic matter) can significantly increase in the remaining wastewater, requiring advanced treatment. • Greywater Reuse: Reusing water from showers/sinks (greywater) for toilet flushing lowers overall demand but also concentrates pollutants in the treated greywater. Examples of Improvements & Benefits: • High-Efficiency Appliances: Toilets, showers, etc., drastically cut wastewater flow, notes a ScienceDirect article. • Efficient Irrigation: Switching to drip or sprinkler systems reduces conveyance losses in agriculture compared to older methods. • Permeable Pavements & Rain Gardens: Capture stormwater, reduce runoff, and replenish groundwater.
Mitigation Measures	Potential Negative Impacts and Mitigation Measures While water conservation is overwhelmingly positive, some implementations can have unintended effects that require mitigation: • Reduced Instream Flows (for off-stream diversions): If conservation leads to significantly reduced water diversions from a river or stream, the resulting higher instream flows are generally

Environmental Impacts and Mitigation Measures of Subproject Types

beneficial for aquatic habitats. However, changes in flow dynamics may need management in specific, highly engineered systems to prevent unexpected changes in water velocity, which could affect sediment transport or habitat suitability.

- **Mitigation:** Implement a watershed management plan that coordinates water outtake with natural flow regimes, ensuring sustainable yield potential and protecting fragile ecosystems and riparian zones.
- **Groundwater Depletion (if relying solely on extraction):** Over-reliance on groundwater extraction without sufficient recharge can deplete aquifers, affecting springs and surface water bodies linked to them.
 - **Mitigation:** Monitor groundwater levels to ensure the natural recharge rate is not exceeded. Promote rainwater harvesting and other artificial recharge methods to replenish aquifers.
- **Wastewater Concentration:** More efficient indoor water use can lead to more concentrated wastewater, which may require adjustments in wastewater treatment processes to maintain effectiveness.
 - **Mitigation:** Ensure wastewater treatment facilities are equipped with appropriate technologies (chemical, physical, or biological processes) to handle concentrated pollutants effectively before discharge into the environment.
- **Chemical Use:** Certain industrial water treatment or conservation methods may involve specific chemicals (e.g., in cooling towers or advanced oxidation processes).
 - **Mitigation:** Use environmentally friendly or biodegradable chemical products where possible, or replace toxic materials with non-toxic alternatives in industrial processes.
- **Habitat Disruption from Infrastructure:** Construction of new water conservation infrastructure (dams, pipelines, desalination plants) can disrupt local habitats and ecosystems.
 - **Mitigation:** Conduct thorough environmental assessments, choose sustainable construction materials, protect existing vegetation cover, and implement best practices for spill avoidance and response during construction.

Inherent Environmental Benefits

Many water conservation improvements naturally mitigate environmental impacts as part of their function:

- **Ecosystem Protection:** Preserving instream flows and maintaining water levels in lakes and wetlands safeguards essential habitats and biodiversity.
- **Reduced Energy Consumption:** Less water extraction, treatment, and transport directly reduce energy use and associated greenhouse gas emissions, contributing to climate change mitigation.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Improved Water Quality: Efficient water use in agriculture, for example, reduces polluted runoff of pesticides and fertilizers into waterways, preventing eutrophication and chemical contamination. • Less Need for New Infrastructure: Effective conservation measures can delay or eliminate the need for new, large-scale water supply infrastructure (like new dams), which often have significant environmental footprints.
Subproject Type-2	Flodd management and drainage & water conservation in Barind hot spot
Environmental Impacts	Positive Environmental Impacts • Habitat Creation: Well-planned projects, particularly soft engineering approaches, can create new freshwater habitats (e.g., artificial wetlands, restored river bends), which can enhance biodiversity. • Improved Water Quality: Natural flood management strategies, such as the use of wetlands and planted trees in catchments, can help filter pollutants, retain sediments, and remove excess nutrients like nitrogen, thereby improving water quality. • Groundwater Recharge: By slowing down runoff and increasing absorption, certain water conservation measures and soft engineering approaches can help to recharge groundwater aquifers. • Soil Conservation and Fertility: Natural flooding can deposit mineral-rich sediments, which improves soil fertility in some deltaic and wetland ecosystems. Specific soil conservation measures can also reduce erosion risks. • Reduced Soil Erosion: Well-managed field drainage can decrease surface runoff and soil erosion, preventing loss of sediment to waterways. Negative Environmental Impacts • Habitat Destruction and Fragmentation: Construction of dams, levees, and channels can destroy or fragment important aquatic and riparian habitats, leading to a loss of biodiversity. Wetlands, which are vital for water purification and flood buffering, are often lost due to drainage. • Altered Hydrology and Sediment Transport: Hard engineering methods like river straightening and channelization increase water flow velocity, which can exacerbate erosion downstream and lead to heavy siltation or sedimentation in other areas. Dams trap nutrient-rich sediment, reducing the fertility of downstream floodplains and affecting delta sustainability. • Water Quality Degradation: Drainage water can carry pollutants such as agricultural chemicals (pesticides, fertilizers), industrial waste, and untreated sewage into natural water bodies. This leads to contamination, algal blooms, oxygen depletion, and accumulation of heavy metals or toxic trace elements in aquatic ecosystems.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Changes in Groundwater and Soil Salinity: Lowered water tables from extensive drainage can increase the risk of soil salinization through capillary rise of saline groundwater, negatively impacting agriculture and local ecosystems. Saline dust storms can also occur if evaporation ponds dry out. • Increased Downstream Flood Risk: By moving water more quickly through a system, flood management in one area (e.g., channel straightening) can simply transfer or increase the flood risk to downstream communities. • Greenhouse Gas Emissions: Flooding behind dams can cause submerged vegetation to rot, releasing methane, a potent greenhouse gas.
Mitigation Measures	Key Mitigation Strategies Nature-Based Solutions (NBS) and Green Infrastructure These approaches leverage natural processes to manage water, often providing multiple co-benefits beyond flood control. • Wetland Restoration: Wetlands act as natural sponges, absorbing and storing excess rainwater, which reduces flood peaks and recharges groundwater. They also filter pollutants, improving water quality and providing critical wildlife habitats. • Reforestation and Riparian Buffers: Planting trees and maintaining vegetated areas along riverbanks (riparian zones) can intercept rainfall, increase soil permeability, reduce surface runoff, and stabilize soils to prevent erosion. • Floodplain Reconnection: Allowing rivers to access their natural floodplains, often by setting back or removing existing levees, provides a natural buffer for excess water and helps restore the river's ecological functions, such as sediment distribution. • Urban Green Infrastructure: In cities, measures such as rain gardens, bioswales, permeable pavements, and green roofs absorb stormwater runoff, reducing the burden on conventional drainage systems and mitigating the urban heat island effect. Sustainable Structural Measures When engineered structures are necessary, their design and operation should minimize environmental harm and incorporate conservation goals. • Multi-purpose Reservoirs: Dams and reservoirs can be designed not only for flood control but also for irrigation, water supply, and power generation, with operational plans that consider environmental flow needs. • Improved Drainage Systems: Ongoing maintenance of existing drainage infrastructure, such as clearing debris from creeks and stormwater systems, maintains hydraulic performance and helps prevent localized flooding and pollution.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Hybrid Approaches: Combining hard infrastructure (like low-height sea walls or levees) with natural barriers (such as mangrove forests or vegetated buffers) can offer effective protection while supporting ecosystems. Planning and Management Practices Non-structural measures focus on policy, awareness, and planning to reduce vulnerability. • Risk-Based Land Use Planning: Enforcing strict zoning laws to limit or prohibit development in high-risk floodplains helps avoid damage and preserves natural water retention areas. • Environmental Assessment: Conducting thorough environmental impact assessments (EIA) for all proposed projects helps identify potential negative impacts and opportunities for cross-sector synergies before implementation. • Public Awareness and Participation: Engaging local communities and stakeholders in the planning and decision-making process ensures public support, fosters environmental stewardship, and incorporates indigenous knowledge of coping with floods. • Water Quality Monitoring: Establishing robust water quality monitoring systems helps detect pollution trends, assess the effectiveness of mitigation measures, and prioritize interventions to protect aquatic life and human health.
	Planning and Design Phase Mitigation • Integrated Risk Management: Adopt a holistic flood and environmental risk management (FERM) approach that considers the entire river basin and the interconnected effects of interventions upstream and downstream. • Environmental Assessment: Conduct thorough Environmental Impact Assessments (EIAs) and Social Impact Assessments (SIAs) before project implementation to identify potential negative impacts and plan specific mitigation measures. • Land Use Zoning: Implement strategic land use planning to restrict construction in high-risk floodplains, designating these areas for uses like parks, recreation, or agriculture, which can absorb floodwaters naturally. • Public Consultation: Engage local communities and stakeholders in the planning process to incorporate local knowledge, ensure acceptance of solutions, and address potential social impacts such as displacement. • Regulatory Compliance: Ensure all projects comply with relevant environmental laws, policies, and regulations to protect sensitive areas like wetlands, nature reserves, and fisheries. Structural and On-Site Measures

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Nature-Based Solutions (NBS): ○ Restore Wetlands and Floodplains: Reconnecting rivers with their natural floodplains and restoring wetlands allows these areas to act as natural sponges, absorbing and storing excess water, filtering pollutants, and providing critical habitats. ○ Afforestation and Reforestation: Planting trees in catchment areas and along riverbanks increases water absorption, stabilizes soil to reduce erosion and sedimentation, and enhances biodiversity. ○ Green Infrastructure: In urban areas, use green roofs, rain gardens, bioswales, and permeable pavements to reduce surface runoff, improve water quality through biofiltration, and recharge groundwater. • Sustainable Drainage Systems (SuDS): Design drainage systems to slow water flow and trap sediment and pollutants. This can involve directing field drains into wetland buffer areas or using sediment traps. • Improved Infrastructure Design: When building "hard" infrastructure like levees or dams, incorporate hybrid designs (e.g., horizontal levees with vegetated slopes) to balance flood protection with ecological benefits. Ensure outlets are designed with appropriate structures (e.g., rock chutes, drop structures) to prevent erosion of the receiving waterway. Management and Maintenance Practices • Pollution Control: ○ Manage Waste: Implement proper solid and hazardous waste management during construction and operation to prevent pollutants from entering waterways. ○ Control Agricultural Runoff: Promote best farming practices, such as proper application of manures and fertilizers, to minimize nutrient and pesticide runoff into drainage channels. • Maintenance: Establish regular maintenance schedules for creeks, stormwater systems, and drainage infrastructure to maintain hydraulic performance and prevent blockages. • Monitoring: Monitor groundwater levels and water quality to ensure that the natural recharge rate is not exceeded and that the project does not negatively impact downstream water resources. • Capacity Building: Provide ongoing training and educational programs for project staff and the local community to raise awareness about environmental sustainability and proper management practices.
Subproject Type-3	Flood management and drainage (FMD) in Barind hot spot
Environmental Impacts	Positive (But Often Overlooked) Impacts • Nutrient & Land Building: Natural floods deposit fertile silt, building land and fertilizing floodplains.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Groundwater Recharge: Increased soil moisture after floods helps recharge groundwater. • Fisheries: Floods create habitats and increase fish production in certain species. Sustainable Approaches (Mitigation) • Integrated Flood Management (IFM): Combines structural (like embankments) with non-structural measures (land-use planning, early warnings). • Green Infrastructure: Using natural systems like wetlands to manage water. • Maintaining Environmental Flows: Designing systems to allow for natural flow variability to support ecosystem health. • Holistic Planning: Considering impacts on water transport, fisheries, and poor communities for more equitable and sustainable outcomes. Negative Environmental Impacts • Ecological Disruption: Altering natural river courses and flow, creating homogenous habitats, and preventing fish migration between floodplains and rivers. • Water Quality & Soil: Reduced natural sediment deposition means less nutrient replenishment, increasing reliance on chemical fertilizers and pesticides, which contaminate water. • Erosion & Sedimentation: Embankments can increase flood velocities, causing severe erosion and deeper flooding in unprotected areas, while altered drainage can lead to soil subsidence or acid sulfate soil formation. • Habitat Loss: Embankments block access to floodplains, reducing grazing areas for livestock and disrupting natural flood-dependent ecosystems. • Disease: Stagnant water trapped by embankments can increase waterborne diseases like cholera and malaria due to reduced flushing of polluted sources.
Mitigation Measures	Key Mitigation Strategies 1. Green Infrastructure & Nature-Based Solutions: • Tree Planting: Roots absorb water, stabilize banks, reduce runoff, improve water quality. • Wetland Restoration: Wetlands act as natural sponges, absorbing excess water. • Permeable Surfaces: Pavements and green roofs filter stormwater, reducing runoff volume. • Vegetated Swales/Bio-retention: Absorb and filter runoff at the source. 2. Integrated Design & Planning: • Holistic Approach: Combine structural (levees, floodwalls) with non-structural (land-use zoning) methods. • Green-Gray Integration: Use green infrastructure to complement gray infrastructure (like pipes/channels) to balance flood control and water quality.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Catchment Management: Manage water at the catchment level using modeling (GIS, hydraulic) to identify hotspots and target interventions. 3. Smart Technology & Maintenance: • Advanced Modeling: Use GIS and hydrological models to predict risks and design resilient systems. • Real-time Monitoring: Sensors and IoT adjust drainage systems dynamically. • Regular Maintenance: Essential for preventing blockages and ensuring system performance, especially for smaller floods. 4. Policy & Community Engagement: • Sustainable Policies: Implement regulations that promote green drainage. • Public Awareness: Educate communities on moisture risks and sustainable practices. • Community-Based Solutions: Involve local stakeholders in planning and implementation. Environmental Benefits • Improved Water Quality: Reduced silt, fertilizer, and pollutant runoff. • Enhanced Biodiversity: Creation of habitats through green infrastructure. • Climate Resilience: Systems designed for future climate extremes. • Reduced Property Damage: Better management lowers flood damage costs.
Subproject Type-4	Water conservation & irrigation (WC & Irr) in Barind hot spot
Environmental Impacts	Positive Environmental Impacts • Water & Energy Savings: Efficient systems like drip irrigation drastically cut water use and the energy needed for pumping, reducing carbon footprints. • Improved Water Quality: Better scheduling and precision application minimize nutrient and pesticide runoff into rivers and lakes, preventing eutrophication. • Soil Health: Reduced excess water prevents waterlogging, soil erosion, and salinization, maintaining soil fertility and structure. • Ecosystem Preservation: Conserving water keeps more in natural systems, supporting wetlands and aquatic habitats. • Reduced Drought/Flood Impacts: Better management buffers against extreme weather. Negative/Complex Environmental Impacts • Construction Footprint: Building new infrastructure (dams, pipes) has its own water and carbon footprint.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Biodiversity Trade-offs: While saving water, some methods (like alternate wetting and drying) can decrease aquatic species richness and abundance, requiring careful design. • Groundwater Issues: While improving recharge, poorly managed extraction can still deplete aquifers and cause land subsidence. • Altered River Flows: Diverting water can harm downstream ecosystems, though efficient use helps mitigate this.
Mitigation Measures	Key Mitigation Measures Technological and Infrastructure Adjustments • Use Water-Efficient Irrigation Systems: Replace traditional, inefficient flood irrigation with modern systems like drip or micro-irrigation and low-pressure sprinkler systems, which minimize water loss through evaporation and runoff. • Implement Smart Technology: Utilize soil moisture sensors, weather-based controllers, and AI-driven systems to schedule irrigation precisely according to crop needs, avoiding over-irrigation. • Improve Conveyance Infrastructure: Line canals or use pipelines to reduce seepage and evaporation losses during water transport. • Manage Drainage Systems: Install appropriate drainage systems in irrigated areas to control the water table, preventing waterlogging and soil salinization. • Promote Rainwater Harvesting and Recycling: Collect and store rainwater or treat and reuse wastewater for non-potable uses, reducing the strain on primary water sources. Land and Crop Management Practices • Adopt Conservation Tillage: Minimize soil disturbance through practices like zero or minimum tillage to retain soil moisture and reduce erosion and runoff. • Select Appropriate Crops: Choose drought-tolerant or water-efficient crop varieties, or change crop patterns to those that require less water in water-scarce regions. • Implement Nutrient Management: Optimize fertilizer use based on soil tests to minimize nutrient runoff (especially nitrogen and phosphorus) into water bodies, preventing eutrophication and contamination. • Control Soil Erosion: Use cut-off drains, replant vegetation on disturbed areas, and leave crop residue on the soil surface to control runoff speed and minimize soil erosion. • Protect Riparian Zones: Fence off waterways and establish vegetative buffer strips to filter pollutants from agricultural runoff and protect aquatic habitats and biodiversity. Planning and Policy Approaches

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Conduct Environmental Impact Assessments (EIA): Perform thorough assessments before project implementation to identify potential negative impacts and plan appropriate mitigation measures. • Involve Stakeholders: Ensure user participation and collaboration among all sectors (agriculture, municipal, industry) at the planning and design stages to ensure equitable and sustainable water use. • Establish Legal and Regulatory Frameworks: Implement and enforce policies and regulations for sustainable water management and pollution control. • Promote Education and Awareness: Educate farmers and communities about water-saving practices and the importance of environmental stewardship to foster a culture of conservation.
Subproject Type-5	Water Conservation & Drainage (WC & DR) in Barind Hot Spot
Environmental Impacts	Water Conservation Impacts • Positive: ○ Ecosystem Health: Reduces demand on rivers, lakes, and aquifers, preserving habitats for aquatic life. ○ Energy Savings: Less water used means less energy for treatment, pumping, and distribution. ○ Reduced Wastewater: Lowers the burden on treatment plants, decreasing pollution discharge. ○ Groundwater Recharge: Techniques like rainwater harvesting can replenish groundwater. • Negative/Challenges: ○ Increased Pollutant Concentration: Lower water volumes in sewers can concentrate pollutants, raising treatment challenges. Drainage Improvement Impacts • Positive: ○ Disease Control: Draining swampy areas reduces mosquito breeding (malaria) and snail hosts (schistosomiasis). ○ Land Reclamation: Makes waterlogged or saline soils productive for agriculture, improving soil quality. ○ Agricultural Productivity: Improves plant health by preventing root rot and mildew. • Negative/Challenges: ○ Habitat Loss: Draining wetlands destroys critical habitats, flood storage, and natural water filters. ○ Nutrient Pollution: Conventional drainage can flush excess nutrients (N, P) into waterways, causing HABs.

Environmental Impacts and Mitigation Measures of Subproject Types	
	Conservation Drainage (Best Practice) • Concept: Manages water flow in agricultural fields to retain water and nutrients on-site. • Benefits: Significantly reduces nitrogen and phosphorus runoff, preventing algal blooms. • Methods: Controlled drainage (using control structures) and saturated buffers (diverting water through vegetated soil). • Impacts: Balances water retention with nutrient management, keeping nutrients in the field longer, reducing downstream pollution, and potentially decreasing greenhouse gas (GHG) emissions indirectly.
Mitigation Measures	General Mitigation Strategies • Conduct Environmental Impact Assessments (EIAs): Perform thorough assessments <i>before</i> project implementation to identify potential ecological risks and plan protective measures. • Integrate Water Management: Adopt an Integrated Water Resource Management (IWRM) approach that coordinates water supply, wastewater treatment, stormwater management, and demand-side interventions to ensure long-term sustainability. • Implement Monitoring and Evaluation (M&E): Establish robust M&E systems to track project performance, assess impacts, and allow for adaptive management strategies. • Involve Stakeholders and Educate the Public: Engage local communities, farmers, and businesses in planning and decision-making to foster a sense of responsibility and ensure the long-term success of conservation and drainage initiatives. Mitigation for Water Conservation Projects Water conservation measures generally have positive environmental impacts by reducing strain on natural sources and lowering energy consumption for water treatment and distribution. Potential negative impacts (e.g., changes in sewer hydraulics) can be mitigated as follows: • Improve Efficiency: Upgrade aging infrastructure to reduce leakage and implement water-saving technologies like high-efficiency fixtures and drip irrigation systems. • Promote Water Reuse: Implement greywater recycling systems and advanced wastewater treatment for non-potable uses like irrigation, reducing the overall demand for fresh water. • Use Alternative Sources: Utilize rainwater harvesting systems to capture and store water for use during dry periods or for recharging groundwater supplies. • Adapt Drainage Systems: If water conservation leads to lower wastewater flows, adapt drainage systems (e.g., reduce pipe

Environmental Impacts and Mitigation Measures of Subproject Types	
	diameter, increase slope) to maintain adequate flow velocity and prevent issues like pipe corrosion or blockages. Mitigation for Drainage Improvement Projects Drainage projects can prevent flooding but may also cause nutrient runoff, soil erosion, and habitat disruption. Mitigation measures include: • Control Pollutants at the Source: ○ Agriculture: Promote sustainable farming practices such as conservation tillage, integrated pest management, and the careful scheduling and application of fertilizers to minimize runoff. ○ Urban Areas: Manage stormwater runoff using green infrastructure like rain gardens, permeable pavements, and urban tree root pits to absorb and filter pollutants before they reach water bodies. • Protect Ecosystems: Avoid construction in ecologically sensitive areas like wetlands and maintain buffer strips of vegetation along waterways to trap sediments and nutrients. • Manage Drainage Water Quality: ○ Construct wetlands or evaporation ponds to treat drainage water, allowing biological and natural processes to remove pollutants like nitrogen and phosphorus. ○ Guide drain flow through a series of artificial treatment systems before discharge into natural water bodies. • Prevent Soil Erosion: Position drains on slight gradients and protect the banks of open ditches with natural vegetation. During construction, use erosion control measures like silt fences and sedimentation ponds.
Subproject Type-6	Drainage (DR) in Barind Hot Spot
Environmental Impacts	Positive Environmental Impacts (When well-managed) • Reduces Soil Erosion: Less surface water means less runoff carrying soil away. • Improves Soil Health: Prevents waterlogging, improves aeration, promotes beneficial microbes, and reduces soil compaction. • Prevents Salinization: Removes excess salts from irrigated land, making it productive. • Increases Productivity: Allows for earlier planting, better nutrient uptake, and higher yields, reducing pressure on other lands. Negative Environmental Impacts (When poorly designed or managed) • Water Pollution: Rapid drainage flushes nutrients (nitrogen, phosphorus), pesticides, and sediment into rivers, causing algal blooms (eutrophication) and harming aquatic life.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Habitat Degradation: Altering natural watercourses, straightening channels, and increasing flow can damage stream beds and banks, destroying riparian habitats. • Downstream Flooding & Erosion: Faster water delivery can increase flood risk and erosion in downstream areas. • Greenhouse Gas Emissions: Pumping water can consume significant energy, contributing to emissions, and altered hydrology can affect soil greenhouse gas cycles. • Disease Vectors: Poorly maintained urban drains create stagnant water, breeding grounds for mosquitoes and disease. Key Considerations for Sustainable Drainage • Integrated Design: Plan systems to slow water flow and incorporate natural features like buffer strips. • Best Management Practices (BMPs): Use gentle slopes, avoid steep banks, and maintain vegetative cover. • Monitoring: Regularly assess water quality (N, P levels) and ecosystem health. • Context Matters: Solutions for urban areas (Dhaka) differ from agricultural lands but both need careful planning to avoid public health and environmental crises.
Mitigation Measures	Design & Construction Mitigation • Use Sustainable Urban Drainage Systems (SuDS): Employ green infrastructure like rain gardens, swales, and permeable pavements to manage stormwater close to its source. • Proper Sizing & Alignment: Design systems with adequate capacity for peak flows (e.g., 100-year floods) and consider basin-wide impacts. • Good Weather Conditions: Install drains during dry periods to minimize soil erosion and compaction. • Right Materials: Use durable, cleanable pipes (like solid PVC) rather than flexible ones that clog easily. • Sediment Control: Install sediment traps and use soil blinding layers (e.g., >15cm) above gravel in closed drains to block nutrient/pesticide entry. Operation & Management Mitigation • Water Table Management: Use drain blocking or controlled drainage to balance water removal with crop needs and habitat requirements, especially in organic soils. • Nutrient Management: Apply fertilizers and pesticides judiciously to reduce runoff contamination.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Buffer Strips: Maintain riparian buffers (vegetated strips) along drains to filter pollutants and protect biodiversity. • Regular Maintenance: Implement routine cleaning (dredging) and inspections to prevent blockages and overflows. • Water Recycling & Treatment: Treat and reuse drainage water where possible, or dispose of it safely in evaporative lagoons. Agricultural Practices Mitigation (Rural Drainage) • Best Management Practices (BMPs): Implement conservation tillage, cover crops, and nutrient management plans. • Deficit Irrigation: Apply less water than crops need to reduce drainage water volume. • Land Reclamation: Use drainage to reclaim saline or waterlogged land, returning it to productive, environmentally beneficial use. Urban Drainage Mitigation • Integrated Approach: Combine infrastructure upgrades with green solutions and public awareness. • Source Control: Manage runoff from roofs (downspouts) and impervious surfaces. • Solid Waste Management: Prevent solid waste from entering drainage systems, which causes blockages.
Subproject Type-7	Drainage (DR) in Coastal Hot Spot
Environmental Impacts	Based on the context of climate-resilient water management in Bangladesh's coastal zones (likely reflecting projects like CDRSSWRMP or similar ADB/IFAD-funded initiatives), the drainage (DR) interventions aimed at enhancing agricultural productivity in hotspots—such as the southwestern coastal districts (Satkhira, Khulna, Jashore)—have complex, mixed environmental impacts. While intended to improve livelihoods, these infrastructure projects, including re-excavating drainage canals and strengthening sluice gates, can have significant environmental consequences. Key Environmental Impacts of Drainage (DR) in Coastal Hot Spots • Drainage Congestion and Waterlogging: Ironically, structural solutions (polders/embankments) built to prevent sea water intrusion often block natural tidal channels, leading to increased sedimentation on riverbeds and resulting in prolonged, severe waterlogging in surrounding basins. • Alteration of Ecosystems and Biodiversity: The modification of tidal creeks and the transformation of saline water environments into freshwater ones through drainage systems disrupt the natural ecology of mangrove areas and reduce habitat diversity. • Salinity Intrusion and Quality Issues: Drainage systems in polders sometimes interfere with natural tidal flushing, which can result in increased salinity levels in soils and water, making the environment

Environmental Impacts and Mitigation Measures of Subproject Types	
	hostile to freshwater species and negatively affecting, ironically, agricultural productivity over the long term. • Sedimentation in Channels: Obstruction of the natural tidal flow (due to polders) causes rivers and channels to lose their capacity to carry sediment, filling up the drainage paths and requiring continuous, expensive re-excavation. • Soil and Land Degradation: Prolonged waterlogging from poor drainage management causes degradation of agricultural land, affecting key crops like Amon rice. • Impact of Associated Infrastructure: While trying to improve drainage, construction of embankments and, in some cases, inappropriate plantation choices (e.g. <i>Acacia auriculiformis</i>), can have negative impacts on local soil health and indigenous vegetation. Mitigation and Sustainable Approaches To mitigate these negative effects, experts suggest: • Restoring Tidal River Management (TRM): Allowing tidal water to enter intentionally managed areas to disperse sediment and raise land elevation naturally. • Revisiting Polder Design: Ensuring tidal creeks and channels act as functional inlets and outlets rather than being permanently dammed. • Integrating Climate Data: Using advanced modeling to ensure drainage infrastructure can handle both high intensity rainfall and sea-level rise.
Mitigation Measures	Mitigation measures for environmental impacts arising from drainage (DR) improvements in the coastal hotspots of the CDRSSWRMP focus on balancing infrastructure development with ecosystem protection, particularly to address waterlogging, salinity intrusion, and flood risks. Key mitigation strategies for drainage-related environmental impacts in these coastal areas include: 1. Structural Mitigation Measures • Re-excavation of Drainage Canals: Dredging and re-excavating existing drainage canals to enhance capacity, reduce water congestion, and improve agricultural land use, while managing excavated soil to prevent bank erosion. • Sluice Gate Rehabilitation: Constructing and rehabilitating embankments and sluice gates to control, manage, and prevent saline water intrusion during high tides while allowing excess fresh water to drain. • Permeable Paving and Drainage Materials: Using permeable materials for construction to allow water infiltration and adopting corrosion-resistant materials (e.g., anodized aluminum) to withstand saltwater exposure.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Slope Protection: Stabilizing canal banks using vegetation or physical barriers to prevent erosion and sedimentation, ensuring long-term structural integrity. 2. Operational and Management Mitigation • Water Management Cooperative Associations (WMCAs): Establishing and empowering WMCAs to manage Operation and Maintenance (O&M) of drainage infrastructure, ensuring local ownership and sustainable practices. • Seasonal Drainage Scheduling: Coordinating drainage operations with tidal cycles and agricultural seasons to maximize water-use efficiency (e.g., for irrigation) and reduce the discharge of high-nutrient water into coastal ecosystems. • Integrated Pest and Nutrient Management: Encouraging the use of organic fertilizers and integrated pest management (IPM) to minimize the pollution load in agricultural runoff. 3. Environmental and Ecological Safeguards • Coastal Afforestation: Planting mangrove or native, salt-tolerant vegetation along embankments and canal banks to create natural barriers against storm surges and reduce coastal erosion. • Wetland Conservation: Restoring existing wetlands and "Khals" (canals) to enhance natural water retention and flood management capacity. • Integrated Aquaculture (Gher) Farming: Promoting "Gher" (enclosed pond) farming that balances shrimp/fish production with agricultural needs to reduce the environmental impact of monoculture and manage salinity. • Heavy Metal Monitoring: Implementing monitoring of effluents in coastal waters to prevent heavy metal contamination of fish and surrounding habitats. These measures are designed to align with the Bangladesh Delta Plan-2100, focusing on sustainable water management, food security, and climate change adaptation.
Subproject Type-8	Water Conservation (WC) in Coastal Hot Spot
Environmental Impacts	The CDRSSWRMP in Bangladesh addresses the extreme vulnerability of coastal districts (e.g., Bagerhat, Satkhira, Khulna) to climate change, specifically targeting water scarcity and salinity intrusion. Water Conservation (WC) measures under this project aim to increase the storage capacity of existing <i>haors and Beels</i>, and <i>Khals</i> to ensure water availability for irrigation during the dry season. The environmental impacts of this water conservation measures in the coastal hot spot include: Positive Environmental Impacts • Increased Dry-Season Water Availability: The excavation and re-excavation of canals, <i>Beels</i>, and <i>Khals</i> enhance water retention

Environmental Impacts and Mitigation Measures of Subproject Types	
	capacity, which is critical for irrigation during the pre-monsoon drought season, reducing the reliance on declining groundwater. • Salinity Intrusion Mitigation: By developing sustainable surface water, the project reduces the need for groundwater extraction, which in turn alleviates the pressure on aquifers and mitigates saltwater intrusion in coastal areas. • Restoration of Wetland Ecosystems: Improved water retention in <i>Bee/s</i> (natural depressions) and canals helps restore aquatic habitats and improves the local ecology, boosting biodiversity, especially when combined with nature-based solutions. • Improved Agricultural Resilience: Enhanced water availability allows for increased cropping intensities, improving soil health by enabling better land management and reducing waterlogging. Potential Negative or Risk-Prone Environmental Impacts • Habitat Disruption During Construction: The rehabilitation and excavation of canals and embankments can temporarily disrupt local habitats and ecosystems, although the project aims to follow sustainable, climate-resilient approaches. • Unstable Side Slopes: A key challenge identified is that avoiding land acquisition has led to unstable side slopes for <i>khals</i> and embankments, which could cause increased siltation and reduce the effectiveness of the water conservation structures. • Maintenance Challenges: If not properly managed by the Water Management Cooperative Associations (WMCAs), conserved water bodies may suffer from premature siltation or become breeding grounds for disease-bearing vectors. Integrated Management and Sustainability The project utilizes a participatory approach, forming WMCAs to operate the infrastructure, which is critical for long-term sustainability. The integration of these water conservation measures with improved drainage and flood management aims to balance economic productivity with environmental protection, addressing the "climate-gender-poverty nexus".
Mitigation Measures	The CDRSSWRMP focuses on enhancing agricultural productivity and climate resilience in coastal hotspots through improved water management. In coastal "hot spots" where salinity, sea-level rise, and flooding are major challenges, the project implements water conservation (WC) measures alongside Flood Management and Drainage (FMD). Mitigation Measures of Environmental Impacts in Coastal Hot Spots: • Re-excavation of Drainage Canals and Khals: To address waterlogging and increase freshwater storage, the project rehabilitates and re-excavates drainage canals, allowing for improved drainage during floods and water retention during the dry season.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Water Retention in Beels and Haors: Developing the water storage capacity of natural water bodies (haors, beels, and khals) increases the availability of irrigation water in coastal areas. • Construction of Sluice Gates and Embankments: Rehabilitation of embankments and construction of sluice gates are utilized to manage flood depths and durations, preventing saline water intrusion into cultivated land. • Improved Irrigation Systems (Command Area Development): To prevent water waste, the project implements better distribution systems, such as command area development, increasing irrigation efficiency and productivity. • Establishment of Water Management Cooperative Associations (WMCAs): Institutional support is provided through WMCAs, which manage the infrastructure, ensuring local involvement in water conservation and maintenance. • Adoption of Salt-Tolerant Agriculture and Aquaculture: To mitigate the impact of salinity, the project encourages shifting from traditional rice farming to salt-tolerant crop varieties and aquaculture. • Ecosystem-Based Solutions (Mangrove Protection): Promoting mangrove plantations and protective vegetation acts as a green belt against storm surges, reducing the impact of cyclones and helping with erosion control. • Nature-Based Solutions (Dune Stabilization): Using vegetation for dune stabilization helps protect against wave action and stabilizes the coastline. These measures are designed to increase climate-resilient agriculture and improve the livelihoods of vulnerable coastal communities.
Subproject Type-9	Drainage and Tidal Irrigation (DR & TIRR) in Coastal Hot Spot
Environmental Impacts	Drainage and tidal irrigation improvements in Bangladesh's coastal hotspots under CDRSSWRMP, aim to mitigate waterlogging and salinity, but they pose significant environmental risks. Key impacts include altered hydraulic regimes, risks of increased salinity intrusion if managed improperly, potential degradation of wetlands, and ecosystem disruption, necessitating careful, sustainable infrastructure design. Environmental Impacts of Drainage & Tidal Irrigation • Hydraulic & Morphological Changes: Improved drainage changes natural tidal flows, leading to altered sedimentation patterns and potential, long-term siltation of rivers and drainage channels. • Salinity Intrusion Risks: While designed to manage water, improper regulation of tidal, sluice gate-controlled systems can inadvertently allow saltwater intrusion, reducing soil quality. • Wetland and Ecosystem Degradation: The modification of natural coastal water bodies "Khals" can impact local biodiversity, reduce

Environmental Impacts and Mitigation Measures of Subproject Types	
	natural fish habitats, and disrupt the delicate, fragile coastal ecosystem. • Waterlogging Risk: Inefficient or unmaintained drainage systems, especially under climate change-induced sea-level rise and increased rainfall, can lead to severe water congestion in surrounding low-lying areas. • Agricultural Land Use Shift: While aimed at supporting farming, these interventions can lead to a shift from traditional crops to aquaculture, which brings its own environmental impacts. Key Mitigation Needs • Sustainable Infrastructure: Projects require robust, climate-resilient designs, such as reinforced embankments and improved sluice gates to control salinity. • Integrated Water Management: Need to combine structural improvements with non-structural measures, such as community-based management to manage tidal flow effectively. • Eco-friendly Maintenance: Regular, environmentally conscious, and effective, participatory, and sustainable small-scale water resources (SSWR) management is essential.
Mitigation Measures	The mitigation measures for environmental impacts of drainage and tidal irrigation in the coastal hotspot zones of the CDRSSWRMP focus on balancing agricultural production with ecological health. Key strategies involve using Tidal River Management (TRM), improving infrastructure resilience, and adopting nature-based solutions to combat waterlogging, salinity, and drainage congestion. Mitigation Measures of Environmental Impacts • Tidal River Management (TRM): This is considered an effective indigenous method where embankment cuts allow tidal flow to enter designated floodplains (Beels), depositing sediments to raise land levels and increase river navigation, thereby addressing waterlogging. • Improving Drainage Structures: To address drainage congestion and waterlogging in coastal polders, the project focuses on upgrading regulators and sluice gates to control saltwater intrusion from tidal rivers. • Climate-Resilient Infrastructure: Construction of cyclone-resistant, climate-resilient water management infrastructure (culverts, sluices, embankment reinforcement) to withstand increased salinity and surge. • Agricultural Adaptation: ○ Salinity-Tolerant Varieties: Introduction of salt-tolerant rice and non-rice crops, and short-duration pulses/vegetables.

Environmental Impacts and Mitigation Measures of Subproject Types	
	○ Alternative Livelihoods: Promoting agroforestry and mixed aquaculture (shrimp/finfish) to improve income while protecting soil quality. ○ Cropping Diversification: Utilizing floating bed gardening and raised bed cultivation (dyke cropping) in waterlogged areas. ● Participatory Water Management (WMCA): Establishing and strengthening 150 new Water Management Cooperative Associations (WMCAs) to manage, operate, and maintain infrastructure through local, participatory approaches, reducing the risk of environmental degradation. ● Nature-Based Solutions (NBS): Replanting mangrove species and using eco-engineering solutions to act as natural barriers against storm surge and coastal erosion. Key Focus Areas for Mitigation The CDRSSWRMP addresses the environmental impacts of salinity intrusion, waterlogging, and riverbank erosion in Bangladesh's southwest coastal region. These actions are designed to support 335,000 households over 220,000 hectares, focusing on sustainable water management to prevent the negative environmental consequences of previous, more rigid flood control, drainage, and irrigation (FCDI) projects.
Subproject Type-10	Water Conservation & Irrigation (WC & irr) in Coastal Hot Spot
	The CDRSSWRMP aims to improve agricultural productivity and climate resilience through water conservation (re-excavating canals, enhancing <i>haor/beeel</i> retention) and modernizing irrigation. In the sensitive coastal hotspot, these interventions have both positive environmental impacts, such as improved soil health and reduced salinity, and potential negative risks, including altered hydraulic regimes and increased salinity intrusion if managed improperly. Key Environmental Impacts of CDRSSWRMP Interventions: ● Mitigation of Salinity and Soil Degradation: The introduction of freshwater irrigation through improved infrastructure (sluice gates, re-excavated canals) directly addresses salinity issues in coastal agriculture, enhancing soil quality and increasing crop productivity in the <i>Rabi</i> (dry) season. ● Water Management and Drainage Improvement: Re-excavating canals and improving drainage systems reduces waterlogging and controls flooding, which is critical for the rehabilitation of coastal land. ● Surface Water Conservation: Creating or enhancing water retention capacities in <i>haors</i> (wetlands) <i>beeel/s</i> (lakes), and Khals (canals) increases the availability of fresh water for dry-season irrigation, reducing reliance on groundwater. ● Potential Risk of Increased Salinity: Large-scale conversion to dry-season irrigation, if not carefully managed, can reduce

Environmental Impacts and Mitigation Measures of Subproject Types	
	freshwater flows in tidal rivers, which may allow sea-level rise (SLR) to increase salinity levels downstream. • Infrastructure Impact on Coastal Ecosystems: The construction of embankments and sluice gates to protect land can sometimes alter natural tidal exchange, impact aquatic ecosystems and fisheries if not designed with ecological considerations. CDRSSWRMP Strategic Approach for Sustainability: The project mitigates negative impacts by employing a "participatory, and sustainable" management approach: • Water Management Cooperative Associations (WMCAs): Strengthening local WMCAs (150 new, 230 existing) ensures that infrastructure operation and maintenance (O&M) are locally led, focusing on both agricultural and fisheries needs. • Climate-Resilient Infrastructure: The projects focus on building "climate- and disaster-resilient" infrastructure (e.g., modernizing the Bakkhali rubber dam) to withstand increasing flood and surge risks. In summary, the CDRSSWRMP's interventions are designed to be sustainable, but in the volatile coastal hotspot, they require careful monitoring of water flow and salinity to prevent adverse impacts on the delicate ecosystem.
Mitigation Measures	The CDRSSWRMP addresses environmental impacts in coastal hotspots by focusing on nature-based solutions, community-led management, and infrastructure improvements that promote sustainability. The project aims to mitigate issues like salinity intrusion, waterlogging, and ecosystem degradation caused by climate change. Key mitigation measures for water conservation and irrigation in coastal areas under this initiative include: 1. Water Conservation and Management • Rainwater Harvesting Systems: Implementing household, community, and institutional rainwater harvesting to provide safe water and reduce reliance on saline groundwater. • Water Retention Capacity Enhancement: Developing the water retention capacity of existing <i>haors</i>, <i>beels</i>, and <i>khals</i> to ensure water availability for dry-season irrigation. • Small Canal Excavation: Digging small canals to ensure water availability for irrigation in coastal areas. • Controlled Infiltration: Using, where appropriate, the seepage from stored freshwater in canals to create freshwater lenses in the aquifer to counteract seawater intrusion. 2. Sustainable Irrigation and Agricultural Practices • Salt-Tolerant Crop Cultivation: Encouraging the cultivation of salinity-tolerant crop varieties to manage the effects of increased soil salinity.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Improved Irrigation Efficiency: Using Command Area Development to improve existing irrigation systems and ensure better distribution to enhance water efficiency. • Optimal Water Resource Use: Combining reservoir storage with deficit irrigation to reduce groundwater over-extraction and prevent salinity buildup. 3. Coastal Infrastructure Rehabilitation and Protection • Nature-based Solutions: Using mangrove afforestation and nature-based solutions to protect embankments and coastal communities from storm surges. • Sluice Gate Management: Constructing and rehabilitating embankments and regulators (sluice gates) to reduce salinity intrusion and manage waterlogging. • Re-excavation of Drainage Canals: Increasing the capacity of drainage systems to reduce flooding and improve agricultural land. • Resilient Infrastructure: Ensuring that new, rehabilitated infrastructures (like the Bakkhali Rubber Dam) are designed to withstand climate risks. 4. Institutional and Community-Based Management • Water Management Cooperative Associations (WMCAs): Establishing and strengthening local WMCAs to ensure participatory management and long-term sustainability of water infrastructures. • Capacity Building: Providing training to local communities on climate-smart agriculture and sustainable water management. • Environmental Monitoring: Using Water Management Groups (WMGs) and project implementation units to ensure that infrastructure projects follow environmental standards, such as conducting site-specific environmental assessments to prevent negative impacts. These measures aim to balance the need for increased agricultural productivity with the environmental sensitivities of the coastal zone, directly combating salinity and water scarcity.
Subproject Type-11	Water Conservation & Drainage (WC & DR) in Coastal Hot Spot
Environmental Impacts	The CDRSSWRMP focus on enhancing climate resilience in Bangladesh's coastal, haor, and drought-prone regions through water conservation, drainage improvement, and flood management. In the coastal "hot spots" these interventions aim to boost agricultural productivity while addressing salinity intrusion and waterlogging. Environmental impacts of these interventions include: Positive Environmental and Livelihood Impacts

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Reduced Waterlogging: Re-excavation of canals and improved drainage systems decrease the duration and depth of floodwaters, making vast <i>Bee/</i> (lowland) areas suitable for agriculture. • Increased Irrigation Availability: Developing water retention capacity in existing <i>Kha/s</i> (canals) and <i>Be/s</i> allows for better irrigation during the dry season, addressing climate-induced water shortages. • Strengthened Ecosystem Resilience: The project supports the installation of climate-resilient, community-managed infrastructure, which reduces damage to local ecosystems. • Protection of Productive Land: Construction of sluice gates and embankment rehabilitation protect agricultural land from tidal surges and saltwater intrusion. Potential Negative Impacts and Risks • Drainage Congestion and Siltation: In some areas, inadequate maintenance leads to siltation of <i>khal</i> mouths and the proliferation of water hyacinth, causing waterlogging. • Impacts on Fisheries: While improving agriculture, some drainage improvements may negatively impact cultured fisheries, as seen in past floods where fish escaped from ponds. • Construction-Related Disruption: Excavation and structural construction can lead to temporary environmental issues, including debris, potential alteration of local hydrology, and unstable bank slopes. • Land Acquisition Concerns: Though the project favors negotiated settlements, previous projects have faced challenges with land acquisition for structural construction, necessitating careful planning to avoid impacting agricultural land. Mitigation and Sustainability Measures • Community Management: The establishment of Water Management Cooperative Associations (WMCAs) ensures that maintenance and operation are handled locally. • Integrated Water Management Plan (IWMP): The project uses an integrated approach to manage water resources, including the preparation of specific plans for vulnerable areas. • Environmental Safeguards: A Resettlement Framework (RF) aligned with ADB's Safeguard Policy Statement (2009) is applied to mitigate involuntary resettlement impacts and address potential environmental risks. • Nature-Based Solutions: The project incorporates vegetative solutions, such as planting trees (including <i>Keora</i>), to stabilize embankments and protect infrastructure.
Mitigation Measures	Mitigation measures for the environmental impacts of water conservation and drainage in the coastal hotspots of the CDRSSWRMP focus on integrating

Environmental Impacts and Mitigation Measures of Subproject Types	
	engineering solutions with nature-based approaches to protect sensitive ecosystems, minimize salinity intrusion, and enhance climate resilience. Key Mitigation Measures: • Nature-Based Solutions & Coastal Protection: ○ Mangrove Restoration: Utilizing mangrove vegetation and tidal wetland restoration to stabilize shorelines, reduce erosion, and act as natural barriers against storm surges. ○ Dune Stabilization: Implementing dune stabilization through vegetation to preserve the natural landscape and protect against wave attacks. ○ Hybrid Structures: Combining grey infrastructure (e.g., embankments) with green, nature-based solutions to enhance ecological co-benefits and reduce structural damage. • Sustainable Water Management & Drainage: ○ Sustainable Drainage Systems (SuDS): Implementing permeable surfaces, swales, and detention basins to manage surface water runoff, enhance groundwater recharge, and reduce flooding. ○ Re-excavation of Khals: Re-excavating drainage canals and strengthening embankments to improve flood management and reduce the duration of farmland flooding. ○ Water Retention Development: Improving water retention in <i>haors</i> and <i>Beels</i>, and <i>Khals</i> to increase irrigation water availability during dry periods. • Environmental & Operational Management: ○ Environmental Management Plan (EMP): Preparing site-specific EMPs for all construction phases to monitor and mitigate significant environmental impacts. ○ Dredging Best Practices: Utilizing environmentally friendly dredgers, using silt screens, and managing dredged materials to minimize turbidity and ecological damage. ○ Salinity Control: Managing sluice gates and water flow to mitigate salinity intrusion into agricultural land. • Community-Based Adaptation: ○ Participatory Approach: Establishing Water Management Cooperative Associations (WMCAs) to ensure local involvement in the operation and maintenance of infrastructure. ○ Climate-Smart Agriculture: Training local communities in climate-smart agriculture and aquaculture practices to adapt to changing water conditions. ○ Flood-Resilient Housing: Promoting elevated, flood-resilient structures to reduce vulnerability in coastal areas.

Environmental Impacts and Mitigation Measures of Subproject Types	
	The project aims to avoid land acquisition to minimize involuntary resettlement impacts, although this may require careful management of construction slopes. These measures are aligned with the Bangladesh Delta Plan 2100 to ensure sustainable development in coastal regions.
Subproject Type-12	Flood Management and Drainage & Tidal Irrigation (FMD & TIRR) in Coastal Hot Spot
Environmental Impacts	The CDRSSWRMP in Bangladesh aims to reduce poverty and improve agricultural productivity in coastal areas through flood management, drainage, and irrigation. While these structural interventions (embankments, sluice gates, channel re-excavation) are essential for adapting to climate change, sea-level rise, and salinity intrusion, they also have significant, complex environmental impacts on the coastal ecosystem. Key Environmental Impacts of FCDI in Coastal Areas (CDRSSWRMP Context) • Alteration of Hydrological Regimes: Flood Control, Drainage, and Irrigation (FCDI) projects, particularly embankments (polders), obstruct natural tidal flows and freshwater drainage, often leading to increased drainage congestion and, in some cases, severe long-term waterlogging. • Loss of Aquatic Biodiversity and Fisheries: The structural control of water restricts the movement of migratory fish species (whitefish), leading to a significant decline in open-water, floodplain fisheries. Fish yields inside regulated embankments can be 50% lower than outside. • Soil Degradation and Salinity Management: While structures are designed to prevent saltwater intrusion, improper drainage can cause water to become saline and stagnant. Conversely, in some areas, preventing seasonal floodwaters prevents natural flushing of salts, leading to increased soil salinity and reduced fertility. • Loss of Nutrients and Increased Agrochemical Use: By restricting natural floodwaters, these projects prevent the deposition of fertile sediment, reducing natural soil nutrients. This leads to a greater reliance on chemical fertilizers and pesticides, which can result in runoff pollution and eutrophication in stagnant water bodies. • Changes in Ecosystem and Vegetation: The shift from a frequently inundated ecosystem to a "controlled" environment reduces natural wetlands, impacts biodiversity, and can reduce grazing areas for livestock. • Reduced Mangrove/Natural Protection: In some instances, the construction of coastal infrastructure can lead to the destruction of mangrove habitats, which are crucial for natural disaster defense. Mitigation and Sustainable Approaches in CDRSSWRMP The CDRSSWRMP addresses these negative impacts by focusing on sustainable, community-based management through:

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Water Management Cooperative Associations (WMCAs): Ensuring local communities (beneficiaries) manage the infrastructure, including WMCAs for operation and maintenance. • Climate-Resilient Design: Utilizing Tidal River Management (TRM) and improved drainage to manage sedimentation and waterlogging. • Livelihood Adaptation: Promoting saline-tolerant crop varieties and diversifying into floating agriculture to adapt to the changing environment. • Environmental Monitoring: The project incorporates social and environmental safeguards (through PIUs and NGO support) to monitor and mitigate impacts, such as involuntary resettlement or habitat disruption. In summary, while the CDRSSWRMP infrastructure provides crucial safety and agricultural benefits against climate-induced disasters, it requires careful management of the hydrological, ecological, and soil-related environmental trade-offs, particularly regarding fisheries and waterlogging.
Mitigation Measures	The mitigation measures for the environmental impacts of flood management, drainage, and irrigation in the coastal areas under the CDRSSWRMP, implemented by the Local Government Engineering Department (LGED) in Bangladesh, are designed to address climate vulnerabilities while enhancing sustainability. Based on the project's focus on participatory and sustainable water management, the key mitigation measures include: 1. Participatory Water Management & Institutional Strengthening • Water Management Cooperative Associations (WMCAs): Establishing and strengthening WMCAs is a primary measure to ensure local ownership and sustainable operation and maintenance (O&M) of infrastructure. • Capacity Building: Training WMCA members in climate-smart agriculture, aquaculture, and sustainable natural resource management to reduce over-exploitation of resources. • Participatory Planning: Engaging local stakeholders, including women and marginalized groups, in the design of subprojects to minimize negative social and environmental impacts. 2. Technical Mitigation Measures for Construction & Infrastructure • Climate-Resilient Design: Incorporating 8-12% higher cost for civil works to account for climate change risks in small-scale irrigation infrastructure. • Sustainable Drainage Re-excavation: Re-excavating drainage canals to improve capacity, coupled with maintaining proper hydraulic gradients to prevent waterlogging and reduce the risk of salinity intrusion.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Greenbelt Development: Planting mangrove and native swamp trees along embankments to reduce erosion caused by wave action and protect against tidal surges. • Rehabilitation of Polders: Rehabilitating and constructing coastal embankments and sluice gates to manage flood levels while maintaining necessary exchange of water to prevent stagnation. 3. Sustainable Agriculture and Environmental Health • Promoting Climate-Resilient Crops: Introducing saline-tolerant crop varieties and encouraging floating vegetable cultivation in waterlogged areas. • Integrated Pest Management (IPM): Reducing dependence on chemical pesticides and fertilizers to protect water quality and aquatic ecosystems. • Aquaculture Enhancement: Implementing cage aquaculture and improving fish habitats in "Beels" and Khals to compensate for the loss of natural fisheries. • Safe Water Supply: Setting up reverse osmosis plants for safe drinking water during disaster periods. 4. Environmental Monitoring and Compliance • Environmental Management Plan (EMP): Implementing EMPs for all subprojects to identify and mitigate risks, particularly in environmentally sensitive areas. • Monitoring and Evaluation: Regular, semi-annual monitoring of social and environmental safeguards to ensure compliance with standards, with reports submitted to stakeholders. • Grievance Redress Mechanism (GRM): Establishing committees at Upazila and district levels to address community concerns regarding environmental and social issues. These measures align with the Bangladesh Delta Plan 2100, aiming to balance economic development with long-term environmental sustainability.
Subproject Type-13	Drainage & Command Area Development /Irrigation (DR & CAD/Irr) in Coastal Hot Spot)
Environmental Impacts	Based on the context of Coastal Drainage and Water Management projects in Bangladesh, such as the CDRSSWRMP, the Environmental Impacts of Drainage and Command Area Development (CAD) /Irrigation can be classified as both positive and negative, significantly altering the ecosystem. Key Positive Environmental Impacts: • Improved Agricultural Productivity: Re-excavation of drainage canals and better water distribution (CAD) reduce waterlogging, allowing for increased cropping intensity (e.g., T-Aman and Boro rice) and improved agricultural returns.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Flood Reduction: Rehabilitation of embankments and sluice gates reduces the depth and duration of farmland flooding, offering protection during monsoon seasons. • Increased Water Availability: Development of water retention capacity in <i>Khals</i> (canals) and <i>Beels</i> (wetlands) improves freshwater availability for irrigation in the dry season. • Improved Fish Culture: Controlled drainage can enhance managed fish culture in ponds within the polders. Key Negative Environmental Impacts: • Waterlogging and Drainage Congestion: Poorly designed or maintained embankments/sluice gates often result in prolonged waterlogging, which severely impacts Aman rice production, leads to soil salinity, and rots crops. • Soil Salinity Intrusion: While aiming to control water, these projects can unintentionally increase salinity due to the upward/lateral movement of saline groundwater in the dry season, particularly when freshwater is scarce. • Loss of Aquatic Biodiversity: Embankments prevent the natural migration of fish between rivers and floodplains, leading to a decline in open-water fisheries. • Loss of Soil Nutrients: Reduction of natural sedimentation (which brings nutrients) due to embankments leads to increased dependence on chemical fertilizers and pesticides, causing soil degradation and surface water pollution. • Disruption of Ecosystems: The change in hydrological regimes alters the natural ecological balance, including the destruction of natural grazing areas and loss of mangrove-related flora/fauna. Specific Coastal Considerations (CDRSSWRMP context): • Siltation: Without regular excavation, drainage channels become filled with silt, destroying their capacity and exacerbating waterlogging. • Climate Change Vulnerability: These projects must account for sea-level rise and cyclone-induced storm surges, which can turn controlled areas into flooded, saline, and non-arable land if the defenses are breached. • Social & Environmental Trade-offs: There is often a trade-off between increased rice production (HYV) and the reduction of natural biodiversity (loss of local rice varieties and fish). To maximize positive outcomes, the project emphasizes the formation of Water Management Cooperative Associations (WMCAs) to ensure sustainable operation and maintenance.
Mitigation Measures	The CDRSSWRMP, implemented by the Local Government Engineering Department (LGED) in Bangladesh, focuses on enhancing agricultural production in coastal areas through flood management, drainage

Environmental Impacts and Mitigation Measures of Subproject Types	
	improvement, and Command Area Development (CAD). To mitigate the environmental impacts of these interventions in sensitive coastal zones—such as soil salinity, waterlogging, and ecosystem disruption—the project adopts participatory and eco-friendly measures. 1. Mitigation of Soil and Water Salinity • Freshwater Irrigation Expansion: Increasing availability of irrigation water in dry seasons, specifically by developing water retention capacity in <i>haors</i>, <i>Beels</i> and <i>Khals</i> to flush out salts. • Controlled Drainage/Sluice Management: Utilizing sluice gates to prevent saltwater intrusion from tidal rivers into agricultural land. • Salt-Tolerant Crop Cultivation: Introducing salt-tolerant crop varieties to maintain productivity in salinity-prone areas. • Surface Water Harvesting: Implementing pond-based sand filter systems to provide fresh irrigation water and reduce reliance on groundwater. 2. Mitigation of Waterlogging and Drainage Congestion • Re-excavation of Drainage Canals: Increasing the capacity of existing canal networks to improve drainage during monsoon seasons. • Sluice Gate Operation: Proper operation of tidal sluices to allow internal water to drain out at low tide while restricting incoming saline water at high tide. • Natural Hydraulic Connectivity: Maintaining water flow paths to prevent long-term waterlogging in Southwest coastal regions. 3. Mitigation of Infrastructure Development Impacts • Eco-friendly Embankments: Using nature-based solutions, such as planting vetiver grass, and employing treated bamboo for protecting against erosion. • Minimized Land Acquisition: Limiting physical interventions and focusing on re-excavating existing canals to minimize land take. • Slope Stabilization: Replanting right species of trees, shrubs, and grasses on disturbed areas, canal banks, and flood control embankments. 4. Institutional and Social Measures (Participatory Approach) • Water Management Cooperative Associations (WMCA): Establishing WMCAs (150 new associations) to manage infrastructure locally, ensuring sustainability and community ownership. • Capacity Building: Training, provided by NGOs and LGED, to local farmers on efficient irrigation, water distribution, and O&M of the systems.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Environmental Monitoring: Active monitoring of social safeguards, including involuntary resettlement, and establishing a Grievance Redress Mechanism (GRM) to address environmental complaints. 5. Mitigation of Agricultural/Chemical Pollution • Improved Water Distribution: Enhancing command area infrastructure to increase irrigation efficiency and reduce overuse. • Promotion of Integrated Pest Management (IPM): Reducing reliance on chemical fertilizers and pesticides that could pollute water bodies during drainage. These measures aim to shift from conventional, gray-infrastructure heavy, to "green" and community-based solutions, ensuring that water management in the coastal zone is both productive and environmentally sustainable.
Subproject Type-14	Drainage & Command Area Development (DR & CAD), Dam in Coastal Hot Spot)
Environmental Impacts	Drainage and command area development (CAD) in coastal areas, particularly under projects like the CDRSSWRMP, aim to boost agricultural productivity but face significant environmental challenges. Key impacts include increased salinity, drainage congestion, land erosion, and ecosystem degradation in fragile, climate-vulnerable zones, requiring careful management. Environmental Impacts of Coastal Water Development • Drainage Congestion and Waterlogging: Improved drainage infrastructure can sometimes lead to localized waterlogging in coastal polders, especially if not adequately designed for climate-induced higher rainfall. • Salinity Intrusion: While coastal embankments (dams/polders) protect from storm surges, they can sometimes accelerate inland salinity intrusion or trap saline water, damaging agricultural land and productivity. • Land Erosion and Sedimentation: The coastal zone, particularly near the Meghna estuary, is highly dynamic, experiencing severe erosion (up to). Dams and water control structures may alter natural sediment flow, leading to sedimentation in channels and reducing their effectiveness, as seen in projects like the Chambī Khal subproject. • Ecosystem Degradation: Development activities can impact marine and local mangrove ecosystems (e.g., Sundarbans), especially through altered water quality, increased pollution, and habitat disruption. • Loss of Agricultural Land: Increased frequency of cyclones, storm surges, and flooding due to climate change, combined with structural interventions, can lead to the permanent loss of productive land. CDRSSWRMP Focus and Mitigation The CDRSSWRMP addresses these issues by promoting:

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Participatory Water Management: Involving local Water Management Cooperative Associations (WMCAs) to manage infrastructure sustainably. • Climate Resilience: Incorporating climate change data to design dams and drainage systems that can withstand increased hazards. • Mitigation Measures: Implementing, monitoring, and maintaining water control structures, including dredging of canals to address sedimentation and drainage issues.
Mitigation Measures	Mitigation measures for environmental impacts of drainage, command area development, and dams in coastal hotspots under CDRSSWRMP (Climate and Disaster Resilient Small-Scale Water Resources Management Project) focus on nature-based solutions, community-led management, and sustainable infrastructure to manage salinity, erosion, and biodiversity loss. Key actions include enhancing coastal greenbelts, implementing multi-purpose infrastructure, and fostering stakeholder-driven water management through Water Management Cooperative Associations (WMCAs). Environmental Mitigation Measures for Coastal Infrastructure: • Coastal Protection & Erosion Control: Implementing nature-based solutions such as mangrove <i>Acacia auriculiformis</i>, Keora (<i>Sonneratia apetala</i>), and Casuarina equisetifolia planting on embankments to stabilize soil and reduce wave energy. • Drainage and Salinity Control: Using tidal river management (TRM) and controlling sluice gates through WMCAs to manage waterlogging and prevent saltwater intrusion into agricultural land. • Command Area Development (CAD): Promoting climate-resilient agriculture, high-yield variety (HYV) crops, and sustainable land-use patterns to manage increased productivity needs. • Water Management Cooperative Associations (WMCAs): Strengthening local institutions for participatory, sustainable management of small-scale water resources to ensure long-term environmental viability. • Infrastructure Design: Adopting "giving more space to water" concepts, such as multi-purpose dikes, and integrating climate-smart agriculture and fisheries. • Risk Management: Using community-based adaptation (CBA) to address localized environmental impacts, such as building raised embankments and clearing drainage paths, reducing risks from cyclones and floods. These measures, part of the ADB-supported CDRSSWRMP, focus on combining structural, non-structural, and natural defenses to protect coastal ecosystems and livelihoods.
Subproject Type-15	Flood Management and Drainage & Water Conservation (FMD & WC) in Haor Hot Spot
Environmental Impacts	The CDRSSWRMP focuses on enhancing flood management, improving drainage, and promoting water conservation in the vulnerable Haor (wetland)

Environmental Impacts and Mitigation Measures of Subproject Types

and coastal hotspots. While these interventions aim to enhance agricultural productivity and climate resilience, they also create significant environmental impacts, balancing socioeconomic gains against ecological changes.

Environmental Impacts in the Haor Hotspot

The Haor region is a unique wetland ecosystem that is naturally submerged for 5-7 months. Interventions such as submersible embankments (designed to protect against early flash floods) result in the following impacts:

- **Reduced Natural Floodplains:** Embankments designed to reduce flash floods can disrupt the natural hydrological regime, leading to reduced sediment deposition inside the protected area, which may affect soil fertility.
- **Fisheries Impact:** While improving rice production, structural interventions can restrict fish migration and reduce the breeding grounds of indigenous fish species in the *Beels* (wetlands).
- **Monoculture Expansion:** Improved drainage encourages the conversion of mixed farming areas to mono-cropping (mainly Boro rice), which reduces biodiversity.
- **Water Quality Changes:** Reduced water exchange can cause drainage congestion and potentially reduce oxygen levels in the water.

Environmental Impacts in the Coastal Hotspot

The coastal area experiences extreme events, including salinity intrusion and tidal surges. Flood control, drainage, and irrigation (FCDI) projects here create the following environmental consequences:

- **Salinity Intrusion Mitigation:** Proper maintenance of embankment-based polders significantly reduces salinity intrusion into agricultural land, preventing soil degradation.
- **Drainage Congestion:** In areas like Khulna and Satkhira, poorly designed or unmaintained drainage systems can lead to long-term waterlogging.
- **Mangrove and Wetland Degradation:** While polders protect land, they can cause ecological imbalances, leading to the destruction of wetlands and affecting mangrove ecosystems.
- **Sediment Management:** Polders often stop the natural siltation process, preventing the accretion of new land (char land) and causing land degradation in surrounding areas.

Water Conservation Impacts

Water conservation activities, such as re-excavation of canals (khals) and rehabilitation of water control structures, bring both positive and negative results:

- **Positive Effects:** Increased availability of surface water for irrigation during the dry season, reduced water logging in the monsoon, and improved agricultural sustainability.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Negative Effects: Potential over-extraction of water during the dry season, impacting the aquatic ecosystem, and disruption of natural water flow if not planned properly. Mitigation and Sustainability Measures To minimize these adverse environmental impacts, the project integrates several strategies: • Nature-Based Solutions: Planting swamp trees for erosion control and using native species to strengthen embankments. • Integrated Crop Management: Encouraging the use of bio-fertilizers and diversified, high-value, salinity-tolerant crops to reduce reliance on chemicals and monoculture. • Participatory Management: Involving local Water Management Cooperative Associations (WMCAs) to ensure sustainable operation and maintenance of infrastructure
Mitigation Measures	Mitigation measures for environmental impacts of flood management, drainage, and water conservation in the Haor and coastal hot spots of CDRSSWRMP focus on nature-based solutions, structural rehabilitation, and livelihood adaptation. Key actions include sustainable embankment reinforcement, re-excavation of canals to restore hydrological flows, and promoting salinity-tolerant farming to enhance biodiversity and minimize ecosystem disruption. Key Mitigation Measures in Haor and Coastal Areas: • Sustainable Infrastructure & Drainage: ○ Embankment Design: Constructing and rehabilitating embankments with climate-resilient designs to manage, rather than completely block, floodwaters. ○ Drainage Improvement: Re-excavating silted drainage canals to enhance capacity, reduce waterlogging, and prevent long-term, deep-water submersion of agricultural land. ○ Sluice Gates & Structures: Utilizing regulatory structures to manage tidal water, reduce salinity intrusion, and facilitate controlled drainage. • Water Conservation & Ecosystem Management: ○ Wetland Restoration: Enhancing water retention capacity in <i>haors and Beels</i>, and <i>Khals</i> to ensure water availability for dry-season irrigation. ○ Nature-Based Solutions: Implementing afforestation (e.g., mangrove protection in coastal areas) and protecting wetlands to boost ecosystem resilience. ○ Biodiversity Conservation: Protecting native fish habitats in <i>haors</i> by avoiding complete drainage and maintaining natural water flow regimes. • Agricultural and Social Adaptation:

Environmental Impacts and Mitigation Measures of Subproject Types	
	○ Salinity-Tolerant Crops: Introducing salt-resistant crops to mitigate agricultural losses from salinity intrusion in coastal areas. ○ Livelihood Diversification: Promoting sustainable aquaculture and improved farming techniques to support fishermen and farmers in changing environments. ○ Community Involvement: Incorporating indigenous knowledge for managing natural resources and strengthening early warning systems for communities. ● Environmental Monitoring: ○ Impact Assessment: Conducting regular environmental assessments to monitor the impacts of subprojects on water quality, aquatic ecology, and agricultural sustainability. ○ Rehabilitation Measures: Ensuring that during construction, topsoil is conserved and construction debris is managed to avoid long-term pollution. These measures aim to strike a balance between structural, protective measures against floods and the need to protect the delicate ecological balance of both the haor and coastal regions.
Subproject Type-16	Water Conservation & Drainage (WC & DR) in Haor Hot Spot
Environmental Impacts	The Haor region in Bangladesh, a critical wetland ecosystem, faces significant environmental, social, and economic impacts from water-related hazards like flash floods, sedimentation, and drought, which are exacerbated by climate change. The CDRSSWRMP, aims to address these by implementing Water Conservation & Drainage (WC & DR) subprojects, such as re-excavating canals and building sluice gates to manage water, improve irrigation, and reduce the impact of floods. Environmental Impacts of WC & DR in the Haor Region: ● Improved Water Management and Agricultural Productivity: The primary positive impact is the enhanced drainage system and water retention capacity in <i>haors</i> and <i>Beels</i> (lakes), allowing for improved irrigation during the dry season. This helps combat the reduced cultivation days caused by irregular, climate-induced flooding. ● Flood Risk Reduction: Drainage improvements, such as re-excavating channels and installing sluice gates, are designed to manage water flow, reducing the depth and duration of farmland flooding. ● Mitigation of Sedimentation Impacts: By managing water flow, these projects can help mitigate the severe sedimentation (sand, silt, coal) that reduces water body depth and converts perennial <i>haors</i> into seasonal ones, a major environmental issue. ● Potential Negative Environmental Effects: ○ Reduced Wetland Functionality: Unplanned embankments or improper drainage can negatively affect the ecosystem by

Environmental Impacts and Mitigation Measures of Subproject Types	
	reducing the natural flushing and circulation of water, which is critical for the <i>haor</i> wetland's biodiversity. ○ Erosion and Sedimentation Changes: While intended to reduce flood impact, some infrastructure works, if poorly planned, can accelerate bank erosion and sedimentation in other areas. ○ Impact on Biodiversity: Excessive water regulation can threaten the diverse aquatic flora and fauna (200+ species of birds, 140+ fish species) that rely on the natural, seasonal flooding cycle. Key Considerations for Sustainability: The success of these interventions in the Haor hotspot depends on a participatory approach that ensures the infrastructure does not disrupt the natural hydrological, topographical, and ecological, features of the <i>haor</i> basin.
Mitigation Measures	The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh aims to improve agriculture and reduce poverty in "hot spots" like the <i>haor</i> region (northeastern wetland basins). The project, implemented by the Local Government Engineering Department (LGED), includes water conservation (retention) and drainage improvements (canal excavation) to manage flash floods and boost productivity. However, these infrastructures can have adverse environmental impacts, such as sediment deposition, reduced biodiversity, and disruption of aquatic habitats. Below are the key mitigation measures based on the project's framework and similar initiatives in the <i>haor</i> region: 1. Mitigation of Drainage and Canal Excavation Impacts Re-excavation of canals to improve drainage is a core component, but it can lead to bank instability and loss of aquatic habitats. • Re-vegetation of Banks: Stabilize side slopes of excavated canals using native vegetation to prevent erosion and sedimentation. • Controlled Dredging: Use environmentally friendly dredging equipment to minimize turbidity and siltation. • Habitat Preservation: Leave sections of the canal un-dredged to serve as refuges for fish and other aquatic species. • Spoil Disposal Management: Properly dispose of or use dredged material for land raising, avoiding the filling of productive wetlands. 2. Mitigation of Water Conservation (Storage) Impacts Developing water retention capacity in <i>Beels</i> (lakes) and <i>Khals</i> (canals) helps irrigation, but can disrupt natural water circulation. • Participatory Water Management: Utilize Water Management Cooperative Associations (WMCAs) to ensure that water retention structures (regulators) are operated in a way that allows for fish migration during breeding seasons.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Selective Dredging: Instead of complete dredging, focus on desilting only critical areas to maintain water depth for irrigation without destroying the entire ecosystem. • "Kua" (Deep Pool) Protection: Protect <i>Kuas</i> (deeper sites within wetlands) which act as dry season fish sanctuaries. 3. Protection of Aquatic Ecosystems and Biodiversity • Fish-Friendly Structures: Incorporate fish passes or operational rules in regulators and sluice gates to allow fish movement between rivers and the floodplain. • Limiting Chemical Use: Promote the use of organic fertilizers and integrated pest management (IPM) to reduce agrochemical runoff into the nutrient-sensitive haor waters. • Plantation of Water-Tolerant Trees: Implement buffer zones with water-tolerant trees to reduce erosion and filter run-off. 4. Technical and Structural Mitigation Measures • Climate Resilient Infrastructure: Design embankments and sluice gates to withstand increased flash flood intensity (higher than 5–7 m). • Proper Slope Design: Ensure stable side slopes for excavated canals to reduce the risk of future bank failure and sedimentation. 5. Institutional and Social Mitigation Measures • Strengthening WMCAs: Enhance the capacity of local WMCAs to manage and maintain the infrastructure sustainably, ensuring they are not controlled by elites. • Grievance Redress Mechanisms (GRM): Implement a robust GRM to receive, address, and resolve community complaints regarding environmental or social issues. • Participatory Approach: Ensure active participation of local communities, especially the landless and women, in the planning and monitoring of the subprojects. These measures aim to address the challenges of siltation, reduced water depth, and ecological disruptions caused by, or associated with, the structural interventions in the haor basin.
Subproject Type-17	Flood Management and Drainage & Irrigation (FMD & Irr) in Haor Hot Spot
Environmental Impacts	The CDRSSWRMP in Bangladesh focuses on enhancing agricultural productivity and climate resilience in haor areas through flood management, drainage improvement, and irrigation. While these interventions, such as constructing submersible embankments and re-excavating canals, are designed to protect Boro rice from flash floods, they bring significant environmental changes to the delicate haor ecosystem.

Environmental Impacts and Mitigation Measures of Subproject Types	
	Environmental Impacts of Flood Management & Drainage (Embankments/Sluices) • Altered Hydrological Regimes: Structural interventions like submersible embankments reduce natural flushing, leading to changed water flow patterns and potential waterlogging. • Loss of Nutrients: Flood-controlled areas experience a reduction in nutrient-rich sediments, reducing natural soil fertility. • Ecosystem Disruption: Embankments and Drainage Improvement Projects can disrupt natural fish migration and breeding, leading to a loss of fishery habitats. • Biodiversity Loss: Changes in the wetland environment and increased human activity, such as monoculture, contribute to a reduction in biodiversity and loss of native floral/faunal habitats. • Increased Flood Velocity Outside: While protected inside, areas outside the embankments may face higher flood velocities and increased erosion of char land. Environmental Impacts of Irrigation & Agricultural Expansion • Increased Agrochemical Contamination: Enhanced irrigation facilities allow for intensified Boro rice cultivation, leading to increased runoff of fertilizers and pesticides into open water bodies, causing water pollution. • Shift in Cropping Patterns: The projects favor increased monoculture (mainly High Yield Varieties of rice) at the expense of agricultural diversity. • Reduced Grazing Areas: Permanent water retention in some areas, or structural changes, can reduce available land for livestock grazing. • Groundwater Strain: Increased reliance on irrigation pumps, particularly during dry seasons, can lower water levels and cause surface water scarcity. Mitigation and Sustainable Management To combat these negative effects, the project emphasizes: • Participatory Approach: Establishing Water Management Cooperative Associations (WMCAs) for sustainable, community-driven operation. • Nature-Based Solutions: Using vetiver grass and treated bamboo for slope protection instead of hard engineering. • Climate-Resilient Infrastructure: Designing submersible roads and embankments that withstand flash floods (locally called <i>Afal</i>) rather than completely blocking water. While the project intends to secure livelihoods against disaster, it fundamentally shifts the haor environment from a natural, flood-dependent system to a managed, agricultural-focused ecosystem.

Environmental Impacts and Mitigation Measures of Subproject Types	
Mitigation Measures	The Climate and Disaster Resilient Small-Scale Water Resources Management Project in Bangladesh, managed by the Local Government Engineering Department (LGED), focuses on mitigating environmental impacts in Haor areas through sustainable, participatory water management. To address the ecological sensitivity of Haors (wetlands) while improving agricultural productivity, the project incorporates several mitigation measures aimed at managing flood control, drainage, and irrigation. Key mitigation measures in the Haor area include: 1. Infrastructure & Design Mitigation Measures • Controlled Drainage Improvement: Instead of large-scale drainage, the project focuses on re-excavating specific canals to increase capacity for agriculture while maintaining necessary wetland water levels to support fisheries. • Climate-Resilient Design: Infrastructure such as submersible embankments and sluice gates are designed to withstand high flash flood risks (increased design capacity by 8–12%), reducing sudden, destructive inundation while allowing natural floodwater recession. • Water Conservation Structures: Constructing specialized water retention structures in Khals and Beels to retain water for irrigation during the dry season, thus reducing the need for excessive groundwater extraction. • Nature-Based Solutions: Using environmentally friendly, natural materials for protection, such as planting vetiver grass and using treated bamboo to prevent erosion of embankments and riverbanks, which helps preserve the natural landscape. 2. Environmental & Ecological Protection Measures • Integrated Crop Management (ICM): Promotion of flood-tolerant, early-maturing, and high-value rice varieties (Boro) to adapt to changing water levels. • Bio-fertilizer Usage: Promoting organic farming and reducing reliance on chemical fertilizers and pesticides to protect the delicate aquatic ecosystem. • Fisheries Management: Incorporating fish-friendly designs in water structures and focusing on fish sanctuary protection to combat reduced fish catches. • Re-excavation Planning: Scheduling excavation of canals and rivers outside the monsoon season to prevent excessive siltation and damage to aquatic habitats. 3. Social and Institutional Mitigation Measures • Water Management Cooperative Associations (WMCAs): Establishing and strengthening local WMCAs (with 40% women membership) to ensure community-led, sustainable operation and maintenance of infrastructure, preventing top-down mismanagement.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Participatory Planning: Utilizing Participatory Rural Appraisal (PRA) to identify local environmental needs and impacts before designing structural interventions. • Land Acquisition Avoidance: Following a policy of avoiding land acquisition where possible (using lease agreements) to minimize involuntary resettlement and preserve existing land-use patterns. • Grievance Redress Mechanism (GRM): Implementing a strict GRM through Upazila and District-level committees to address community concerns regarding environmental or social damage promptly. 4. Emergency & Safety Mitigation • Construction of Killas & Flood Shelters: Building raised earth platforms (killas) for sheltering livestock and people during extreme flood events, which also serve as community spaces. • Safe Water Supply: Installing reverse osmosis plants to ensure access to clean water during disaster periods. These measures ensure that the development of small-scale water resources, which reduces the loss of harvest, does not come at the cost of the Haor's ecological integrity.
Subproject Type-18	Flood Management and Drainage (FMD & DR) in Haor Hot Spot
Environmental Impacts	The environmental impact of Flood Management and Drainage (FMD) and associated Small-Scale Water Resources Management (SSWR) projects—similar to those in the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP)—in the Haor districts of Bangladesh is complex, offering significant agricultural benefits while causing long-term ecological shifts. The Haor region, characterized by 5-7 months of natural inundation, sees FMD projects that aim to control flash floods, enabling high-yield Boro rice cultivation. Positive Environmental Impacts • Reduced Flash Flood Damage: Embankments (submersible) and sluice gates protect Boro crops from pre-monsoon flash floods, reducing agricultural losses in March-April. • Improved Drainage: Re-excavation of canals increases drainage capacity, allowing faster removal of water and reducing prolonged waterlogging in agricultural lands. • Improved Land Use: Provides increased flood-free land for agriculture, settlement, and rural infrastructure (e.g., village protection walls). Negative Environmental Impacts • Disruption of Hydrological Regimes: FMD structures alter natural water flow, leading to increased siltation in rivers and canals, reducing their capacity over time.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Loss of Fishery Habitats: Reduced inundation limits the migration of fish between rivers and floodplains, resulting in a decline in open water fisheries. • Reduction of Soil Nutrients: By restricting natural flooding, the deposition of fertile nutrient-rich sediment is reduced, causing soil quality to deteriorate over time. • Increased Dependency on Inputs: The push for high-yield variety (HYV) monoculture leads to increased use of chemical fertilizers and pesticides, polluting surface and groundwater. • Water Quality Issues: Controlled, stagnant water inside embankments can lead to water quality deterioration and increased incidences of water-borne diseases. Mitigation and Sustainable Approaches To address these impacts, projects like CDRSSWRMP and related Haor initiatives focus on: • Nature-based Solutions: Using vetiver grass and treated bamboo for embankment stabilization to prevent erosion. • Community-Based Management: Involving locals in water management cooperative associations (WMCAs) to manage, operate, and maintain infrastructure to ensure sustainability. • Balanced Land Use: Incorporating fish-friendly structures and maintaining some connectivity to support ecological, rather than just agricultural, needs.
Mitigation Measures	Mitigation measures for the environmental impacts of flood management and drainage projects—such as those under the CDRSSWRMP and similar initiatives by the Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED)—focus on balancing agricultural protection (specifically Boro rice) with the ecological health of the Haor ecosystem. Key mitigation measures include: 1. Water Management and Hydrological Mitigation • Submersible Embankments: Instead of full-height embankments, submersible embankments are constructed to protect Boro crops from early pre-monsoon flashes (April-May) while allowing the haor to submerge during the main monsoon season (June-September), which maintains the nutrient-rich sediment deposition and wetland ecology. • Controlled Drainage Structures: Regulators and sluice gates are designed to allow controlled discharge of water, preventing long-term waterlogging within the protected area and ensuring the timely drainage of water to prevent crop damage. • Re-excavation of Khals (Canals): Increased capacity of natural Khals ensures that water can drain out faster from the haor basin into the surrounding rivers during pre-monsoon surges.

Environmental Impacts and Mitigation Measures of Subproject Types	
	2. Aquatic Ecosystem and Fisheries Management • Fish-Friendly Infrastructure: Sluice gates are designed with proper fish pass features to maintain the connectivity between rivers and Beels (wetlands), essential for the migration of fish species and breeding. • Wetland Retention Development: Developing and protecting the water retention capacity of existing haors, beels, and khals ensures the preservation of habitats during the dry season. • Closed-Season Regulation: Restricting fishing activities during critical spawning periods to allow fish stock recovery. 3. Sustainable Agricultural Practices • Crop Diversification: Promoting short-duration, high-yield, and flood-tolerant rice varieties that can be harvested before the flash floods arrive. • Integrated Pest Management (IPM): Encouraging the reduction of chemical pesticides to prevent water pollution in the sensitive haor ecosystem, using natural alternatives. 4. Erosion and Slope Protection • Nature-Based Solutions (Bio-engineering): Planting native reeds, grasses, and trees along the toe of embankments and riverbanks to protect them from wave action and erosion. • Slope Stabilization: Using geobags and armor blocks for protecting crucial, high-risk points in embankments rather than concrete everywhere, allowing for better ecological integration. 5. Institutional and Community Mitigation • Water Management Cooperative Associations (WMCAs): Strengthening local participation to manage water resources, ensuring that embankment operation and maintenance (O&M) are carried out by the beneficiaries. • Flood Forecasting and Warning Systems: Utilizing real-time data to warn farmers about flash floods, allowing for urgent, early harvesting. • Labour Contracting Societies (LCS): Involving local community members (particularly women) in the construction and maintenance of infrastructure, which provides income and improves ownership of the mitigation measures. 6. Mitigation of Construction Impacts • Environmental Management Plan (EMP): Ensuring that all construction activities follow an EMP that prohibits the dumping of construction debris into water bodies, requires proper management of wastewater from camps, and restricts construction during the monsoon season.

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Site Rehabilitation: Restoring temporary construction sites (e.g., burrow pits) to their original condition after the project is completed.
Subproject Type-19	Water Conservation (WC) in Haor Hot Spot
Environmental Impacts	Based on the context of the CDRSSWRMP, water conservation (WC) interventions in the haor (wetland) hot spot—such as re-excavating canals and developing water retention capacities in existing haors, Beels, and Khals—are designed to increase irrigation water availability while mitigating climate risks. These interventions have complex, mixed environmental impacts: Positive Environmental Impacts (Benefits) • Enhanced Water Availability in Dry Season: By increasing the water retention capacity of haors and canals, these measures provide essential, reliable irrigation water during the dry season. • Mitigation of Flash Flood Impacts: Infrastructure to manage water levels can help reduce the vulnerability of agricultural lands to early flash floods, which are a major threat to the region. • Improved Ecosystem Resilience: Sustainable management of water resources aids in maintaining biodiversity by ensuring that wetlands do not dry out completely, which helps protect aquatic flora and fauna. • Reduced Ground Water Pressure: Efficient surface water storage reduces reliance on groundwater extraction in regions that may face future water scarcity. Negative Environmental Impacts and Risks • Disruption of Wetlands Biodiversity: While aimed at resilience, inappropriate infrastructure development can disturb the unique ecosystem of the haor, which is vital for migratory birds and native aquatic species. • Disruption of Fish Migration: Improved water retention structures (such as sluice gates or embankments) can interrupt the movement of fish between rivers and the haor, affecting fisheries. • Siltation and Morphological Changes: Increased water retention in stagnant, artificial, or improved canals can lead to higher sedimentation rates, requiring continuous maintenance and potentially altering the local flow of water. • Potential for Increased Agrochemical Runoff: Increased agricultural intensity (supported by improved irrigation) may lead to higher use of fertilizers and pesticides, causing pollution in the freshwater, which threatens aquatic animals and plants. Contextual Considerations The project emphasizes establishing Water Management Cooperative Associations (WMCAs), which are crucial for balancing, as these groups are responsible for managing the infrastructure and mitigating negative

Environmental Impacts and Mitigation Measures of Subproject Types	
	environmental impacts. The overall goal is to transition from natural inundation-based fishing to a more controlled, agricultural-friendly system, which brings inherent ecological trade-offs.
Mitigation Measures	The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh aims to enhance water retention in haor, Beel, and Khals for irrigation. To mitigate environmental impacts such as reduced aquatic biodiversity, wetland degradation, and altered hydrological regimes in the sensitive Haor Hot Spot, the project implements specific, nature-based, and participatory measures. Mitigation Measures for Water Conservation in the Haor Region: • Nature-Based Solutions (NbS): Instead of concrete, the project utilizes soft engineering for embankment stabilization, such as planting vetiver grass and using treated bamboo to prevent erosion from waves and flash floods. • Fish-Friendly Infrastructure: To minimize threats to aquatic ecosystems, regulators and sluice gates are designed to facilitate fish movement, maintaining connectivity between floodplains and water bodies. • Participatory Water Management (WMCA): Water Management Cooperative Associations (WMCAs) are established to manage water resources locally, ensuring that conservation efforts do not excessively dry out wetland habitats. • Hydrological and Ecological Planning: Re-excavation of canals is designed to increase capacity without disrupting natural wetland ecosystems, avoiding complete drainage of Beels (permanent wetlands). • Agricultural Adaptation: To reduce reliance on excessive water extraction, the project promotes the cultivation of climate-resilient crops, such as salt-tolerant or short-duration rice varieties. • Integrated Weed and Pest Management: To mitigate water quality degradation from agricultural runoff, the project promotes reduced chemical inputs, minimizing the risk of eutrophication in stagnant waterbodies. • Land Use Optimization: The project seeks to avoid significant land acquisition to minimize negative impacts on local livelihoods and to protect existing ecological habitats. These measures are designed to ensure that increased water availability for agricultural productivity does not come at the cost of the unique biodiversity and ecological services provided by the Haor wetland system.
Subproject Type-20	Water Conservation & Command Area Development (WC & CAD) in Haor Hot Spot
Environmental Impacts	The CDRSSWRMP aims to address the vulnerabilities of the Haor region—characterized by 5-7 months of annual inundation, flash floods, and limited dry-season water access—through infrastructure development. The project includes Water Conservation (re-excavating <i>Beels</i> and <i>Khals</i> to enhance

Environmental Impacts and Mitigation Measures of Subproject Types	
	water retention) and Command Area Development (improving irrigation distribution). The environmental impacts of these interventions are mixed, ranging from improved resilience to potential ecological disruption if not managed correctly. Key Environmental Impacts in the Haor Hotspot • Positive Impacts (Benefits) ○ Enhanced Water Availability: By increasing the water retention capacity of <i>Beels</i> (natural depressions) and <i>Khals</i> (canals), the project helps secure irrigation water for the dry season (Boro rice season), supporting agricultural sustainability. ○ Flood Risk Management: The rehabilitation of embankments and construction of sluice gates reduce the depth and duration of farmland flooding, protecting crops from early flash floods. ○ Improved Aquatic Biodiversity (Controlled): Proper design of re-excavation can create habitat diversity, and the project aims to promote cage aquaculture and floodplain fisheries, which, when managed by Water Management Cooperative Associations (WMCAs), can improve, rather than degrade, local aquatic resources. ○ Improved Drainage: The re-excavation of drainage canals improves water flow, reducing prolonged waterlogging. • Negative Impacts (Risks and Challenges) ○ Ecological Disruption: Over-development of water infrastructure (e.g., rigid embankments) can hinder the movement of fish and native aquatic species, disrupting the delicate wetland ecosystem. ○ Waterlogging and Siltation: The alteration of natural flow regimes, particularly with embankments, can cause unexpected drainage congestion and increased sediment deposition in unintended areas. ○ Agrochemical Accumulation: Enhanced irrigation (Command Area Development) often increases cropping intensity, which may lead to higher, potentially unsustainable, use of pesticides and fertilizers, harming aquatic biodiversity. ○ Loss of Wetland Habitats: While conservation is a goal, improper dredging or re-excavation of <i>beels</i> can lead to the destruction of swamp forests and the degradation of habitats for migratory birds. • Mitigation and Management Approach ○ Participatory Approach: The establishment of WMCAs is crucial, allowing local stakeholders to guide infrastructure development and maintenance.

Environmental Impacts and Mitigation Measures of Subproject Types	
	○ Environmental Management Plan (EMP): Initial Environmental Examinations (IEEs) are mandated to evaluate impacts and develop mitigation strategies, such as using water-tolerant tree species for protection, avoiding over-extraction, and promoting bio-fertilizers. ○ Improved Infrastructure Design: Using submersible roads and, where appropriate, less intrusive structures help maintain natural connectivity during high-water seasons. The project, which operates in 42 districts including the flash-flood-prone Haor region, aims to balance agricultural economic gains with the need to protect the fragile ecosystem of the Ramsar-designated Haor areas.
Mitigation Measures	Mitigation measures for the environmental impacts of water conservation and command area development in the Haor regions—specifically within the context of projects like the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP)—focus on balancing increased agricultural productivity with ecological protection. Based on similar initiatives in the Bangladesh Haor basin, key mitigation measures include: 1. Mitigation of Water Conservation Impacts (Beels/Haors/Khals) • Fish-Friendly Infrastructure: Construction of regulators, sluice gates, and embankments must include fish passes to allow the free movement of fish species between rivers and wetlands, essential for maintaining biodiversity. • Wetland Protection: Rehabilitation of water bodies must ensure that sediment dredging does not destroy wetland habitats. Techniques should maintain the depth of <i>beels</i> (lakes) to protect perennial water, as excessive sedimentation turns them into temporary, non-productive areas. • Conservation of Local Flora/Fauna: Implementing, or protecting existing, swamp forests (e.g. <i>Hijol</i> and <i>Koroch</i>) along the edges of haors to act as natural windbreaks and to maintain aquatic habitats. 2. Mitigation of Command Area Development (Irrigation/Agriculture) • Sustainable Water Use: Implementing participatory water management through Water Management Cooperative Associations (WMCAs) to regulate water extraction during the dry season, preventing the depletion of <i>Beels</i>. • Integrated Pest Management (IPM): Introducing IPM to reduce the use of agrochemicals, pesticides, and fertilizers in Boro rice cultivation, protecting water quality in the wetlands. • Efficient Distribution Systems: Improving irrigation infrastructure to minimize water wastage and reducing the need for increased, harmful groundwater extraction. 3. Mitigation of Infrastructure & Erosion Risks

Environmental Impacts and Mitigation Measures of Subproject Types	
	• Ecological Revetments: Using bio-engineering techniques—such as planting Vetiver grass, using geojute texturing, and adopting concrete hollow blocks—for bank protection instead of traditional solid concrete blocks. These are more effective against wave action and environmentally friendly. • Controlled Siltation Management: Ensuring that re-excavated canals do not promote faster, uncontrolled sedimentation in the wetlands. • Avoiding Land-Use Mismanagement: Prohibiting the conversion of wetlands for unplanned agriculture or brickfields. 4. Institutional & Social Mitigation • Community-Based Monitoring: Establishing WMCAs to ensure that operations and maintenance (O&M) of infrastructure are done in an environmentally sustainable manner. • Capacity Building: Providing training to farmers on climate-smart agriculture and on the impacts of excessive fertilizer use on local ecology. These measures are often incorporated into Environmental Management Plans (EMP) and Environmental Code of Practice (ECoP) to ensure the projects are compliant with environmental standards.

Table 23: Overview of Environmental Impacts by Subproject Type

Category	Type		Potential Environmental Impacts	
			Positive	Negative
1. Simple – Unregulated, uncontrolled flow	DR	Drainage	• Reduce water logging • Increase crop production • May improve in-channel fishery • Increase employment • Improve surface water quality • Improve nutrition and health	Affects wetland May affect aquatic habitat May affect groundwater table
2. Complex – Regulated flow (with gated structures or other means of flow control)	FM	Flood Management	• Reduce crop damage • Reduce homestead damage • Reduce damage to culture fishery • Reduce damage to roads • Reduce hyacinth damage • Reduces pollution from herbicides, pesticides • Improves financial stability	Without fish passes, disrupts migration Modifies regional flood pattern Land loss for embankment footprint
	IRR	Irrigation	• Increased crop production • Increased crop diversification • Increase employment • Improve nutrition and health	From groundwater, lowers water table From surface water may impact downstream users

Category	Type		Potential Environmental Impacts	
			Positive	Negative
				May increase use of chemicals for crop production
	WC	Water Conservation	• Increase crop production • Increased crop diversification • Increase employment • Improve nutrition and health	Impacts potential downstream users May increase use of chemicals for crop production
	FMD	Flood management and drainage	• Reduce water logging • Increase crop production and reduces flood damage • May improve in-channel fishery and reduce damage to culture fisheries • Reduce damage to roads • Reduce hyacinth damage • Reduces pollution from herbicides, pesticides • Increase employment • Improve surface water quality • Improve nutrition and health	Without fish passes, disrupts migration Modifies regional flood pattern Land loss for embankment footprint Affects wetland May affect aquatic habitat May affect groundwater table
	FMWC	Flood management and water conservation	• Increase crop production and reduce flood damage • Reduce homestead damage • Reduce damage to culture fishery • Reduce damage to roads • Reduce hyacinth damage • Reduces pollution from herbicides, pesticides • Improves financial stability • Increased crop diversification • Increase employment • Improve nutrition and health	Impacts potential downstream users May increase use of chemicals for crop production Without fish passes, disrupts migration Modifies regional flood pattern Land loss for embankment footprint
	CAD	Command area development	• Increased crop diversification • Increased crop production • Increased employment • Improved nutrition and health	

5.2 Environmental Impacts of Proposed Interventions under CDRSSWRMP

5.2.1 Re-sectioning of embankment

Re-sectioning of an embankment involves re-shaping, widening, or strengthening an existing earth structure to improve its stability, safety, or functional capacity, often necessitated by

erosion, subsidence, or upgrading requirements. It is a critical civil engineering intervention for maintaining infrastructure integrity, particularly in flood-prone areas.

1) Requirements for Re-sectioning an Embankment

Re-sectioning is typically required under the following conditions:

- **Structural Damage/Instability:** Damage caused by erosion, slope failure, seepage, or piping.
- **Settlement and Subsidence:** Excessive settlement leading to loss of crest height or width.
- **Upgrading and Widening:** The need to add additional carriageways, rail tracks, or increase the crest width for safety.
- **Flood Risk Management:** Raising the crest height or strengthening slopes to meet higher flood protection levels.
- **Slope Stability Issues:** When the slope is too steep or the material is weak, requiring flatter slopes or reinforcement (e.g., geomaterials).
- **Inadequate Drainage:** Poor drainage conditions requiring the restructuring of slopes to improve water management.

2) Impacts of Re-sectioning

The re-sectioning process can have several environmental, social, and structural impacts:

- **Structural Impact on Existing Structure:** Improper bonding between new and old material, if not properly benched, can lead to new planes of weakness.
- **Environmental Degradation:** Construction activities, such as excavation and soil compaction, can result in noise, dust, and loss of vegetation.
- **Ecological Disruption:** Potential destruction of aquatic or riparian habitats, especially during shoreline dredging.
- **Land Acquisition/Resettlement:** Widening projects may require the acquisition of adjacent land and relocation of residents or businesses, causing social impacts.
- **Water Management Issues:** Alteration of existing drainage paths or interference with natural flow systems.

3) Mitigation Measures

To mitigate the adverse impacts, the following steps are required:

- **Proper Bonding (Benching):** When widening, continuous horizontal benching (e.g., 300 mm wide) should be cut into the old slope to ensure proper bonding with the new material.
- **Material Selection and Quality Control:** Using suitable fill materials (free from organic matter) and ensuring proper moisture control and compaction (95–97% of Maximum Dry Density).
- **Erosion Control and Stabilization:** Using geotextiles, geogrids, riprap, or slope vegetation to improve stability and prevent further erosion.
- **Drainage Management:** Providing proper drainage (e.g., toe drains) to prevent saturation, which causes instability.

- Social and Environmental Management Plan (ESMP): Identifying spoil disposal sites, conducting environmental monitoring, and managing land acquisition efficiently to reduce impacts on local communities.
- Slope Geometry Optimization: Conducting slope stability analysis to determine the optimal slope ratio (e.g., 2:1 or 3:1) for safety.
- Temporary Drainage Control: Ensuring that during construction, the drainage of the existing embankment is not obstructed.

5.2.2 Re-excavation of Khal

Under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP)—often linked with ADB-supported initiatives like the Climate Resilient Integrated Southwest Project (CRISP)—the re-excavation of *khals* (canals) is a core component designed to enhance water management.

1) Requirements for Re-excavation of Khals

The re-excavation is driven by the need to revive degraded water bodies, improve drainage, and enhance agricultural production in the face of climate change. Key requirements include:

- Target Areas: Silted, obstructed, or dysfunctional canals (khals/Nalas) located in rural areas (e.g., Haor, High Barind, and Southwestern regions).
- Purpose: Increasing water retention for dry-season irrigation, enhancing drainage to prevent waterlogging during monsoon, and facilitating agricultural intensification.
- Project Scope: Involves dredging/excavation, slope protection, and sometimes the construction of water control structures (regulators) and access roads.
- Design & Standards: Must include leveling, dressing, and proper compaction of excavated soil on embankments.
- Water Management: Provision for pumping and bailing out water from the *khal* during the work.

2) Environmental and Social Impacts

While beneficial, the projects have potential negative impacts, categorized in environmental and social reports (e.g., EIA/EMP):

- Environmental: Increased dust and noise during construction, water pollution from turbidity, temporary disruption to aquatic habitats, and potential loss of vegetation on banks.
- Social & Economic: Potential for temporary loss of agricultural land or land-based livelihoods, impact on informal occupants (squatters) of the embankment, and disruption to local transport.
- Involuntary Resettlement: Minor economic displacement, typically impacting people losing income from crops cultivated on government land (Khas land) along the canal slopes.

3) Mitigation Measures

To address these, project frameworks include an Environmental Management Plan (EMP) and a Resettlement Framework:

- **Mitigation of Environmental Impacts:**
 - Dust/Noise Management: Sprinkling water on haul roads and restricting construction to daytime hours.
 - Water Quality Control: Limiting excavation during peak fish breeding seasons and implementing sedimentation controls.
 - Revegetation: Stabilizing bank slopes immediately after excavation to prevent erosion.
- **Mitigation of Social Impacts:**
 - Compensation & Assistance: Providing in-kind compensation or cash assistance to displaced persons (APs) for lost crops or income, particularly focusing on vulnerable households.
 - Information Disclosure: Holding consultations with stakeholders to discuss subproject benefits and potential negative effects before work begins.
 - Grievance Redress Mechanism (GRM): Implementing a local committee to resolve disputes efficiently.
- **Construction Best Practices:** Working in sections (segmental approach) to minimize access disruptions for locals.

The implementation of these measures is mandated for contractors to reduce negative impacts while achieving the intended improvements in agricultural water access and disaster resilience.

5.2.3 Construction of Foot Bridge

The CDRSSWRMP, implemented by the Local Government Engineering Department (LGED) with support from IFAD, ADB, and the Government of the Netherlands, focuses on strengthening rural infrastructure in Bangladesh against climate risks. Footbridges are a critical component under this project to improve rural connectivity, particularly in flood-prone and coastal regions, ensuring that communities can access markets and services safely year-round.

1) Requirements and Selection Criteria for Foot Bridges

Under the CDRSSWRMP framework, footbridges are prioritized based on specific climate-resilient and social-impact criteria:

- **Targeted Vulnerability:** Selection prioritizes flood-prone areas, especially in the Hoar and coastal regions, to reduce isolation during extreme weather events.
- **Community Connectivity:** Bridges are required to connect remote villages with growth centers, rural markets, schools, and health centers.
- **Climate Proofing:** Structures must be built according to climate-proof standards, considering forecasted climate changes, increased flood levels, and higher temperatures.

- **Beneficiary Selection:** Selection is often made in consultation with Water Management Cooperative Associations (WMCAs) or local community stakeholders to maximize impact on the poor and functionally landless households.

2) Potential Impacts

- **Positive Impacts:**
 - **Improved Mobility:** Safe, year-round access across canals and small rivers, especially for school-going children and women.
 - **Economic Empowerment:** Facilitates easy transportation of agricultural products to markets and boosts non-farm employment.
 - **Disaster Resilience:** Acts as an escape route or safe passage during floods and cyclones.
- **Adverse Impacts (Construction & Operational Phase):**
 - **Environmental:** Potential loss of vegetation, agricultural land, and disturbance to aquatic habitats during foundation construction.
 - **Social:** Temporary displacement or land acquisition for approach roads.
 - **Construction Risks:** Air pollution from dust, noise pollution, and potential water pollution from construction waste.

3. Mitigation Measures

To comply with environmental and social safeguards, the following mitigations are typically implemented:

- **Design Considerations:** Designing structures with adequate vertical clearance to handle increased flood flows and avoiding highly productive agricultural land.
- **Construction Management:**
 - **Pollution Control:** Utilizing noise barriers, limiting construction time to daylight hours, and ensuring proper storage of hazardous materials.
 - **Waste Management:** Creating designated disposal sites for dredged materials and construction waste.
- **Rehabilitation:** Implementing comprehensive Resettlement Action Plans (RAP) for any affected families and undertaking re-vegetation of areas exposed during construction.
- **Safety Measures:** Providing Personal Protective Equipment (PPE) for workers and placing warning signs to minimize accidents.

CDRSSWRMP generally adopts an Environmental Management Plan (EMP) to ensure these negative impacts are minimized and the project is environmentally sound.

5.2.4 Construction of Box Culverts

Box culverts are rigid frame reinforced concrete structures crucial for conveying water (streams, storm drainage) under roadways, or embankments, particularly when headroom is limited and when dealing with soft soil conditions. They are preferred for their structural strength, longevity, ability to handle high flow, and reduced construction time, especially when using precast units.

The Climate and Disaster Resilient Small-Scale Water Resources Management Project, implemented by the Local Government Engineering Department (LGED), requires the construction of robust box culverts to address drainage congestion, flood risks, and water logging, particularly in coastal zones. These structures are designed to provide climate-resilient water management, supporting agricultural productivity and providing access to rural areas.

1) Requirements for Box Culverts under CDRSSWRMP

Box culverts under the project are designed as reinforced concrete structures (RCC), selected for their suitability in weak soil conditions, high rigidity, and efficiency in handling high discharge. Key requirements include:

- **Structural Design:** Monolithic RCC construction, designed to withstand maximum bending moments, shear forces, and earth pressures using standards such as AASHTO LRFD.
- **Dimensions:** Typically, 2m x 2m or 3.5m x 3.5m, often single or multi-celled based on required capacity.
- **Loads:** Must withstand Class 70R or Class A loading, vertical loads (dead/live), and water pressure.
- **Components:** Must include cut-off walls and wing walls for erosion control, with aprons to ensure stability on weak coastal soils.
- **Durability:** Minimum concrete grade (e.g., M25 or M35) with adequate cover to prevent corrosion.

2) Impacts of Box Culvert Construction

While providing significant benefits, the construction and operation of box culverts can have both positive and negative impacts:

Positive Impacts

- **Improved Drainage:** Reduces water logging in polder areas, addressing drainage congestion in the southwest coastal zone.
- **Salinity Management:** Facilitates the flushing of salts from the soil, improving agricultural land quality.
- **Enhanced Connectivity:** Provides all-weather access roads, benefiting rural communities.

Potential Adverse Impacts

- **Construction Disruption:** Temporary turbidity in water bodies, noise, and dust pollution.
- **Sedimentation:** Improper design may lead to sediment accumulation, requiring frequent maintenance.
- **Environmental Degradation:** Scour at the outlet if protection measures are inadequate.
- **Loss of Land:** Temporary or permanent acquisition of land for construction.
- **Construction Impacts:**

- Traffic Disruption: In-situ construction causes significant, long-term traffic delays compared to precast options.
- Environmental Degradation: Construction can lead to turbidity, sediment runoff, and destruction of habitat in and around the stream.
- **Structural Risks:**
 - Settlement: Uneven settlement if the bedding is not properly compacted.
 - Cracking: Cracking due to temperature variations or improper reinforcement placement.

3) Mitigation Measures

To reduce adverse impacts, the project incorporates several measures:

- **Waterway Optimization:** Sizing culverts (e.g., to 25-year storm events) to prevent perching, erosion, and flow restriction.
- **Erosion Control:** Installing grouted riprap or rock pitching (aprons) to protect against scouring and erosion at both ends of the culvert.
- **Environmental and Social Management Plan (ESMP):** Including mitigation costs in the construction contract to address site-specific impacts.
- **Labor Contracting Societies (LCS):** Engaging local communities for construction, ensuring sustainable, community-managed infrastructure.
- **Water Management Cooperative Associations (WMCAs):** Providing training on repair and maintenance to ensure long-term functionality.

5.2.5 Construction of Sluice

Sluice gates are critical hydraulic structures designed to regulate, manage, and cut off water flow in various environments, including irrigation systems, flood control, water supply, and dam management. They are crucial for maintaining water levels, providing flood protection, and facilitating navigation.

The CDRSSWRMP, supported by IFAD, ADB, and the Bangladesh government, involves the construction of climate-resilient water infrastructure, including **60 composite sluice gates** to reduce flood risks and improve drainage over 87,000 hectares of land. Sluice gates under this project are crucial for controlling water flow, protecting crops, and enhancing agricultural productivity, yet they pose environmental and social risks requiring mitigation.

1) Requirement of Sluice Gates (CDRSSWRMP)

- **Water Management & Protection:** Sluice gates are essential for managing water logging, mitigating saline intrusion, and regulating water levels in flood-prone areas.
- **Agricultural Productivity:** They enable enhanced cropping intensity by managing water in canals and regulating water retention for dry-season irrigation.
- **Resilience:** The project mandates the construction of modern, composite sluice gates (60 units) to replace or complement existing inefficient structures and to build new infrastructure in vulnerable regions.
- **Management:** Formation of Water Management Groups (WMGs) and sluice gate committees is required for operation and governance.

2) Potential Impacts

1. **Water Logging & Drainage Congestion:** Improperly operated or designed sluices can lead to water logging within polders, particularly if not synchronized with tidal changes.
2. **Environmental Degradation:** Reduced water flow can cause siltation of riverbeds, narrowing of estuaries, and altered morphology.
3. **Social & Economic Disruption:** Poorly managed sluices may limit fishing opportunities, impacting the livelihoods of fishermen.
4. **Acquisition of Land:** New infrastructure requires 50.14 acres of land acquisition, potentially leading to displacement.

Key Impacts of Sluice Operation

The installation and operation of sluices create several environmental and operational impacts:

- **Water Quality Degradation:** Sluice operation can cause reduced dissolved oxygen (DO) by 18-19%, increased chlorophyll-a, and higher phosphorus levels.
- **Algal Blooms:** Slow, stagnant, or trapped water upstream of the sluice promotes the growth of filamentous algae (like *Spirogyra*), resulting in floating mats, foul odors, and reduced light penetration.
- **Reduced Connectivity & Fish Passage:** They disrupt natural fish migration, hindering fish from entering or leaving tidal creeks, and can isolate water bodies after floods.
- **Hydrodynamic Impact (Vibration & Erosion):** High-velocity flow during discharge causes vibrations in the structure, which can cause erosion of the channel bed.
- **Structural Damage:** During floods, debris (like floating logs or steel tubes) can impact and damage radial gates, leading to potential structural failure.

3) Mitigation Measures

- **Effective Operational Rules:** Establishing specialized sluice gate committees to ensure proper operation, especially during monsoon and dry seasons to avoid water logging and ensure drainage.
- **Integrated Management:** Implementing Water Management Groups (WMGs) to ensure local participation and accountability in sluice operation.
- **Water Retention Systems:** Installing 4-V Water Retention Structures (WRS) adjacent to existing 1-V sluice gates to maximize water conservation in the dry season while allowing ecological flow.
- **Mitigation of Social Impacts:** Providing compensation and rehabilitation for families affected by the construction and acquisition of land for the infrastructure.

The project also includes building 110 kilometers of farm access roads and rehabilitation of existing structures, with an emphasis on incorporating climate adaptation strategies.

To reduce the negative impacts and ensure sustainable operation, several mitigations are employed:

- **Optimized Regulation & Operation:** Implementing small, frequent gate openings rather than large, sporadic ones can maintain lower pollution levels (e.g., maintaining flow discharge between 10-60 m³/s).
- **Flow Velocity Control:** Maintaining a minimum flow velocity (e.g., 0.05 m/s) in channels can effectively suppress algal blooms.
- **Fish-Friendly Designs:** Utilizing side-mounted gates or self-regulating (flap) gates, which allow for lower discharge velocities, enables better fish passage.
- **Structural Reinforcement & Protection:** Installing stiffer beams or anti-collision devices (e.g., rubber bumpers) on gate piers and arms protects against floating debris impacts.
- **Regular Maintenance:** Conducting routine cleaning to remove debris, along with inspection of seals and lubrication, prevents valve sticking and structural failure.
- **Environmental Monitoring:** Active monitoring of dissolved oxygen and nutrient levels ensures proactive management of eutrophication.

5.2.6 Construction of WMCA Office Building

The construction of a Water Management Cooperative Association (WMCA) office building involves rigorous institutional, technical, and environmental requirements aimed at enhancing rural water management infrastructure. Project under this scope, often supported by partners like ADB, IFAD require careful planning to mitigate environmental impacts and ensure long-term functionality.

Under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), implemented by the Local Government Engineering Department (LGED) and financed by ADB/IFAD, the construction of Water Management Cooperative Association (WMCA) office buildings is a key component to strengthening local institutions. The project aims to establish 150 new WMCAs and strengthen 230 existing ones, providing them with climate-resilient infrastructure.

1) Requirements for Construction of WMCA Office Buildings

The construction of these offices follows specific standards to ensure resilience and sustainability:

- **Climate Resilience:** Buildings are designed to withstand extreme climate events, including floods, cyclones, and waterlogging.
- **Location and Land:** Usually constructed on land secured by the WMCA or provided by the local government, adhering to strict land acquisition procedures (approximately 50.14 acres are designated for total project infrastructure).
- **Purpose:** To serve as a community hub for O&M (Operation and Maintenance) management, agricultural input storage, meeting space, and for hosting training programs, including for women and vulnerable community members.
- **Compliance:** Construction must adhere to the Environmental Management Plan (EMP) as part of the initial environmental examination (IEE) to be approved by the Department of Environment (DOE).

2) Environmental and Social Impacts

Construction activities, although small-scale, may cause temporary or minor permanent impacts:

- Land Acquisition & Involuntary Resettlement: Minor impacts on land owners if site selection is not carefully managed, potentially causing loss of agricultural land or, rarely, physical displacement.
- Environmental Degradation: Dust, noise pollution, and increased waste (solid/liquid) during construction in rural settings.
- Drainage Congestion: Potential for temporary obstruction of existing natural drainage or canals.
- Occupational Health and Safety (OHS): Risks to workers and local communities due to lack of personal protective equipment (PPE) or safe working procedures.
- Social Disruption: Temporary disruption to local transportation or access, particularly if constructing near existing roads.

3) Mitigation Measures (Environmental and Social Management Plan)

To manage these impacts, the following mitigations are typically enforced in the bidding and contractual documents:

- Resettlement Plan Implementation: Proper compensation for land or loss of assets according to the project's resettlement framework, prioritizing voluntary land donation where applicable.
- Waste Management: Proper disposal of construction debris and hazardous waste, designating specific areas for stockpiling.
- Water Management: Protecting nearby water sources and ensuring construction does not impede existing water flow, particularly in flood-prone areas.
- OHS Protocols: Implementing strict OHS measures including mandatory PPE, safety briefings, and sanitation facilities for workers.
- Community Consultations: Continuous engagement with local communities and the WMCA to address grievances via a formalized Grievance Redress Mechanism (GRM).
- Environmental Monitoring: Regular inspection by project staff (PISC - Project Implementation Support Consultants) to ensure compliance with the EMP.

5.2.7 Rehabilitation of WMCA Office Building

Rehabilitation of Water Management Cooperative Association (WMCA) office buildings under the CDRSSWRMP, implemented by the Local Government Engineering Department (LGED), is crucial for enhancing institutional capacity and providing a space for climate-smart agriculture and fishery agribusiness activities. The project focuses on strengthening existing WMCAs by improving their infrastructure to be more resilient against climate-induced disasters.

1) Requirements for Rehabilitation

Rehabilitation works typically include making the office buildings climate-resilient to serve as functional hubs for rural stakeholders. Requirements include:

- **Structural Upgrades:** Repairing and strengthening existing structures to withstand floods and cyclones.
- **Climate Adaptation Features:** Enhancing energy efficiency, enhancing ventilation, and ensuring safe water and sanitation facilities, often aligning with net-zero and sustainable building goals.
- **Functional Improvements:** Retrofitting buildings to include space for meetings, training, and storage units for agricultural produce.
- **Accessibility & Safety:** Incorporating features for women, youth, and people with disabilities.
- **Energy Efficiency & Net Zero Goals:** Retrofitting to reduce energy demand, potentially replacing HVAC systems with high-efficiency alternatives, upgrading insulation, and installing LED lighting.
- **Structural Safety & Remediation:** Identifying and removing unsafe external wall systems (cladding), strengthening structural elements, and enhancing fire safety measures.
- **Sustainability & Resource Management:** Using sustainable, low-impact materials and implementing strategies that extend the building's lifecycle.
- **Occupant Health and Comfort:** Improving indoor air quality, lighting, and thermal comfort to enhance the working environment.

2) Potential Environmental and Social Impacts

Rehabilitation activities may cause minor, temporary, and localized adverse impacts:

- **Air and Noise Pollution:** Dust generation and noise from rehabilitation activities like drilling, hammering, and material transport.
- **Waste Generation:** Generation of construction debris, such as old cladding, concrete, and metal, requiring proper disposal.
- **Drainage Congestion:** Improper storage of materials and waste could cause localized flooding or drainage blockages.
- **Occupational Health and Safety:** Risks to workers if improper procedures are followed.

3) Mitigation Measures

To comply with Asian Development Bank (ADB) safety standards and national regulations, the following mitigations are typically implemented:

- **Environmental Management Plan (EMP):** A site-specific environmental management plan (SEMP) will be developed and implemented by contractors to manage site-specific risks.
- **Waste Management:** Construction waste will be systematically collected, stored, and disposed of at approved sites to avoid environmental contamination.
- **Dust/Noise Control:** Watering down construction sites to suppress dust and restricting loud activities to working hours.
- **"Use of Local Labor:"** Promoting local labor, especially rural poor women, through Labor Contracting Societies (LCS) to enhance social inclusion.

- **Safety Protocols:** Implementing measures for COVID-19 H&S and using personal protective equipment (PPE) on site.

These measures ensure that the rehabilitation of WMCA offices leads to a sustainable, climate-resilient environment without causing significant long-term negative impacts on the surrounding ecosystem.

The rehabilitation process, while necessary, can lead to various environmental and social impacts.

Table 24 : Potential Impacts and Mitigation of Rehabilitation of WMCA Office

Impact Area	Potential Impacts	Mitigation Measures
Environmental	Generation of construction waste (debris, old materials).	Implementing waste minimization strategies, including on-site waste separation, recycling, and reuse.
Environmental	High carbon footprint from construction activity and new materials.	Using sustainable, locally sourced, and low-impact materials; conducting lifecycle analysis to ensure long-term environmental benefits.
Operational	Disruption of daily work, noise, and dust within the office building.	Scheduling noisy works during off-hours, providing temporary workspaces, and using temporary noise barriers.
Social	Health risks for occupants due to noise, dust, or potential hazardous materials.	Maintaining high safety standards, controlling dust emissions, and ensuring proper ventilation.
Functional	Incompatibility of new systems with existing structures.	Conducting a comprehensive diagnosis and using expert design to ensure retrofitted systems complement the original building fabric.
Economic	High initial upfront costs for modern technology and retrofit compliance.	Utilizing funding from the £167 million Buildings Retrofit Pilot and focusing on long-term operational savings.

5.2.8 Development of farm access road

Farm access roads are crucial infrastructure for modernizing agricultural logistics, reducing transport costs, and enabling rural communities to access markets, healthcare, and education. However, their construction and operation entail significant environmental and social impacts that require careful mitigation.

Under the CDRSSWRMP, implemented by the Local Government Engineering Department (LGED), the construction of farm access roads is a key component designed to improve agricultural productivity and livelihood resilience, with plans to construct approximately 110 kilometers of such roads.

1) Requirement of farm access road

- **Climate-Resilient Connectivity:** The roads must be built to withstand increasing climate hazards (floods, heavy rainfall), connecting rural farming areas to markets.
- **Support for Agriculture:** These roads facilitate the transport of agricultural inputs and products, reducing post-harvest losses and improving income, targeting a benefit area of 220,000 hectares.

- **Participatory Planning:** Subprojects are demand-driven, requiring the formation of Water Management Cooperative Associations (WMCAs) to identify and manage the infrastructure to ensure sustainability and social inclusion.
- **Synergy with Infrastructure:** Roads are integrated with water management infrastructures, such as embankments, regulators, and canal re-excavation.

2) Potential Impacts

1. Environmental Impacts:

- (i) **Soil Erosion and Siltation:** Construction activities may disrupt local hydrology and increase siltation in adjacent water bodies.
- (ii) **Loss of Agricultural Land:** Construction can lead to the loss of productive agricultural land or homesteads.
- (iii) **Waterlogging:** Inadequate design or improper culvert placement might obstruct natural drainage, leading to waterlogging.

2. Social Impacts:

- (i) **Land Acquisition:** The project may require land acquisition (estimated at 50.14 acres), which can lead to displacement or loss of assets.
- (ii) **Safety Hazards:** Construction works could pose risks to local communities.
- (iii) **Noise and Pollution:** Dust and noise during construction may affect nearby residents.

3) Mitigations Measures

The CDRSSWRMP employs an Environmental and Social Management Framework (ESMF) to mitigate these impacts.

- **Nature-Based Solutions:** Using green solutions, such as planting vetiver grass, to stabilize embankments and protect against soil erosion.
- **Adequate Drainage Design:** Ensuring roads are built with sufficient cross-drainage structures (bridges, culverts) to prevent waterlogging and maintain natural flow.
- **Resettlement Planning:** Preparing Resettlement Action Plans (RAP) and conducting Inventory of Losses (IOL) to compensate for any land acquisition or loss of assets.
- **Construction Safety Management:** Implementing a code of conduct for contractors, including controlling dust, managing noise, and creating temporary sheds for machinery.
- **Community Engagement:** Involving local communities to ensure the infrastructure is sustainable, culturally appropriate, and addresses the needs of vulnerable populations.

5.2.9 Construction of new Regulator

The construction of a new water regulator—a hydraulic structure used to control flow in canals is a major infrastructure project requiring meticulous planning, structural engineering, and environmental management. A regulator can be a cross regulator, located on the main canal to hold up water, or a head regulator, positioned at the entrance of a distributary canal. The process involves several key requirements, potential environmental and social impacts, and necessary mitigation measures to ensure project sustainability.

The CDRSSWRMP, implemented by the Local Government Engineering Department (LGED), aims to improve water management across 220,000 hectares in Bangladesh by 2029. A key component is the construction of new regulators and sluice gates to manage flooding, enhance drainage, and control irrigation.

1) Requirement for New Regulators under CDRSSWRMP

The construction of new regulators is driven by the need to address climate change impacts—such as increased flooding, drainage congestion, and salinity intrusion—and to boost agricultural productivity.

- **Targeted Areas:** The project focuses on four hotspots: Barind and drought-prone areas, coastal zones, Haor/flash flood areas, and river systems/estuaries.
- **Infrastructure Objectives:**
 - **Flood Control:** Regulators prevent excessive water from entering farming land during high tide or monsoon floods.
 - **Drainage Improvement:** They allow excess water to drain out during low tide.
 - **Irrigation Support:** By retaining water at the end of the monsoon, they ensure supply for irrigation during the dry season.
 - **Climate Resilience:** The structures are designed to be "climate-proofed" to withstand natural calamities.
- **Key Project Targets:** The project includes the formation of 150 new Water Management Cooperative Associations (WMCAs) and the establishment of 60 composite sluice gates/regulators.

2) Potential Impacts

Construction and operation of new regulators can bring both positive and negative impacts.

Positive Impacts:

- **Agricultural Boost:** Improved water control leads to increased crop yields (15–70% reported).
- **Livelihood Protection:** Reduced risk of crop loss from flash floods and droughts boosts farmer incomes.
- **Improved Drainage:** Reduced waterlogging in agricultural lands.
- **Social Inclusion:** Participatory management ensures poor farmers, women, and the landless benefit.

Negative/Environmental Impacts:

- **Habitat Disruption:** Physical disturbance of riverbanks, canals, or floodplains during construction.
- **Disruption to Fish Migration:** Improperly designed regulators can block fish migration routes, affecting fisheries.
- **Acquisition of Land:** Construction may require acquiring land, potentially affecting 50.14 acres for project infrastructure.
- **Construction Risks:** Soil erosion, sedimentation, and noise pollution during construction activities.

3) Mitigation Measures

To counteract these negative impacts, the project incorporates several mitigation strategies:

- **Environmental Management Plan (EMP):** Implementation of a strict EMP for construction sites to manage waste, control erosion, and restore sites.
- **Fish-Friendly Design:** Ensuring regulators allow fish movement to minimize impact on local aquatic habitats.
- **Participatory Approach:** Engaging local WMCAs in the site selection and planning process to address social concerns.
- **Rehabilitation/Modernization:** Instead of only new construction, strengthening existing, underperforming structures reduces the need for new, disruptive construction.
- **Safeguard Protocols:** Adhering to Asian Development Bank (ADB) and government environmental policies to manage social and environmental risks, keeping the project within Category B (moderate impact)
- **Erosion Control & Land Restoration:** Installing siltation ponds and fencing sand/gravel stockpiles helps manage soil erosion. Re-vegetation of the site is required post-construction.
- **Water Quality Protection:** Construction should ideally take place during the dry season to minimize siltation. Concrete work should be strictly controlled, using fast-setting mixes if submerged to prevent cement washout.
- **Waste & Material Management:** Proper disposal of construction materials, hazardous waste, and concrete slurry must be implemented. Temporary sanitation facilities for workers are required.
- **Noise & Air Pollution Control:** Using low-noise machines, regular maintenance of equipment to reduce emissions, and watering dry surfaces to manage dust are standard mitigation techniques.
- **Public Safety & Social Management:** Installing safety signage, enforcing traffic management (e.g., using traffic aides), and engaging in community consultation and negotiations for compensation.

By carefully integrating engineering design with environmental management, the impacts of constructing a new regulator can be significantly reduced, ensuring that the infrastructure provides its intended benefits while protecting the local ecosystem.

5.2.10 Rehabilitation of existing Regulator

The rehabilitation of an existing regulator—a crucial hydraulic structure used to control water levels and discharge—is typically required due to structural deterioration, operational inefficiencies, or the need to upgrade for modern safety standards. The process involves significant environmental and social challenges, requiring a structured approach to mitigate impacts.

The CDRSSWRMP, implemented by the Local Government Engineering Department (LGED) from 2023 to 2029, focuses on enhancing climate resilience by rehabilitating and strengthening existing Flood Control, Drainage, and Irrigation (FCDI) infrastructure, including regulators. The project covers 42 districts and aims to boost agriculture, fisheries, and rural

livelihoods across 220,000 hectares, with a specific focus on mitigating impacts in flood-prone and drought-prone regions.

1) Requirements for Rehabilitation of Existing Regulators

Under CDRSSWRMP, the rehabilitation of regulators must meet specific sustainability and climate-resilient criteria:

- **Participatory Approach:** Rehabilitation must be supported by strengthened Water Management Cooperative Associations (WMCAs) to ensure local ownership and long-term sustainability.
- **Climate-Resilient Infrastructure:** Upgrades must consider future climate projections, including increased flood intensity and reduced rainfall in certain seasons.
- **Performance Enhancement:** Focus on enhancing the operational functionality of underperforming or damaged FCDI schemes.
- **Structural Modernization:** Incorporating robust engineering standards, such as constructing composite sluice gates, to handle increased water flows.
- **Environmental Compliance:** Subprojects must go through a screening process against the Environmental Assessment and Review Framework (EARF), complying with Environmental Conservation Rules (ECR 2023).

2) Potential Impacts

Rehabilitation works, while necessary, can introduce temporary or long-term environmental and social disturbances:

- **Water Quality Degradation:** Siltation, disposal of dredged materials, and construction runoff could affect water quality in adjacent canals.
- **Disruption to Water Management:** Temporary closure of regulators can disrupt irrigation schedules or cause drainage congestion for surrounding agricultural land.
- **Loss of Habitat/Flora and Fauna:** Construction activities can affect local biodiversity, particularly in delicate ecosystems like the Haor region.
- **Community Disruption:** Temporary noise, dust, and reduced access to water for fishing or navigation during construction.
- **Irrigation Service Interruptions:** Temporary closure for repairs can disrupt agricultural water supply, affecting crop production.
- **Sedimentation and Water Quality:** Construction activities often lead to increased sediment loading, turbidity, and potential pollution of surface water from spills.
- **Noise and Air Pollution:** Operation of heavy machinery creates dust and elevated noise levels.
- **Land Degradation:** Temporary storage of materials, construction spoils, and access paths can damage local flora and soil.
- **Impact on Ecology:** Disruption to local aquatic habitats, particularly in sensitive wetlands.

3) Mitigation Measures

To reduce negative effects, the project follows an Environmental Management Plan (EMP):

- **Site Management:** Minimizing the extent of cleared and disturbed land to reduce the loss of vegetation.
- **Water Management Controls:** Using appropriate dredging techniques to minimize turbidity and storing soil responsibly to prevent erosion and sedimentation.
- **Construction Planning:** Scheduling construction work during dry seasons to avoid peak agricultural, fishing, and flood seasons, thereby reducing impacts on livelihoods.
- **Waste Management:** Ensuring safe disposal of construction debris and materials.
- **Livelihood Support:** Providing vocational training and job creation for vulnerable populations impacted by the infrastructure changes.
- **Water Supply Management:** Scheduling works during low-demand seasons (e.g., dry season) and implementing temporary water diversion or storage to maintain minimum flow.
- **Sediment Control:** Installing silt fences, hay bales, and utilizing cofferdams to prevent construction materials from entering the waterway.
- **Construction Best Practices:** Using low-noise machinery, water sprinkling for dust control, and proper stockpiling of excavated materials.
- **Revegetation:** Restoring disturbed areas around the site, re-planting vegetation to stabilize banks.
- **Safety Measures:** Setting up traffic management (if necessary), conducting site safety briefings, and creating restricted areas for hazardous materials.

The project aims to make rural infrastructure more sustainable by combining structural rehabilitation with "nature-based solutions," such as bank protection, to strengthen the resilience of grey infrastructure.

Key Considerations for Success

- **Reliability-Based Design:** Modern rehabilitation often uses a reliability-based design to optimize repair methods (e.g., choosing between strut systems or concrete thickening) to achieve a desired service life rather than a one-size-fits-all approach.
- **Emergency Plans:** Establishing contingency plans for unexpected flooding or structural failure during the construction process.
- **Regulatory Compliance:** Ensuring compliance with all local environmental regulations, including proper waste disposal and environmental impact assessment (EIA) requirements.

5.3 Construction of Rubber Dams

5.3.1 Requirements for Rubber Dam Construction under CDRSSWRMP

Under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), rubber dams are constructed as cost-effective, sustainable alternatives to traditional dams to enhance dry-season irrigation, increase agricultural yield, and manage

drought risks, particularly in Haor and Barind regions. Key requirements include solid foundation stability, proper sediment management, and participatory management via Water Management Cooperative Associations (WMCAs) to mitigate impacts like reduced downstream flow and minor siltation (**Table 25**).

Steps for Rubber Dam Construction

- **Site Selection:** Dams should be built on stable, straight river sections where flow is uniform and bank slopes are stable.
- **Technical Specifications:** The dam involves a flexible, high-strength rubber bag attached to a reinforced concrete foundation, often requiring specialized imported components and expert installation.
- **Engineering Parameters:** Typically involves a 4-5 meter high bag with a 15-20 year lifespan, installed with automated inflation/deflation systems for flood protection.
- **Sediment Mitigation:** Design must ensure the foundation level is higher than the downstream riverbed to minimize sediment build-up directly behind the dam.
- **Community Engagement:** Operation and maintenance (O&M) are delegated to beneficiary committees (WMCAs) to ensure sustainability.

Table 25: Table Impacts and Mitigation Measures of Rubber Dams

Type of Impact	Specific Impact	Mitigation Measures
Environmental	Reduced Downstream Flow: Lowered water levels in the dry season affect aquatic ecology.	Implementing Environmental Management Plans (EMP) to maintain minimum environmental flow (e-flow).
Environmental	Siltation & Sedimentation: Increased silt deposition behind the dam.	Periodic inspection and dredging of silt and debris from both upstream and downstream.
Social/Physical	Disruption to Navigation: Impeded boat movement due to the inflated structure.	Providing pass-through facilities or operating schedule adjustments; installing early warning systems.
Social/Physical	Flooding/Waterlogging: Potential upstream waterlogging during monsoon.	Timely deflation of the rubber dam during peak flood seasons to allow free flow.
Social/Physical	Loss of Land/Assets: Temporary land acquisition for construction.	Adhering to the Environmental and Social Management Framework (ESMF) for compensation and resettlement.

Key Benefits & Performance of Rubber Dams

- **Irrigation:** Efficiently raises upstream water levels for Boro rice cultivation and reduces dependency on over-abstracted groundwater.
- **Flood Control:** Provides rapid deflation capabilities during sudden floods or high-flow events, acting as a flexible flood risk management tool.
- **Social & Economic:** Improves livelihoods of marginal farmers and laborers through higher crop production (up to 1.7 times in certain areas) and fisheries development.

- Sustainability: Reduced construction cost and shorter implementation period compared to traditional structures.

5.3.2 Construction Bakkhali Rubber Dam under CDRSSWRMP

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) aim to modernize the Bakkhali Rubber Dam (BRD) to enhance agricultural productivity and flood resilience. The subproject focuses on expanding dry-season irrigation, benefiting 3,000 hectares, reducing waterlogging, and supporting sustainable water management through Water Management Cooperative Associations (WMCAs).

Requirements for Construction

- Infrastructure: Rehabilitation and modernization of the existing rubber dam, including the rubber bag, pumping machinery, and control systems.
- Capacity Building: Formation and strengthening of WMCAs to manage the dam, resolve conflicts, and ensure operation and maintenance (O&M) cost recovery.
- Technical Support: Specialist supervision for the installation of imported rubber components.
- Land Acquisition: Procurement of land, including for irrigation infrastructure and access roads.

Impacts (Environmental & Socio-economic)

- Positive: Increased dry-season water availability for irrigation (Boro rice), reduced irrigation costs, increased agricultural yield, and improved incomes.
- Negative: Reduced environmental flow (e-flow) downstream during the dry season, sedimentation causing morphological changes, disruption to upstream boat navigation, and potential waterlogging in upper reaches.

Mitigation Measures

- Flow Management: Proper seasonal deflation of the rubber dam to allow fish passage and maintain environmental flows (e-flow).
- Dredging: Regular maintenance dredging in the upstream and downstream to counteract sedimentation and maintain water flow.
- Participatory O&M: Engaging local communities (WMCAs) in monitoring for leakages and operating pumps to resolve issues quickly.
- Technical Optimization: Improving irrigation management to reduce the depth of standing water in fields, reducing the demand for raw water.

The project emphasizes sustainability by strengthening local ownership, ensuring that the infrastructure is managed effectively by the beneficiaries rather than relying solely on central maintenance.

5.3.3 Agricultural Benefits of Bakkhali Rubber Dam

The Bakkhali Rubber Dam (BRD), rehabilitated under the CDRSSWRMP, boosts agriculture by providing critical dry-season irrigation, enabling year-round cropping (Boro rice/diversified crops), and protecting 87,000 hectares from salinity. The project mitigates environmental

impacts through improved water management, canal excavation, and modernizing the dam to prevent failure and manage floods.

The BRD, a crucial infrastructure in Southern Bangladesh, provides several key agricultural benefits, particularly after its modernization under the CDRSSWRMP:

- **Dry Season Irrigation:** The dam creates a reservoir that stores freshwater, providing essential water for irrigation during the dry season.
- **Crop Intensification & Diversification:** The stored water allows farmers to switch from single-cropping to triple-cropping, including the cultivation of high-yield Boro rice and other dry-season crops.
- **Reduced Salinity:** By maintaining a fresh water head, it protects arable land in the downstream area from tidal saline water intrusion, enhancing soil fertility.
- **Increased Yield and Income:** The improved irrigation reduces reliance on costly groundwater pumping, directly increasing farmer income and food security.

Mitigations & Modernization under CDRSSWRMP

The CDRSSWRMP (2023-2024 onwards) focuses on addressing previous failures of the BRD (which failed in 2020) and managing environmental consequences. Key mitigations include:

- **Modernization & Rehabilitation:** Urgent, robust reconstruction of the rubber dam, built in 2002, to prevent catastrophic failure and manage hydraulic stress.
- **Integrated Water Management:** Implementation of "participatory water management," where the dam is managed by Water Management Cooperative Associations (WMCAs) to ensure equitable distribution and reduced water waste.
- **Canal Excavation:** Re-excavation of canals to restore hydrological connectivity and increase water storage capacity in the Bakkhali River system.
- **Improved Drainage:** The project addresses waterlogging and drainage issues, which were exacerbated by earlier, stagnant water conditions, by optimizing the operation of the dam and associated regulators.
- **Disaster Resilience:** Designing the upgraded infrastructure to be more resilient to climate-induced shocks, such as floods and excessive drought.

The project, which is supported by the Asian Development Bank and IFAD, aims to improve a total area of over 220,000 hectares across various schemes.

5.3.4 Fisheries and Aquatic Benefits of Bakkhali Rubber Dam

The Bakkhali Rubber Dam (BRD) modernization under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) offers significant fisheries benefits by improving aquatic habitats, increasing water availability, and enhancing regional food security. It enhances fisheries by securing perennial water in the upstream reservoir. This creates sustainable habitats for fish, boosting local production, aquaculture, and income for surrounding households through improved year-round water storage. The project facilitates sustainable water management for 3,000 hectares, improving local fishing livelihoods in Cox's Bazar.

Key Fisheries and Aquatic Benefits:

- **Perennial Water Conservation:** The dam holds back water in the upstream, creating a larger, more stable reservoir, which provides a consistent habitat for various fish species.
- **Enhanced Aquaculture Habitat:** The dam creates a stable, perennial, and larger reservoir area, which is suitable for fish farming, rather than seasonal fishing.
- **Increased Fish Production:** Improved water management and retained, deep water areas support higher fish stock levels and enhanced aquaculture opportunities, contributing to local food supplies. Consistent water availability allows for increased fish cultivation, supporting improved economic conditions for local communities.
- **Strengthened Livelihoods:** The project, through the Asian Development Bank (ADB) and Local Government Engineering Department (LGED), ensures that water management cooperatives (WMCAs) manage the water resources, which helps in better managing fishing access and improving the income of local fishing households. The project aims to improve fish agribusinesses and livelihoods, particularly supporting smallholders and rural communities.
- **Improved Water Quality:** By managing the flow of the Bakkhali River, the dam maintains favorable water quality conditions necessary for fish survival in the region.
- **Optimal Water Management:** The modernization provides controlled water levels, which can be managed for better fisheries production.

The project also addresses ecological concerns by strengthening the Water Management Cooperative Associations (WMCAs) to ensure sustainable use of the reservoir.

The modernization project focuses on replacing the damaged rubber dam (originally built in 2002) to maintain these water-dependent benefits for the long term.

5.3.5 Social Impact of the Bakkhali Rubber Dam

The Bakkhali Rubber Dam in Cox's Bazar has significantly boosted local agriculture by providing irrigation for over 6,000 hectares, increasing farmer income, and reducing groundwater dependence. However, it created issues like upstream waterlogging, downstream salinity reduction, and siltation. Mitigation under CDRSSWRMP (2024-2030) involves urgent rehabilitation, modernization, improved water management, and enhanced stakeholder participation to ensure sustainable, climate-resilient benefits.

Positive Impacts:

- **Agricultural Growth:** The dam enables irrigation during the dry season, significantly increasing agricultural productivity (yields of Boro rice), reducing, or often eliminating, the need for chemical fertilizers in some areas, and creating new farming opportunities.
- **Income Generation:** Approximately 45% of surveyed locals reported a rise in income due to improved irrigation, allowing for multiple cropping cycles.
- **Reduced Groundwater Dependence:** By storing freshwater in the river, the dam decreases reliance on underground water sources, preserving the water table.

- **Fisheries Enhancement:** The large reservoir created by the dam provides a breeding ground, boosting the available fish population, which supports local fishing livelihoods.

Negative/Adverse Impacts:

- **Upstream Waterlogging & Siltation:** The accumulation of silt upstream has altered the river's morphological structure, leading to waterlogging in some areas and disrupting traditional agricultural practices.
- **Downstream Environmental Changes:** Reduced environmental flow (e-flow) in the downstream area, especially during the dry season, has altered the brackish ecology and caused, or worsened, salinity intrusion issues.
- **Disruption of Transport:** The dam hinders boat navigation, affecting the traditional transportation of goods and people.

Mitigations Under CDRSSWRMP

The CDRSSWRMP focuses on rectifying these issues through structural and management interventions.

1. **Emergency Rehabilitation & Modernization:** The project includes the immediate repair of existing rubber bags and the modernization of the dam machinery to ensure efficient, long-term operations.
2. **Water Management Cooperative Associations (WMCAs):** The project establishes new, and strengthens existing, WMCAs to manage water distribution. These groups are designed to be inclusive, ensuring participation of women and poor, landless farmers in decision-making.
3. **Infrastructure Upgrades:** The initiative involves excavating/re-excavating surrounding canals to improve water distribution and mitigate the waterlogging issues reported upstream.
4. **Flood & Drought Management:** The project improves flood control, drainage, and irrigation systems, providing a comprehensive approach to managing water-related disasters in the region.
5. **Environmental Management Plan (EMP):** A specific EMP is implemented, which focuses on mitigating the negative impacts on fishermen, protecting the river bank from erosion, and enhancing the livelihoods of those negatively affected by the dam's operation.

These measures aim to shift the subproject from a purely agricultural focus to a sustainable, inclusive, and environmentally conscious water management system that boosts farm productivity while minimizing the adverse social and ecological impacts.

5.3.6 Climate Change Impacts on Bakkhali Rubber Dam

The Bakkhali Rubber Dam (BRD) in Cox's Bazar, currently undergoing modernization under the Asian Development Bank-financed CDRSSWRMP, faces climate risks like increased salinity intrusion, sea-level rise, and intense flooding. Mitigation efforts include emergency rehabilitation, strengthening Water Management Cooperatives (WMCAs), and improving drainage to reduce flood risks and boost agricultural productivity.

Climate Change Impacts on Bakkhali Rubber Dam

- **Increased Salinity Intrusion:** Sea-level rise and reduced freshwater flow during dry seasons allow brackish water to move upstream, harming the ecosystem.
- **Flooding & Waterlogging:** Climate-induced high-intensity rainfall increases flood risks, while sediment accumulation restricts water discharge.
- **Structural Damage:** The existing structure is vulnerable to severe tidal surges and increased riverbank erosion.
- **Reduced Operational Life:** Higher temperatures and increased sediment load affect rubber bag durability and pump efficiency.

Mitigations under CDRSSWRMP (2023-2029)

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), managed by the Local Government Engineering Department (LGED), aims to address these risks:

- **Modernization & Rehabilitation:** Emergency rehabilitation of the existing rubber dam to withstand current and future climate stresses.
- **Water Management Cooperative Associations (WMCAs):** Establishing and strengthening participatory WMCAs to improve operation and maintenance (O&M), including monitoring for leakage and siltation.
- **Drainage and Flood Protection:** Excavation/re-excavation of canals and construction of regulators to enhance drainage and mitigate flooding in the surrounding 3,000 ha area.
- **Infrastructure Improvement:** Construction of 110 km of climate-resilient farm access roads.
- **Agriculture Support:** Promoting climate-resilient farming techniques (e.g., salinity-tolerant crop varieties) to ensure food security despite changing water conditions.

The project aims to improve agricultural productivity for over 220,000 hectares across Bangladesh, with the Bakkhali Rubber Dam serving as a key infrastructure point in the coastal zone.

5.4 Impact Prediction

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is projected to significantly enhance agricultural resilience and improve rural livelihoods across four key geographical hotspots (Barind, coastal, Haor, and river systems). With a total estimated cost of approximately \$180 million, the project aims to benefit 335,000 farming households and 45,000 landless/vulnerable households over a six-year period.

Key impacts predicted for the project include:

- **Increased Agricultural Productivity and Income:** The project aims to boost farm incomes and increase crop yields and cropping intensities, with projections indicating a 60% reduction in crop losses and a 45% increase in food production in similar, earlier, IFAD-supported initiatives.

- **Climate-Resilient Infrastructure:** The initiative will develop or enhance approximately 550 small-scale water resources subprojects (150 new, 400 existing) designed to mitigate flooding, improve drainage, manage water during droughts, and improve water conservation.
- **Strengthened Water Management Associations:** Over 150 Water Management Cooperative Associations (WMCAs) will be established or supported to manage infrastructure, improve agricultural practices, and ensure sustainability through community participation.
- **Value Chain Development:** The project will support market-driven agriculture, including improving marketing for 10 key crops and fostering fishpond and cage aquaculture to improve profitability.
- **Social and Gender Inclusion:** Focus on strengthening the roles of women and landless people in agricultural and fisheries businesses, providing them with training, employment opportunities, and improved access to market facilities.
- **Environmental Benefits:** By improving water management, the project is expected to reduce erosion and support ecosystem-sensitive agricultural practices.

Project Context and Risk Factors

The project is a collaboration between the Government of Bangladesh, IFAD, ADB, and the Netherlands, with the Local Government Engineering Department (LGED) as the implementing agency. While anticipated impacts are positive, risks include potential minor land acquisition (approx. 20.3 ha) and temporary disruptions during construction. The project is aligned with the Bangladesh Delta Plan 2100 to combat risks from climate change, such as increased flooding, salinity intrusion, and drought.

5.4.1 The nature, magnitude, extent and duration of significant impacts

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, initiated in 2023 with co-financing from IFAD, ADB, and the Government of the Netherlands, is a 6-year endeavor (until 31 December 2029) designed to foster sustainable, climate-resilient development. The project aims to reduce poverty by enhancing agricultural productivity and climate resilience across 42 districts, targeting four key "hotspots" in the Bangladesh Delta Plan 2100: Barind/drought-prone, coastal, haor/flash flood, and river system/estuarine zones.

Nature of Significant Impacts

Although the project is classified as Category Red for environmental impacts, meaning it is expected to have mostly positive, site-specific impacts with manageable, minor adverse effects during construction.

Positive (Direct): Improved flood management through rehabilitated embankments/sluice gates, enhanced drainage, increased irrigation capacity (including buried pipe systems), and improved market access.

Positive (Social/Economic): Increased crop yields, higher cropping intensities, improved nutrition, and creation of non-farm employment for approximately 335,000 farming households and 45,000 functionally landless people.

Structural: Formation of 150 new, and strengthening of 230 existing, Water Management Cooperative Associations (WMCAs) to ensure sustainable, participatory management.

Environmental: Improved natural resource management, including potential for nature-based solutions to enhance gray infrastructure.

Magnitude of Impacts

Geographical Coverage: Over 220,000 hectares (ha) will benefit from modernized water management infrastructure, with 86,000 ha covered by new, and 130,000 ha by strengthened, subprojects.

Economic Impact: The project expects to significantly boost agricultural profitability and, if successfully implemented, could help increase regional GDP, with goals aligned with the Eighth Five Year Plan.

Disaster Risk Reduction: The project specifically aims to reduce flood duration and depth, as well as mitigate the effects of droughts on agriculture in vulnerable areas.

Extent of Impacts

Geographic Scope: 42 districts in Bangladesh, focusing on areas identified under the Bangladesh Delta Plan 2100.

Target Population: 380,000 households, with a focus on women, small ethnic communities, and the landless.

Infrastructure Scope: 110 kilometers of farm access roads and 1,276 metric tons of irrigation infrastructure.

Duration of Impacts

Project Life: Six years (2023-2029).

Short-Term: Immediate employment opportunities for local labor during construction and rehabilitation, as well as improved drainage during the first rainy seasons of the project.

Long-Term/Sustainable: The establishment of WMCAs is designed to ensure the operation and maintenance of infrastructure beyond the project duration (2029+), fostering sustainable, long-term climate adaptation and livelihood improvements.

Minor Adverse Impacts (Mitigation Measures in Place)

Resettlement: Minor land acquisition (50.14 acres) for embankments and structures is expected, requiring a Resettlement Framework to manage compensation and prevent loss of livelihood.

Construction Hazards: Temporary disruption to local access, noise, dust, and waterlogging risks are expected, which will be managed through a Site-Specific Environmental Management Plan (SEMP).

5.5 Impact Evaluation

The CDRSSWRMP in Bangladesh aims to reduce poverty and enhance food security by implementing sustainable water management infrastructure across 42 districts. It establishes 150 new Water Management Cooperative Associations (WMCAs) to boost agricultural productivity, strengthen climate resilience for ~86,000 hectares, and improve livelihoods for over 380,000 households, including 30,000 women.

Key Impacts and Evaluations:

- **Agricultural and Economic Growth:** The project focuses on increasing agricultural productivity and income for rural households, specifically targeting poor, functionally landless, and vulnerable groups.
- **Climate Resilience:** It provides climate-resilient water management infrastructure, such as rubber dams, to address challenges like salinity intrusion, flooding, and droughts, which are major threats to food security in coastal areas.
- **Institutional Strengthening:** The project supports the Local Government Engineering Department (LGED) and reinforces participatory development through the Water Management Cooperative Associations (WMCAs).
- **Gender and Social Inclusion:** Specific emphasis is placed on the inclusion of women, youth, and small ethnic communities in the decision-making process.
- **Strategic Alignment:** The project aligns with national priorities, including the Bangladesh Delta Plan 2100 (BDP2100) and the Eighth Five Year Plan.

5.5.1 Magnitude of Environmental Impact

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a major initiative (approx. US\$180–225 million total cost) designed to improve rural livelihoods and increase agricultural resilience in the face of climate change. Implemented by the Local Government Engineering Department (LGED) from 2024 to 2029, the project focuses on constructing or enhancing small-scale water management infrastructure, such as flood management, drainage, and irrigation systems.

Magnitude of Impact

The expected impacts of the project include:

- **Geographical and Beneficiary Scope:** The project intends to improve about 150 new subprojects and enhance 400 existing ones across four climate-vulnerable regions (Barind, Coastal, Haor, and river systems).
- **Target Population:** It targets a wide reach of rural beneficiaries, including smallholder farmers and vulnerable households.
- **Water Management Improvements:** The project will provide climate-resilient water infrastructure, improving drainage and irrigation to reduce risks from floods and drought.
- **Agricultural Productivity:** Through improved water control, the project aims to increase crop yields, increase cropping intensity, and improve profitability for farmers, including in sub-sectors like fisheries and aquaculture.
- **Value Chain and Livelihoods:** The project includes components to strengthen agricultural value chains, fostering increased income for Water Management Cooperative Associations (WMCAs).
- **Gender and Social Inclusion:** Specific attention is given to involving women and marginalized groups in the management of water resources and enhancing their economic opportunities.
- **Institutional Capacity Building:** The project strengthens the capacity of local institutions (WMCAs and LGED) to manage and maintain infrastructure for long-term sustainability.

Key Focus Areas

- **Climate Adaptation:** Addressing the impacts of increased salinity, waterlogging, and erratic rainfall in vulnerable areas.
- **Disaster Risk Reduction:** Proactive measures to minimize damage to crops and livelihoods from floods and cyclones.

The project is crucial for bolstering the resilience of the agricultural sector, which is highly vulnerable to climate change-induced disasters in Bangladesh.

5.5.2 Extent of Environmental Effect

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is a 6-year, Tk 22.36 billion (approx. \$180 million) initiative designed to build on previous Asian Development Bank (ADB) and International Fund for Agricultural Development (IFAD) projects. It aims to foster climate resilience and reduce poverty by transforming water management in 42 of Bangladesh's 64 districts.

The extent of the project's effect spans several key areas:

1. Geographical and Structural Coverage

- **Targeted Area:** The project focuses on four key "hotspots" in the Bangladesh Delta Plan 2100: Barind and drought-prone areas, the coastal zone, the haor and flash-flood areas, and river systems/estuaries.
- **Infrastructure Impact:** The project includes the development of 150 new, climate-resilient water management subprojects and enhances 230 existing subprojects.
- **Land Coverage:** The infrastructure interventions are designed to directly benefit an estimated **86,000 hectares** with new, climate-resilient infrastructure and a total of **220,000 hectares** when including strengthened existing systems.
- **Specific Assets:** Projects include the rehabilitation of the Bakkhali Rubber Dam (benefiting 3,000 ha) and the construction of embankment/sluice gate systems to control flooding and drainage.

2. Socio-Economic and Agricultural Impact

- **Beneficiary Scope:** The initiative aims to support the livelihoods of approximately **380,000 households**, including about 45,000 functionally landless and vulnerable households.
- **Agricultural Productivity:** By improving flood management and drainage, the project aims to increase cropping intensities, agricultural productivity, and farm incomes.
- **Fisheries & Value Chains:** The project supports cage aquaculture, floodplain fisheries, and the development of post-harvest management infrastructure, such as cold storage and processing facilities for fish, fruit, and vegetables.

3. Institutional and Community Capacity Building

- **Water Management Cooperative Associations (WMCAs):** A core component is the establishment or strengthening of 150 new, inclusive WMCAs (and strengthening 230 existing ones) to manage water resources, which ensures long-term sustainability and local ownership.

- **LGED Strengthening:** The project empowers the Local Government Engineering Department (LGED) by strengthening its Integrated Water Resources Management Unit (IWRMU) to better plan, implement, and monitor small-scale water resources.
- **Gender and Social Inclusion:** The project actively works to include women and marginalized communities in the management committees.

4. Climate Adaptation

- **Resilience Building:** The project addresses key climate risks, including increased flooding, drought, and salinity intrusion, by building infrastructure that can withstand extreme weather events, which are expected to intensify by 2050.
- **Water Management:** The project works on water conservation in existing haors (wetlands), Beels (lakes), and Khals (canals) to increase water availability during dry seasons.

The project serves as a crucial component of the government's 8th Five Year Plan (FY2021-FY2025) to manage rural water resources effectively.

5.5.3 Duration of the Impact

The CDRSSWRMP has a primary implementation duration of approximately **6 years**, running from **2022/2023 to 31 December 2029**.

Key details regarding the duration of the impact and implementation include:

- **Implementation Period:** The project was approved in May 2022 (with some components becoming effective in Jan 2024) and is scheduled to conclude on **December 31, 2029**.
- **Target Impact:** The project aims to achieve sustainable and inclusive development resilient to climate change, with impacts lasting beyond the project completion date through sustainable water management infrastructure.
- **Project Scope:** The project covers 42 out of 64 districts in Bangladesh, focusing on four main "hotspots": Barind and drought-prone areas, the coastal zone, the haor and flash flood areas, and river systems.
- **Beneficiaries:** It is designed to benefit 380,000 households, including 45,000 functionally landless people.
- **Sustainability:** The project involves the establishment of Water Management Cooperative Associations (WMCAs) to ensure the long-term, post-project operation and maintenance of the infrastructure.

The project is financed by the Asian Development Bank (ADB), the International Fund for Agricultural Development (IFAD), and the Government of Bangladesh.

The impact evaluation determines the magnitude of impacts through analyses of the scale of the impact, the spatial extent of the impact, and the duration of the impact using the criteria presented in the **Table 26**.

Table 26 Magnitude of Environmental Impacts

Criteria	Ranking Description
Scale	Whether or not the magnitude (intensity) of the impact would be high, medium, or low. ➤ Minor - insignificant change to the receiving environment - where impact alters the affected environment in such a way that natural processes of

Criteria	Ranking Description
	functions are not affected in any significant way. Effect is within normal range of natural variation. No perceptible or readily measurable change from baseline conditions. ➤ Moderate - moderate deterioration of the existing environment - where the affected environment is altered; however, function and process continue, albeit in a modified manner. Reversible damage to natural environment but likely to easily revert back to earlier stage with mitigation; Perceptible change from baseline conditions. ➤ High – significant deterioration of the existing environment - where function or process of the environment is seriously altered and disturbed to the extent where it temporarily or permanently ceases. Irreversible damage to natural environment and/or likely difficult or may not to revert back to earlier stage with mitigation; Major changes in comparison to baseline conditions and / or likely to regularly or continually exceed the standard.
Spatial Extent	The physical and spatial size of the impact; a description of whether the impact would occur on a scale described as follows: ➤ Site/local – project site and the immediate vicinity. The impact will affect the environment or communities along the border of the project area or in the extended area adjacent to the site or perhaps outside the immediate environment. ➤ Regional - whether the impact extends beyond the project area affecting areas on a regional scale. ➤ National - whether the impact extends beyond the study area affecting areas on a national scale.
Duration	The duration of the impact is expressed in the lifetime of the project. Whether the impact will be: ➤ Short term – the impact will occur in a span shorter than the construction phase. ➤ Medium term - the impact will last for the period of the construction phase. ➤ Long term - the impact will continue, last for the operational life, or spread beyond the lifecycle of the Project

The magnitude combines the impact characteristics of scale, extent, and duration to provide the intensity of the change predicted to occur to the resource/receptor as a result of the impact. The **Table 27** below is used to determine the resulting magnitude on the basis of the assessment of the three parameters.

Table 27: Assessing Magnitude of Impact

Scale	Spatial Extent	Duration	Magnitude
High	National	Long term	High
		Medium term	High
		Short term	High
	Regional	Long term	High
		Medium term	High
		Short term	Medium

Scale	Spatial Extent	Duration	Magnitude
	Site-specific/local	Long term Medium term Short term	High Medium Medium
Moderate	National	Long term Medium term Short term	High High Medium
	Regional	Long term Medium term Short term	High Medium Low
	Site-specific/local	Long term Medium term Short term	Medium Low Low
Minor	Regional	Long term Medium term Short term	Medium Low Low
	Site-specific/local	Long term Medium term Short term	Low Low Negligible
	Site-specific/local	Long term Medium term Short term	Low Low Negligible

The result of the multicriteria analysis to evaluate the magnitude of the predicted impacts by considering the scale, spatial extent, and duration of impacts are combined with the receptor sensitivity/value to determine impact significance.

The sensitivity, value, importance and vulnerability of the impacted resource or receptor is analysed through application of key factors or criteria depending on the type of receptor, which includes the rarity, potential for substitution, sensitivity to changes and in particular those resulting from the project activities and impacts. The local, regional, national, and international importance of the receptor including rarity is an important aspect of the determining the sensitivity. The **Table 28** below presents the sensitivity ranking and corresponding contributing criteria.

Table 28: Sensitivity Ranking and Contributing Criteria

Sensitivity Ranking	Contributing Criteria
High	- Existing physical environment quality is already threatened and highly sensitive to change - Ecologically sensitive/protected area, provides habitat for internationally protected species - Multiple levels of vulnerability that reduces the ability of the environment to bounce back from the Project's expected impacts - Human receptor/vulnerable groups are present within the Project areas and directly affected
Moderate	- Existing physical environment quality is prone to be stressed, and sensitive to changes in quality or physical instabilities - Natural habitat provides habitat for species protected under National regulations

Sensitivity Ranking	Contributing Criteria
	- Some, but few areas of vulnerability; still retaining a limited ability to adapt partly to change brought by the Project. - Human receptors/ vulnerable community are located adjacent the project site and likely to be affected by the project
Low	- Existing physical environment quality is good - Modified habitat provides habitat for common species - Human receptors are located away and are not likely to be affected due to the Project related activities

Where impacts of the same type are accumulated by the subproject activities and impacting the same receptor or increasing the footprint these are considered as cumulative impacts. The impacts on the same receptors accumulates and may increase the scale of the impact, the spatial extent, or the duration.

5.5.4 Evaluating Significance of Impacts

Knowing the sensitivity and value of the receptor or resource and the magnitude of the impact, the significance of the impact can be assessed using the two-dimensional matrix below. On the horizontal axis the sensitivity and value of the receptor or resource is shown, while on the vertical axis is the magnitude of impact. Using these two values the significance of impact can be ascribed.

Table 29: Assessing Significance of Impact

Magnitude of Environmental Impact	Low	Moderate	Substantial	High
Corresponding Environmental Category	Green	Yellow	Orange	Red
Environmental Assessment (Please put Yes/No in the appropriate cell)	N/A	IEE	IEE/EIA	EIA
Does the sub-project activities require details IEE/ EIA including EMP as per ECR'23				

An impact of negligible significance is one where there is no perceptible or readily measurable effect on the resource or receptor. An impact of minor significance is one where the effect on the resource or receptor is noticeable, but the sensitivity or value of the receptor is low, or the variation is within the normal range of background variation and within applicable standards. An impact of moderate significance is one where the environment is altered and a perceptible change of the baseline, but any damage is reversible or there is great potential for substitution. An impact of high significance is a considerable change to the baseline conditions or exceeding accepted limits or standards and the sensitivity or value of the receptor is high or moderate.

The interaction matrix identified potential for significant impacts on physical, environmental, and social resources. The **Table 30** below elaborates the potential impact of these interactions.

Table 30: Interactions and Potential Impact

Interaction	Description of Potential Impact
Alteration of topography and drainage	- Excavating and raising land and construction work may lead to changes in local topography and drainage patterns. - Work on the existing drainage system and infrastructure will influence the drainage capacity in the construction period.
Impact on Soil Quality	- Excavations and earthworks may impact soil properties and stability, through compaction, erosion, and contamination. - Vehicle movement may lead to compaction and erosion. - Disposal of construction solid and liquid wastes may lead to contamination of soil.
Impact on Surface and groundwater resources	- Impacts to surface water and groundwater may occur through construction works in and near water bodies, earthworks, and disposal of construction solid and liquid wastes. - Leaks, spills, and runoffs may also lead to impact.
Changes in land use and land cover	Impacts to land use and land cover may occur primarily through clearance of sites to prepare for construction and at sites used temporarily during construction.
Impact on Air quality	Vehicle movement, operation of vehicles and machinery, construction works, excavation, and transportation of materials and waste will lead to emission of dust and emission of pollutants such as NO_x and SO₂.
Impact on Noise levels	Construction works, excavation, piling, vehicle movement, operation of vehicle and machinery will emit noise that will impact ambient noise levels.
Disturbance of Traffic flows	Construction work is associated with increased traffic flows and temporary disturbance of traffic at construction sites.
Solid waste	Construction waste and excavated material, including sediments and water hyacinths from the Khals and ponds will need to be managed and deposited appropriately.
Biodiversity/Water quality?	- Construction will take place near and in water bodies and may impact water quality and thus impact dependent flora and fauna. - Clearance of sites may clear vegetation that supports fauna. - Excavation in Khals may disturb existing aquatic vegetation in the Khals.
Impact on livelihood and jobs	- Livelihoods of workers/staff at businesses located at project sites and displaced by the construction or subproject may be impacted. - The subprojects will also have a positive impact through job creation especially in construction and to a smaller degree in operation.
Infrastructure and services	- Impact to infrastructure and services may include impact to roads and transportation network, including water ways during construction as well as potential impact to utilities during work on the drainage system, which involves trench work. - The drainage system and infrastructure may potentially be impacted temporarily during construction.
Resettlement - physical & economic displacement	- Clearance of sites for construction will impact structures and assets, including residential and businesses at these sites. - There is limited land purchase for the pumping station, but otherwise subprojects are located on public, state-owned land.
Community health and safety	- Hazards to community health and safety includes increased traffic loads and disturbance of traffic flows, and noise and dust emissions. - Open trenches constitute a safety risk for the communities. - Work on the drainage system will influence drainage capacity during construction, and thus potentially cause flooding.

Interaction	Description of Potential Impact
Occupational health and safety	Hazards to occupational health and safety includes use of construction machinery, excavation and trench work, working in the drainage system and canals that receives wastewater, work in a noisy and dusty environment, working with electrical equipment.
Landscape, visual and aesthetic impact	Natural or culturally significant landscapes may potentially be modified through the construction work
Impact on cultural resources	Heritage, cultural, and religious sites located in the vicinity of the construction sites may be temporarily disturbed during construction by noise or dust emissions. Chance finds during construction may occur.

5.5.5 Reversibility of Condition /Impact Area

The CDRSSWRMP in Bangladesh is a targeted intervention aimed at reversing the degradation of agricultural livelihoods caused by climate-induced hazards. It works on mitigating risks through infrastructure development, such as rehabilitating coastal embankments, excavating canals, and building water management cooperatives (WMCAs).

Impact Areas and Scope

The project focuses on enhancing the resilience of small-scale water resources to climate change, with a particular focus on the following areas and objectives:

- **Geographical Focus:** Primarily coastal areas (Khulna, Patuakhali, Barisal, Noakhali, Chittagong) and regions prone to flooding, drought, and salinity.
- **Targeted Coverage:** The project aims to benefit over 220,000 hectares of land.
- **Key Infrastructure:** Rehabilitation and modernization of water management infrastructure, including the Bakkhali Rubber Dam.
- **Specific Improvements:** Construction of 110 kilometers of farm access roads, 60 composite sluice gates, and re-excavation of canals.
- **Institutional Capacity:** Strengthening 150 new and 230 existing Water Management Cooperative Associations (WMCAs).

Reversibility of Conditions

The project acts on the principle that many environmental impacts, while severe, can be mitigated or reversed through proper water management and infrastructure improvements:

- **Reversing Waterlogging and Flooding:** By improving drainage and constructing flood-resilient infrastructure (e.g., sluice gates, embankments), the project aims to reduce risks on over 87,000 hectares of land.
- **Mitigating Salinity and Drought:** The project enhances water retention and management, which helps to counteract increased salinity intrusion in coastal areas and water scarcity during the dry season.
- **Restoring Agricultural Productivity:** By improving irrigation systems and water accessibility, the project works to reverse declining agricultural productivity in affected areas.
- **Long-Term Resilience:** The project strengthens local capacity to manage water resources, which is crucial for managing the long-term, compounding effects of climate change.

The project, which builds on previous ADB-financed small-scale water resources projects, works to improve the resilience of rural communities against the impacts of climate change, such as those arising from the 100-year flood or increased salinity.

5.5.6 Cumulative impact

The CDRSSWRMP, often in partnership with IFAD, ADB, and the Netherlands, aims to create sustainable, community-driven water management systems. Its cumulative impacts include enhancing agricultural productivity, improving climate resilience for vulnerable communities, and promoting economic empowerment, particularly for women.

Key cumulative impacts and outcomes include:

- **Agricultural and Economic Growth:** The project focuses on improving water management, flood control, and irrigation over 220,000 hectares, aiming to increase crop yields and farm income for over 335,000 farming households and 45,000 landless/vulnerable households. It has demonstrated a significant increase in crop and fish sales, with some related projects reporting over 100% and 50% increases, respectively.
- **Climate Resilience and Infrastructure:** By rehabilitating and constructing small-scale water infrastructure (re-excavating canals, flood protection), the project reduces flood damage and protects rural assets. This includes strengthening Water Management Cooperative Associations (WMCAs) to manage these systems sustainably.
- **Social Empowerment and Livelihoods:** The project, through Labour Contracting Societies (LCS) and WMCAs, creates jobs for women and landless people, with reports showing significant income increases for women through self-employment and wage employment.
- **Institutional Capacity Building:** The project strengthens the Local Government Engineering Department (LGED) to better plan and implement climate-smart water management.

Cumulative Results (including related projects like PSSWRSP/CCRIP):

- **Health & WASH:** Related initiatives reduced waterborne illnesses from 60% to 35% in targeted areas, with 93% gaining access to safe drinking water.
- **Infrastructure & Income:** Improved roads and markets have resulted in a 60% reduction in transport costs, 55% decrease in travel time, and 70% increase in market sales.
- **Poverty Reduction:** The project aims to reduce poverty by providing secure, year-round, three-meal-a-day, and better access to health and nutrition for rural households.

The project, valued at approximately BDT 2,235.80 crore (including BDT 2,235.80cr for the main project plus additional funding), focuses on long-term sustainability to protect the rural economy against climate change.

5.5.7 No impact, Significant impact, Insignificant impact, Unknown impacts, Mitigated impact

The CDRSSWRMP in Bangladesh is designed to enhance resilience in specific high-risk, rural areas. Therefore, its "no impact" or "outside scope" areas are primarily **urbanized areas**, regions with **no small-scale water management infrastructure needs**, and areas outside the four targeted geographic hotspots, which are:

- **Urban and Municipal Centers:** The project focuses on rural agriculture and small-scale water infrastructure, not major urban, commercial, or metropolitan infrastructure.
- **Non-Hotspot Regions:** The project specifically targets 42 districts covering four specific hotspots: Barind and drought-prone areas, coastal zones, Haor and flash flood areas, and river systems. Areas that do not fall within these, or areas with established large-scale, efficient water systems, are generally excluded.
- **Large-Scale Infrastructure Areas:** Areas requiring large, macro-level infrastructure (like major bridges or large-scale, non-small-scale dams) are not the focus of this project.

Project Scope:

- **Target Areas:** The project focuses on 42 districts representing 64% of the national area, specifically targeting 150 new Water Management Cooperative Associations (WMCAs) and 230 existing ones, benefiting about 335,000 farming households and 45,000 landless people.
- **Focus:** It aims to reduce poverty by increasing agricultural productivity and climate resilience in rural, disaster-prone areas.

The CDRSSWRMP is designed to have a significant impact on agricultural productivity and rural livelihoods across four key climate-vulnerable hotspots. The project, implemented by the Local Government Engineering Department (LGED), focuses on strengthening community resilience through sustainable water management.

Significant Impact Areas (Geographical Hotspots)

The project targets 42 districts, focusing on areas identified in the Bangladesh Delta Plan 2100:

- **Barind and Drought-Prone Areas:** Focus on water conservation in regions prone to drought.
- **The Coastal Zone:** Focused on protecting against salinity intrusion, storm surges, and tidal flooding.
- **The Haor and Flash Flood Areas:** Addressing flash floods, particularly in the northeastern region.
- **River Systems and Estuaries:** Managing drainage congestion and river erosion.

Key Impacts on Sectors and Populations

- **Agricultural Productivity:** The project aims to enhance water management for approximately 220,000 hectares, supporting 335,000 farming households by increasing crop yields and intensity.
- **Disaster Risk Reduction:** The project includes the construction of climate-resilient rural infrastructure, such as embankments, sluice gates, and re-excavation of drainage canals to reduce flood damage.
- **Livelihood & Economic Empowerment:** Targeted at 45,000 functionally landless households and vulnerable people, providing opportunities for income-generating activities in fisheries and agricultural value chains.
- **Institutional Strengthening:** Building the capacity of Water Management Cooperative Associations (WMCAs) to manage, operate, and maintain water infrastructure, fostering local, participatory management.
- **Infrastructure Improvement:** Modernizing infrastructure, such as the Bakkhali Rubber Dam, and enhancing 230 existing subprojects.

The project, with support from the Asian Development Bank (ADB), IFAD, and the Netherlands, spans 6 years and focuses on transforming vulnerabilities into opportunities for sustainable, climate-resilient growth.

5.6 Impact of fertilizers and pesticide use in agriculture

Fertilizer use in agriculture significantly impacts soil and water by enhancing crop yields but causes long-term environmental degradation through over-application. Key impacts include soil acidification, nutrient imbalances, reduced microbial activity, increased compaction, and water contamination leading to eutrophication, which destroys aquatic ecosystems.

5.6.1 Impact of fertilizer on agricultural soil

Impact on Soil

- **Soil Acidification:** Overuse of nitrogen-based fertilizers can cause the soil to become overly acidic, which reduces the availability of essential nutrients.
- **Nutrient Imbalance and Toxicity:** Excessive application can lead to a deficiency in some nutrients while causing toxic levels of salts and heavy metals, degrading overall soil health.
- **Physical Degradation:** Chemical overuse damages soil structure, resulting in compaction, lower water retention, and increased susceptibility to erosion.
- **Reduced Microbial Activity:** Long-term use of synthetic fertilizers can decrease organic matter and harm beneficial soil microorganisms.

5.6.2 Impact of fertilizer on agricultural water

Impact on Water

- **Eutrophication:** Runoff from fertilized fields carries phosphorus and nitrogen into rivers and lakes, triggering algae blooms that consume oxygen and devastate aquatic life.
- **Groundwater Contamination:** Nitrogen fertilizers can leach into groundwater, causing pollution that makes water unsafe for human consumption.
- **Increased Toxicity:** Heavy metals from fertilizers can accumulate in water bodies, posing risks to both aquatic life and human health.

5.6.3 Impact of pesticide on agricultural soil

Agricultural pesticides severely degrade soil health by killing beneficial microorganisms and disrupting nutrient cycling, while runoff and leaching contaminate surface water and groundwater, harming aquatic ecosystems. These chemicals, including glyphosate, accumulate in the topsoil and, via erosion, can be transported into water bodies, causing algal blooms, reduced oxygen levels, and biodiversity loss.

Impact on Soil

- **Microbial Disruption:** Pesticides kill beneficial microorganisms (fungi, bacteria) that decompose organic matter and enhance soil fertility.
- **Nutrient Imbalance:** Chemical residues hinder nitrogen fixation and nitrification, reducing nutrient uptake by plants.
- **Contamination and Degradation:** Pesticides accumulate in the topsoil, leading to reduced structural stability and long-term degradation, sometimes lasting decades.

Erosion-Induced Transport: Contaminated soil particles are transported via wind or rain, allowing toxins to spread beyond the agricultural site.

5.6.4 Impact of pesticide on agricultural water

Impact on Water

- **Surface Water Contamination:** Runoff from fields transports pesticides into rivers, lakes, and oceans, causing toxic environments for aquatic life.
- **Groundwater Pollution:** Pesticides leach through the soil, contaminating groundwater sources used for drinking.
- **Ecosystem Disruption:** Chemical contamination triggers algal blooms that deplete oxygen, resulting in fish kills and reduced biodiversity.
- **Bioaccumulation:** Pesticides accumulate in the food chain, affecting aquatic species and birds.

Long-Term Consequences

- **Loss of Biodiversity:** Excessive use reduces beneficial insect populations (pollinators) and soil organisms, leading to ecological imbalances.
- **Reduced Nutritional Value:** Soil contamination can lower the nutrient density of crops.
- **Human Health Hazards:** Residues can enter the human food chain and water supply, causing potential long-term health risks.

Table 31: Potential Impacts of Project Activities and the Mitigation Measures

Important Environmental Component	Baseline Condition	Subproject Activities and Impacts	Mitigation Measures
Physical Environment			
Regional/outside the subproject area hydrology, sedimentation, water quality	Baseline hydrologic, sedimentation, and water quality conditions outside the area (ie. downstream on the Bakkhali) were modified in the dry season (only) prior to 1995 and in 2020-1 by the annually constructed earthen dams, and from 1995 to 2020 the previous rubber dam	No impact anticipated. SP rubber dam will be at the same site and operated in the same manner as the previous dam: inflated every year late November/ yearly December, deflated mid-April. When deflated, dam has no impacts	Not required
SP area flooding (level/frequency, date of onset, source=rainwater, river, tides)	Cultivated area is all F0 and F1. Inundation is not generally problematic and is not addressed by the SP	No impact anticipated	Not required
SP water logging, drainage, and surface water conservation / storage	Drainage provided by existing khals and regulator is suboptimal	Khal re-excavation and upgraded/ rehabilitated regulators will improve drainage and water conservation	Regulator operation and maintenance per WMAC operational plan to achieve positive drainage and water retention impacts.
Natural monsoon flushing	Subproject area is naturally flushed with pre-monsoon and monsoon rainfall	No impact anticipated	Not required
Ground water table	Ground water use in the area is very low	No impact anticipated	Not required
Water quality	Water quality is typical of rural areas. There are no local or upstream point sources of water pollution (industries etc.). For several decades, dams have excluded salinity intrusion from the Bakkhali.	Local non-point source fertilizer and pesticide pollution and seasonal eutrophication could increase along with subproject-led agriculture expansion and intensification	WMCA training in integrated crop management
Erosion and siltation	Erosion upstream and downstream of the dam site (ie environment -on-project impact). Khals vulnerable to siltation	SP dam vulnerable to river erosion, re-excavated Khals vulnerable to siltation (ie environment -on-project impacts)	Increased dam width, riverbank protection mitigates erosion threat to dam. WMCAs manage recurrent Khal re-excavation
Soil characteristics /fertility			
Ecological Environment			
Aquatic habitats	Aquatic habitat comprises the Bakkhali and Khals, no other seasonal or permanent waterbodies or floodplain fish habitat (F2 or F3 area). Baseline Bakkhali aquatic habitat is	SP rubber dam will occupy same site and be operated in same manner as previous rubber dam	Potential enhancement measure: during operation, water retention in re-excavated Khals behind upgraded regulators may increase dry season aquatic habitat.

Important Environmental Component	Baseline Condition	Subproject Activities and Impacts	Mitigation Measures
	water retention reservoir during the dry season.		
Open water fisheries	Open water fish production is limited to the Bakkhali and Khals. Aquaculture occurs in household ponds	No impact anticipated	WMCA will explore options for aquaculture in the Bakkhali and khals
Terrestrial Habitat, including natural and plantation forest	Terrestrial habitat consists of homesteads and social afforestation. There is no forest in the study area. Semi-natural vegetation has developed since 1995 on 3700 m ² of land on the Bakkhali right bank, that LGED acquired but did not use for the 1995 dam (and subsequently kept fenced which promoted vegetation development).	To mitigate erosion risk to proposed dam, SP dam is wider than previous dam and will extend further onto the right bank, into the 1500 m ² of vegetated area on LGED land	Within engineering constrain constraints SP dam design minimizes vegetated area used. Additional disturbance during construction will be avoided /minimized by careful planning and contractor supervision. Possible enhancement measures: WMCA tree plantation on khal banks.
Wildlife and biodiversity	Screening of IUCN Bioecological Zone 9a-Chittagong Hill tracts species against the IUCN Red List identified several of concern, however all were subsequently screened out from exposure to potentially significant SP impacts	No impact anticipated	Not required
Unwanted aquatic weed eg. hyacinth	Aquatic weeds are present in the SP Khals but not considered a significant problem	Weeds and hyacinth could increase	WMCA will monitor impacts of weeds on the khal and its beneficial uses (irrigation, fisheries), and devise and implement appropriate management measures as needed.
Human and Economic Development			
Displacement	Not applicable	Minor temporary physical and economic displacement impact during construction are expected	Addressed in Subproject Resettlement plan
Agriculture	Cropping intensity is 170 percent (4250 ha on 2500 ha net cultivated area), cropped areas are: (i) rice 4025 ha and (ii) non-rice 225 ha.	Cropping intensity is expected to 197 per cent (4925). Cropping areas by season are expected to be: (i) rice 3950 ha and (ii) non-rice 975 ha, large yield changes are not expected	Enhancement/ benefit realization measures: WMCA supported to operate and maintain water resources infrastructures, and to shift and improve agriculture to realize expected subproject agriculture benefits
Aquaculture	Some aquaculture in homestead ponds	Area fisheries are interested to undertake aquaculture in Bakkhali and Khal water retention bodies	Enhancement measures: WMCA to explore options for aquacultures in Bakkhali and Khal water retention bodies in the dry season

Important Environmental Component	Baseline Condition	Subproject Activities and Impacts	Mitigation Measures
Road transport and navigation	National highway N1 and the under-construction railway, both running from Chattogram to Cox's Bazar, pass through the subproject area. Previous dam had a footbridge but no boat pass. Small boats ply the Bakkhali in near the previous dam site. Unpaved village roads are used in the SP area.		Enhancement measures: SP dam incorporates vehicle bridge and boat pass.
Employment	Underperformance of agriculture since the previous dam failed represent missed opportunities for agriculture-related employment	Increased employment is expected from increased agriculture and aquaculture activity plus other WMCA income-generation activities, especially for vulnerable people, women, and youth. Temporary construction jobs will also be created.	Positive employment and income impacts flow from subproject construction and operation.
Health, nutrition, and occupational health/safety	Underemployment negatively impacts nutrition and health of vulnerable groups. Farmers and day laborers are exposed to occupational health and safety hazards of agriculture work including use of manual and power-driven machinery and tools (pump, tractors, excavators etc.)	Increased employment opportunities are expected positively impact health and nutrition of vulnerable people. Subproject activities do not involve novel activities or equipment	Positive health and nutrition impacts flow from employment and income increases
Impact on vulnerable groups	Subproject has many landless and marginal farmer households, and a small number of small ethnic community households	Positive impacts are anticipated via employment and WMCA income generation activities	Positive impacts on vulnerable groups flow from subproject-led employment and income increases, and from WMCA income generation activities
Physical cultural resources	Cox's Bazar District has no Department of Archeology Protected Monuments. Five Burmese Arakan wooden pagodas dating to the latter half of the 1800s survive in Ramu Upazila. At least two of these, Lamar Para and U Chit San (Rakhine) Monasteries are in the SP area on non-cultivated high land.	Chance finds (unexpected exposure of physical cultural resources) during land clearance and excavation are possible but unlikely	Environmental Management plan and bidding documents include chance find procedures

Table 32: Residual Impact, Mitigation Measures, and Potential Benefits

Important Environmental Component	No (+) or (-) Impacts?	Potential (+) Beneficial Impact, Enhancement measures	Potential (-) Adverse Impact	Measure(s) to mitigate (-) Adverse Impact	Residual (-) Adverse Impact
Physical Environment					
Regional/outside the subproject area hydrology, sedimentation, water quality	x				
SP area flooding (level/frequency, date of onset, source=rainwater, river, tides)	x				
SP water logging, drainage, and surface water conservation / storage		Khal re-excavation and upgraded / rehabilitated regulators will improve drainage and water conservation			
Natural monsoon flushing	x				
Ground water table	x				
Water quality			Local non-point source fertilizer and pesticide pollution and seasonal eutrophication could increase along with subproject-led agriculture expansion and intensification	WMCA training in integrated crop management	Insignificant
Erosion and siltation			SP dam vulnerable to river erosion, re-excavated khals vulnerable to siltation (ie environment -on-project impacts)	Increased dam width, riverbank protection mitigates erosion threat to dam. WMCAs manage recurrent Khal re-excavation	Insignificant
Soil characteristics/fertility	x				
Ecological Environment					
Aquatic habitats		Potential enhancement measures: during operation, water retention in re-excavated khals behind upgraded regulators may increase dry season aquatic habitat			

Important Environmental Component	No (+) or (-) Impacts?	Potential (+) Beneficial Impact, Enhancement measures	Potential (-) Adverse Impact	Measure(s) to mitigate (-) Adverse Impact	Residual (-) Adverse Impact
Open water fisheries	x				
Terrestrial habitat, including natural and plantation forest		Within engineering constrains SP dam design minimizes vegetated area used. Additional disturbance during construction will be avoided / minimized by careful planning and contractor supervision. Possible enhancement measure: WMCA tree plantation on khal banks			
Wildlife and biodiversity	x				
Unwanted aquatic weed eg. hyacinth			Weeds and hyacinth could increase	WMCA will monitor impacts of weeds on the khal and its beneficial uses (irrigation, fisheries), and devise and implement appropriate management measures as needed.	Insignificant
Human and Economic Development					
Displacement			Minor temporary physical and economic displacement impact during construction are expected	Addressed in subproject resettlement plan	Insignificant
Agriculture		Enhancement/ benefit realization measures: WMCA supported to operate and maintain water resources infrastructures, and to shift and improve agriculture to realize expected subproject agriculture benefits			
Road transport and navigation		Enhancement measure: WMCA to explore options for aquaculture in Bakkhali and khal water retention bodies in the dry season			
Employment		Enhancement measures: SP dam incorporates vehicle bridge and boat pass			
Health, nutrition, and occupational health/safety		Increased employment is expected from increased agriculture and aquaculture activity plus other WMCA income-			

Important Environmental Component	No (+) or (-) Impacts?	Potential (+) Beneficial Impact, Enhancement measures	Potential (-) Adverse Impact	Measure(s) to mitigate (-) Adverse Impact	Residual (-) Adverse Impact
		generation activities, especially for vulnerable people, women, and youth. Temporary construction jobs will also be created.			
Impact on vulnerable groups		Increase employment and income earning opportunities are expected to have a positive impact on health and nutrition of vulnerable people. Subproject infrastructure O&M does not involve novel activities or equipment			
Physical cultural resources		Positive impacts are anticipated via employment and WMCA income generation activities			

6 CLIMATE RISK SCREENING AND ASSESSMENT OF 42 DISTRICTS

6.1 Sensitivity of Project Components to Climate Conditions and Sea Level

The CDRSSWRMP in Bangladesh, is highly sensitive to climate change, particularly given its focus on water management infrastructure in a low-lying, disaster-prone delta. The project components are designed to manage water in four specific climate hotspots and are highly vulnerable to changing weather patterns.

Key Sensitivities of Project Components:

- **Small-scale Water Resources Management Infrastructure (Embankments, Drainage/Irrigation Canals):**
 - **Sensitivity:** High. These structures are susceptible to damage from extreme flood events, increased monsoon rainfall, and tidal surges.
 - **Climate Risks:** Increased runoff, riverbank erosion, and siltation (reduced flow) due to intense rainfall patterns.
- **Water Management Cooperative Associations (WMCAs) & Equipment:**
 - **Sensitivity:** Medium to High. While primarily institutional, these associations manage infrastructure that is exposed to salinity intrusion and sea-level rise (SLR), which can alter agricultural land use and reduce productivity.
- **Rural Roads and Connectivity Infrastructure:**
 - **Sensitivity:** High. Infrastructure in coastal districts is directly affected by sea-level rise, higher precipitation, and storm surges.
 - **Climate Risks:** Increased risk of submergence and erosion of road access due to rising sea levels and flooding.
- **Agricultural Production & Water Management (Bakkhali Rubber Dam/Irrigation):**
 - **Sensitivity:** High. Increased temperatures and drought during the dry season, alongside salinity intrusion, threaten crop yields and irrigation capacity.
- **Nature-Based Protective Structures:**
 - **Sensitivity:** Moderate. While designed to enhance resilience, these can be affected by extreme heat and drought.

Key Environmental Factors:

- **Sea Level Rise (SLR):** Projected to severely affect coastal districts (e.g., Satkhira, Barguna, Bhola), with 17% of territory potentially lost by 2050. This causes increased salinity and erosion of coastal infrastructure.
- **Erratic Rainfall and Floods:** Increased intensity of monsoons causes severe flooding, while lack of rain in the dry season causes drought, damaging irrigation, agriculture, and water infrastructure.

The project aims to mitigate these risks by constructing more robust, climate-resilient water management systems, including rehabilitating existing systems and strengthening institutional capacity for operation and maintenance

6.2 Climate Risk Screening

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, is rated with high climate risk, necessitating adaptation measures to combat floods, cyclones, salinity, and erratic rainfall. It focuses on enhancing infrastructure, improving water management via 150 new Water Management Cooperative Associations (WMCAs), and promoting resilient agriculture for 86,000 hectares.

Key Climate Risks and Vulnerabilities (CDRSSWRMP)

- **Hazards:** Increased frequency of floods, cyclones, and waterlogging.
- **Salinity Intrusion:** Growing salinity in coastal areas threatens agricultural sustainability.
- **Inadequate Infrastructure:** Existing water infrastructure is insufficient to handle extreme weather, causing high vulnerability.
- **Climate Change Projection:** Temperatures are projected to rise, with increased rainfall variability, impacting agricultural productivity.

Projected Risk Management Strategies

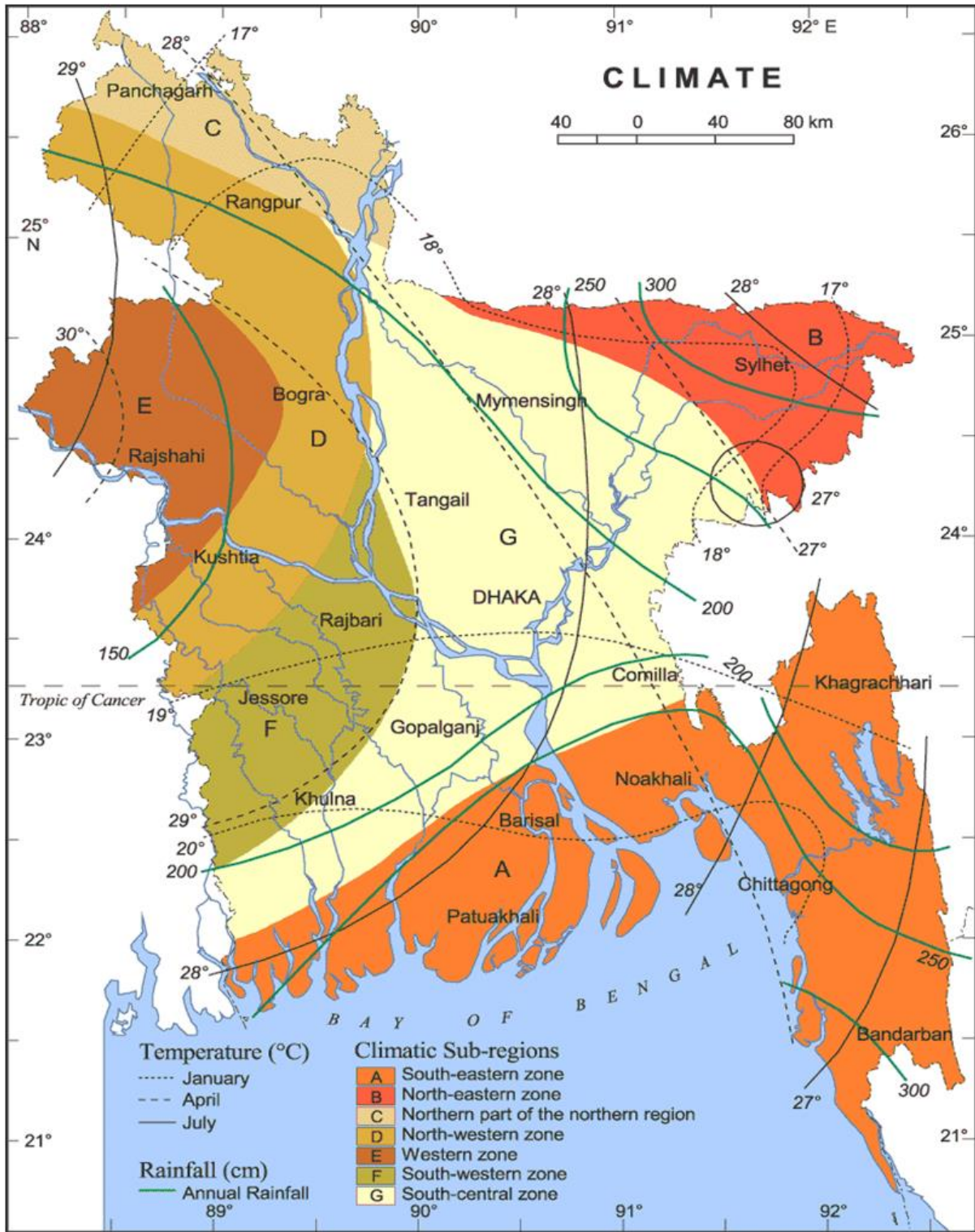
- **Resilient Infrastructure:** Construction of climate-proofed water management, drainage, and irrigation systems.
- **Capacity Building:** Strengthening 230 existing and 150 new WMCAs to operate, maintain, and adapt to climate-resilient water systems.
- **Climate-Smart Agriculture:** Promotion of salt-tolerant crops, diversified farming, and improved value chains to boost food production and incomes.
- **Integrated Management:** Enhancing the capacity of the Local Government Engineering Department (LGED) for sustainable water resource management and planning.

Screening and Implementation

- **Approach:** The project uses a risk screening system to assess subprojects, focusing on vulnerable coastal regions.
- **Components:** Activities include rehabilitating existing infrastructure, upgrading rural roads for connectivity, and providing training on climate-resilient farming techniques.

6.3 Climate Risk and Adaptation Assessment

The CDRSSWRMP addresses high climate risks by strengthening, upgrading, and constructing climate-resilient water management infrastructure, protecting over 210,000 hectares of land. Key adaptation measures include improving 110 km of rural roads, repairing flood-prone infrastructure, and supporting over 190,000 households with climate-resilient farming and water management practices. Climate zone map of Bangladesh is given in the **Figure 20**.



Source: <https://pubs.sciepub.com/jfs/7/1/2/figure/1>

Figure 20: Climatic Zone Map of Bangladesh

Key Climate Risks Assessed

The project operates in a high-risk environment, with hazards including:

- **Floods and Cyclones:** Intensifying, disrupting agriculture and destroying infrastructure.

- **Salinity Intrusion:** Increasing in coastal areas, reducing arable land.
- **Drought and Erosion:** Groundwater depletion and riverbank erosion threaten rural livelihoods.

Adaptation and Resilience Measures (CDRSSWRMP)

The project implements several, structural and community-based, adaptation strategies:

- **Infrastructure Resiliency:** The project is upgrading 230 existing Water Management Cooperative Associations (WMCAs) and constructing 150 new, climate-resilient subprojects to enhance drainage and flood control.
- **Agricultural Adaptation:** Introduction of climate-resilient technologies and improved Operation & Maintenance (O&M) practices for over 190,000 households.
- **Coastal Protection:** Implementation of rainwater harvesting and pond-based ultra-filtration systems to address water salinity.
- **Community-Led Initiatives:** Promoting "locally led adaptation" (LLA) through training and support, including swamp tree plantation and, habitat restoration to build local resilience.

Project Focus and Scope

- **Coverage:** 150 new subprojects (86,000 ha) and 230 existing subprojects (130,000 ha).
- **Key Focus Areas:** Ensuring, sustainable, food systems, enhancing livelihood, and, strengthening, disaster, resilience, in,, areas, like, Sunamganj, and, coastal, zones.
- **Objective:** To reduce, vulnerability, to, climate, change, while, improving, rural, livelihoods, through, better, water, management,

The project, which is supported by the IFAD, integrates detailed climate risk assessments into its design, focusing on long-term sustainability.

6.4 Climate Risk Screening Tool and / or Procedure Used

The CDRSSWRMP in Bangladesh utilizes a comprehensive, two-stage climate risk management framework, often aligned with Asian Development Bank (ADB) guidelines, involving initial screenings (checklists) followed by detailed Climate Risk and Vulnerability Assessments (CRVA) to assess hazards, exposure, and vulnerability. The process focuses on integrating resilience measures into subproject design (e.g., in water infrastructure) through participatory, stakeholder-driven processes managed by the Local Government Engineering Department (LGED).

Key Components of the Screening Procedure:

- **Two-Stage Approach:** Initial screening at the project concept phase (using checklists) and a more in-depth CRVA during the project preparation phase.
- **Methodology Steps:** The procedure includes (i) hazard identification, (ii) exposure assessment, (iii) vulnerability assessment, (iv) adaptive capacity assessment, (v) climate risk classification, and (vi) modulation of risk by the project.
- **Risk Assessment Tools:** Utilization of risk matrices to categorize risks (e.g., flood, drought, cyclone) as low, medium, or high.

- **Participatory Approach:** Incorporation of stakeholder-driven, community-based planning, specifically targeting women, youth, and vulnerable groups for localized adaptation.
- **Focus Area:** The project focuses on 42 districts to build resilient small-scale water resources, ensuring infrastructures can withstand climate-induced impacts.

The project, often in collaboration with organizations like IFAD (International Fund for Agricultural Development), also emphasizes monitoring these risks during implementation.

6.5 Climate Adaptation Plans within the Project

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, managed by the Local Government Engineering Department (LGED), focuses on reducing climate vulnerability in flood-prone and high-barind regions. It aims to enhance resilience through climate-resilient water infrastructure, diversified livelihoods, and strengthened community-based water management.

Key climate adaptation plans within the CDRSSWRMP include:

- **Resilient Infrastructure:** Construction and rehabilitation of small-scale water resources infrastructure, such as embankments and water control structures, designed to withstand floods and cyclones.
- **Agricultural Adaptation:** Promotion of climate-resilient farming, including the use of salt-tolerant or drought-resistant crop varieties to maintain productivity.
- **Water Management Associations (WMCAs):** Establishing 150+ new, inclusive, and sustainable water management cooperative associations to manage, operate, and maintain infrastructure.
- **Livelihood Diversification:** Implementing strategies to boost farm incomes, such as promoting aquaculture and alternative income-generating activities to improve economic resilience against climate shocks.
- **Institutional Strengthening:** Building the capacity of the LGED's Integrated Water Resources Management Unit (IWRMU) to better plan, monitor, and implement climate-conscious projects.

The project aligns with Bangladesh's broader National Adaptation Plan (NAP) 2023-2050 and the Delta Plan-2100, with a focus on protecting agricultural productivity and improving food security.

6.6 Environmental Impacts and Mitigation of Climate Adaptation Activity

The Climate and Disaster Resilient Small-Scale Water Resources Management Project in Bangladesh, implemented by the Local Government Engineering Department (LGED) and supported by the ADB and IFAD, aims to boost agricultural productivity and climate resilience across 42 districts. While the project is designed to enhance sustainability, it involves civil works that have associated environmental impacts requiring mitigation.

Key Climate Adaptation Activities

- **Infrastructure Development:** Construction/rehabilitation of embankments, sluice gates, and re-excavation of drainage canals to manage flooding.
- **Water Management:** Developing water retention capacity in *haors*, *Beels*, and *Khals* for irrigation.
- **Modernization:** Rehabilitating the Bakkhali Rubber Dam.
- **Access Improvements:** Upgrading on-farm and village roads.
- **Livelihood Support:** Promoting climate-resilient agriculture and aquaculture.

Environmental Impacts of Activities

The project is categorized as "**B**" for environment (ADB) and "Red" (potentially, under ECR 2023) due to construction-related impacts, which are largely temporary and site-specific.

- **Construction-Phase Impacts:**
 - **Soil Erosion and Siltation:** Excavation of canals and construction of embankments may lead to bank instability and sedimentation of water bodies.
 - **Air and Noise Pollution:** Dust and noise from construction equipment and transport of materials.
 - **Vegetation Loss:** Removal of trees and plants during construction.
 - **Disruption of Aquatic Habitat:** Disturbance to fish habitats during hydraulic structure construction.
- **Operational-Phase Impacts:**
 - **Groundwater Over-extraction:** Increased irrigation capacity could lead to lowering water tables.
 - **Water Logging:** Potential, if drainage improvements are not properly designed.
 - **Salinity Intrusion:** In coastal areas, improper water management could accelerate saltwater intrusion.

Mitigation Measures

The project incorporates environmental safeguards, including Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) for subprojects, to manage risks.

- **Engineering and Design Controls:**
 - **Slope Protection:** Proper engineering design to prevent unstable side slopes for Khals and embankments.
 - **Sustainable Drainage:** Designing regulators and sluice gates to manage, not just block, water flow, preventing waterlogging.
 - **Salinity Control:** Using specialized sluice gates in coastal areas to prevent saltwater intrusion into freshwater sources.

- **Construction Site Management:**
 - **Pollution Mitigation:** Regular spraying of water to control dust and restrictions on noise during nighttime.
 - **Waste Management:** Proper disposal of construction debris and oil spillage control.
 - **Revegetation:** Prompt re-plantation of disturbed areas.
- **Operational Management:**
 - **Groundwater Monitoring:** Establishing water monitoring stations to avoid over-withdrawal of groundwater.
 - **Water Management Cooperative Associations (WMCAs):** Empowering local communities to manage operations and maintenance (O&M) sustainably.
 - **Nature-Based Solutions:** Integrating, where possible, nature-based protections (such as greenbelts) alongside structural barriers.
- **Institutional Measures:**
 - **Contractor Compliance:** Appointing Environment, Health, and Safety (EHS) focal persons for all construction works.
 - **Grievance Redress Mechanisms (GRM):** Establishing committees at Upazila and district levels to resolve social and environmental grievances.
 - **Monitoring:** Regular submission of Social and Environmental Monitoring Reports to the ADB.

Table 33: Environmental Impacts and Mitigation of Climate Adaptation Activity

Adaptation Activity-1	1. Heighten and strengthen flood embankments along rivers and in coastal areas
Environmental Impacts	Geomorphological and Hydrological Impacts • Increased Flood Levels and Velocity: Confining the river flow within embankments prevents water from spreading into the floodplain, which leads to higher and faster flood waves within the channel. • Riverbed Sedimentation (Siltation): Embankments cut rivers off from their floodplains, preventing sediment from spilling over and being deposited on the land during floods. As a result, sediment settles within the river channel itself, raising the riverbed elevation over time. • Need for Continuous Raising: As the riverbed rises, the embankments must be kept in required height to maintain the same level of flood protection, leading to a cycle of building higher and higher walls to contain an ever-rising river. • Land Subsidence: Areas behind the embankments are deprived of the regular sediment accumulation that naturally builds up land

	elevation. Due to a lack of new sediment and natural soil compaction, the land behind the levee actually subsides and becomes lower than the riverbed and surrounding intertidal areas. • Increased Erosion Risk: The higher flow velocities and channel deepening increase the potential for riverbank erosion, which threatens the stability of the embankments themselves. This can lead to catastrophic failure, causing sudden severe flash floods in the low-lying protected areas. The side slop needs to be protected by blocks. • Drainage Congestion: Embankments can impede the natural drainage of surface water from the land side back into the river, leading to waterlogging and more frequent pluvial (rain-induced) flooding within the protected areas. Ecological and Environmental Impacts • Habitat Fragmentation and Loss: Embankments disconnect the river from its natural floodplain and associated wetlands, which are critical habitats for many species. • Changes in Vegetation and Biodiversity: The altered hydrology and reduced flooding frequency change soil moisture and salinity gradients, negatively impacting natural vegetation patterns and species diversity, such as mangrove forests in coastal deltas. • Groundwater Alteration: Embankments can decrease shallow groundwater levels and increase groundwater salinity in adjacent floodplains, further stressing natural ecosystems. Loss of Natural Nutrient Supply: Floodplains are naturally fertile due to the deposition of nutrient-rich river-borne sediments during floods. Embankments cut off this natural fertilization process, which can reduce the fertility of agricultural land over time.
Mitigation Measures	Engineering and Structural Measures • Bank reinforcement: Use materials such as concrete blocks, geo-bags, geo-tubes, and bamboo bundles to strengthen vulnerable sections of the embankment and prevent erosion. • Embankment design improvements: Widen the embankment base to better withstand river current impacts and ensure slopes are gentle and stable. • Advanced technologies: Employ modern design techniques, potentially including articulated concrete block mattresses for slope protection, to increase durability and stability. • River channel management: Dredge River sedimentation regularly to maintain channel capacity and prevent the river bed from rising, which can be a consequence of confined flow. • Sluice gate construction: Build new or improve existing sluice gates to control water flow and manage drainage, especially at the junction of tributaries. Environmental Mitigation

	• Afforestation and tree planting: Plant trees in wetland areas and along the embankment to stabilize the soil, prevent erosion, and create wildlife habitats. This is considered a "soft engineering" approach with low carbon footprint benefits. • Habitat preservation: Avoid construction in sensitive fish habitats or other valuable ecosystems during the planning phase. • Integrated planning: Adopt a holistic approach to river management that considers the entire river system (upstream and downstream effects) and incorporates nature-based solutions where feasible.
Adaptation Activity-2	2. Provide deeper channels with more stable, flatter side slopes for water conservation and drainage
Environmental Impacts	Positive Environmental Impacts The primary positive impacts are related to the engineering goals of improved water management: • Increased Capacity and Efficiency: Deeper and wider channels can accommodate larger volumes of water flow, which effectively reduces flood risk on adjacent land and improves drainage of waterlogged or salt-affected land for agricultural use. • Reduced Local Erosion (of banks): Flatter side slopes are inherently more stable than steep ones, which helps to prevent bank collapse and slumping, thereby reducing a major source of sediment input into the channel system from the banks themselves. • Improved Navigation: Deeper channels facilitate shipping and navigation, which has economic benefits and can indirectly reduce land-based transport impacts if goods are moved by water instead. • Water Conservation Potential: In some systems, engineered channels can be part of a broader water management strategy, potentially redirecting water for agricultural or industrial use and preventing water seepage if properly lined and managed. Negative Environmental Impacts The negative impacts on the natural environment are typically extensive and long-lasting: • Habitat Destruction and Alteration: The construction process physically removes or alters natural aquatic and riparian (stream-side) habitats, including sensitive ecosystems like wetlands and seagrass areas, leading to a reduction in the size, number, and species diversity of fish and other aquatic life. • Lowering of Groundwater Levels: Deep channels can intercept the local water table, which draws down the water level in adjacent land areas. This can drain nearby wetlands, alter the surrounding terrestrial habitats (e.g., clearing floodplain hardwoods), and reduce the ability of the ground to recharge from stream flow. • Increased Downstream Flooding and Erosion: By moving water more efficiently, channelization increases flow velocities and volumes downstream. If the receiving waterway cannot

	accommodate this extra water, it can lead to exacerbation of flooding, increased erosion, and habitat disturbance further along the watercourse. • Sedimentation and Water Quality Degradation: While local bank erosion might decrease, the overall increased flow can lead to more bed erosion and greater transport of sediment, which negatively impacts water quality. Dredging itself also stirs up sediments and can release trapped contaminants (e.g., heavy metals, pollutants) into the water column, posing risks to aquatic food chains. • Saltwater Intrusion: In estuarine environments, deepening channels can increase tidal range and lead to greater saltwater intrusion further upstream, which fundamentally changes the water chemistry and ecosystem, affecting drinking water supplies and agricultural irrigation. • Disruption of Natural Processes: Channel modifications disrupt natural riverine processes such as meanders and the dynamic equilibrium of sediment movement. The engineered system requires continuous maintenance (e.g., ongoing dredging) to prevent it from returning to a natural, self-cleansing state.
Mitigation Measures	Erosion and Sediment Control • Establish vegetation: The most effective and cheapest protection is establishing a mix of native trees, shrubs, and groundcover along channel banks and slopes. Root systems provide structural integrity to the soil, slow water flow, and filter pollutants. • Divert upland runoff: Install a berm or channel above the slope to divert rainwater runoff around the disturbed area or into a stable ditch to prevent it from causing further erosion. • Install barriers: Place silt fences, brush barriers, or rock berms at the toe and at intervals on long slopes to trap sediment. • Use erosion control products: Erosion control blankets and turf reinforcement mats can provide excellent protection for seedbeds, especially on steep slopes. • Control flow velocity: Ensure flow velocities within the drain are non-erosive (e.g., less than 0.6 m/s in silts and loams) through careful design to prevent channel bed and bank scour. Habitat and Ecological Preservation • Minimize disturbance: Plan the layout of infrastructure to avoid disturbing sensitive areas like deep peat or existing high-quality riparian habitat. • Restore natural features: Reconnect isolated floodplain features (e.g., channels, ponds) and restore natural meanders to provide diverse habitats for fish and wildlife. • Maintain environmental flows: Ensure adequate compensation flows (minimum instream flows) are released downstream of any

	water diversion to sustain aquatic ecosystems and biota during the dry season. • Protect water quality: Use silt traps to prevent runoff pollution from entering watercourses and properly manage drainage water to avoid contaminating groundwater or surface water with salts or toxic elements. • Control livestock access: Fence off drains to prevent livestock from damaging banks and defecating in the water, which reduces erosion and nutrient levels that encourage weed growth. Planning and Management • Conduct environmental impact assessments (EIAs): Identify potential ecological risks and opportunities early in the project planning phase to inform mitigation strategies. • Avoid 'over-design': Design the system with the minimum effective gradient and size necessary to achieve the objective, which avoids excessive earthworks and bank armoring. • Schedule work appropriately: Construct drainage systems during dry months to minimize turbidity and muddying of the waterway downstream. • Monitor effectiveness: Regularly check for erosion and monitor groundwater levels and the success of mitigation measures to allow for adaptive management and remediation if necessary.
Adaptation Activity-3	3. Increase SSWR structures capacity and operational flexibility
Environmental Impacts	Positive Socio-economic and Agricultural Impacts • Improved Food Security and Agricultural • Productivity: Enhanced water availability through better storage and flexible allocation allows for supplemental irrigation, which can substantially increase crop yields and enable farmers to grow higher-value, market-oriented crops. This is particularly vital in regions heavily reliant on rainfed agriculture vulnerable to climate variability. • Economic Growth and Poverty Reduction: Increased agricultural output directly leads to higher farmer incomes, increased savings, and the creation of local employment opportunities in construction, engineering, and agriculture, stimulating the rural economy. • Enhanced Climate Resilience: Greater capacity allows communities to better manage the "climatic paradox" of intense wet seasons (flood mitigation) and pronounced dry seasons (drought mitigation), providing a stable water supply despite variable rainfall patterns exacerbated by climate change. • Improved Public Health and Livelihoods: Reliable access to clean water reduces the incidence of waterborne diseases and cuts down on the time spent collecting water, which disproportionately benefits women and children and allows for more time dedicated to education and economic pursuits.

	• Decentralized and Participatory Management: SSWR schemes often facilitate local, participatory management, empowering communities to take ownership of their water resources, which can lead to more efficient and sustainable use tailored to local needs. Environmental Impacts • Groundwater Management: Well-managed SSWR systems, such as small dams and water harvesting structures, can help recharge local groundwater tables and improve water quality by enhancing infiltration. • Ecosystem Alteration: While generally having fewer negative impacts than large dams, increasing the capacity of SSWR structures can still alter local hydrology and ecosystem functions. Changes to natural water flow can impact downstream water availability and the migration and spawning grounds of local fish species, necessitating careful planning and mitigation measures.
Mitigation Measures	Environmental Mitigation Measures • Integrated Water Resources Management (IWRM): Implement a holistic management approach that considers the entire water catchment area (watershed), balancing social, economic, and environmental needs. • Ecosystem Protection and Restoration: Mitigate negative impacts on aquatic habitats by including measures such as: ○ Renaturation of rivers and wetlands: Restoring natural river flow regimes and floodplains to maintain ecological functions. ○ Maintaining minimum flows: Ensuring sufficient environmental flows (minimum stream flow) even during lean seasons to support aquatic life. ○ Riparian zone management: Planting vegetation on river banks and catchment areas to prevent soil erosion, retain moisture, and filter pollutants. • Water Quality Control: Prevent the degradation of stored water quality and downstream contamination by: ○ Reducing agrochemical runoff: Promoting low input of fertilizers and pesticides in agriculture in catchment areas. ○ Managing internal contamination: Addressing issues like excessive algae growth, which can lead to low oxygen levels in the water. • Sustainable Infrastructure Design: Design and modernize infrastructure with climate and disaster resilience in mind, using nature-based solutions where possible • Efficiency in Water Use: Maximize "crop or dollar per drop of water" by promoting water-saving technologies like drip irrigation and drought-resistant crops to reduce overall water demand. Social and Institutional Mitigation Measures

	• Participatory Management: Involve local actors and communities, especially Water Management Cooperative Associations (WMCAs), in all stages of the project, from planning to operation and maintenance. This ensures solutions are tailored to local needs and promotes sustainable practices. • Equitable Access and Benefit Sharing: Establish clear policies and governance frameworks to ensure equitable water distribution and access among all stakeholders, including vulnerable segments of the community. • Capacity Building: Provide training and support to WMCAs and government institutions to strengthen their ability to operate, manage, and maintain the new or enhanced infrastructure effectively and sustainably. • Addressing Land Tenure Issues: Mobilize expertise to help communities clarify land tenure rights, which can be critical for implementing water improvements and associated land use changes. • Monitoring and Adaptive Management: Implement comprehensive monitoring programmes to check the success of the measures and foster an adaptive management approach that can respond to unforeseen negative impacts or changing conditions. • Public Awareness and Education: Conduct campaigns to educate the public on water conservation and the importance of protecting water bodies.
Adaptation Activity-4	4. Provide modernize pumped irrigation and water distribution systems
Environmental Impacts	Positive Environmental Impacts • Water Conservation: Modern methods like drip and sprinkler irrigation deliver water directly to the root zone, significantly minimizing losses from evaporation and runoff compared to traditional flood irrigation. This reduces the overall pressure on freshwater sources, including rivers and aquifers. • Energy Efficiency & Reduced Emissions: Automated and high-efficiency systems (e.g., those using variable-speed pumps or solar power) consume less energy for pumping and distribution. This leads to a smaller carbon footprint and reduced greenhouse gas emissions. • Improved Soil and Water Quality: Precise water application helps in better control of soil salinity by preventing the buildup of salts on the soil surface. It also minimizes the leaching of excess fertilizers and pesticides into groundwater and downstream water bodies, mitigating non-point source pollution and the associated harm to aquatic ecosystems. • Biodiversity Preservation: By maintaining more natural water flows in rivers and wetlands and reducing agrochemical runoff, modern systems help protect aquatic and terrestrial habitats and the species dependent on them.

	Potential Negative Environmental Impacts • Groundwater Depletion: If not properly managed, increased pumping efficiency can encourage over-extraction of groundwater (water mining), leading to the lowering of the water table, land subsidence, and saltwater intrusion in coastal areas. • Increased Energy Consumption (in some cases): While efficiency often improves, the <i>construction</i> of new, high-tech infrastructure can have a significant upfront carbon footprint. Also, if farmers are encouraged to pump more water due to lower operational costs (e.g., from subsidized energy), overall energy consumption could increase. • Waterlogging and Salinization (if designed improperly): Despite the benefits of modern technology, improper design or inadequate drainage systems can still lead to waterlogging and soil salinization in irrigated areas over time. • Ecosystem Disruption: Large-scale projects, including the construction of dams or major diversion systems, can still alter natural hydrology, disrupt fish migration routes, and damage sensitive downstream wetlands and flood forests if environmental impact assessments are not properly conducted and mitigated.
Mitigation Measures	Technical and Operational Measures • Select High-Efficiency Pumps and Systems: Use pumps with high-efficiency ratings and ensure they are appropriately sized for the system's pressure and flow requirements to minimize energy consumption. • Utilize Pressurized Piped Networks: Replace open canals with closed pipe networks to drastically reduce water losses from seepage and evaporation. • Implement Smart/Precision Irrigation: Integrate sensors (soil moisture, weather), the Internet of Things (IoT), and automation (e.g., SCADA systems) to apply the precise amount of water needed at the right time, preventing over-irrigation or under-irrigation. • Employ Drip and Sprinkler Irrigation: Encourage the adoption of micro-irrigation techniques, which deliver water directly to the plant root zone, significantly enhancing water use efficiency. • Optimize System Design: Use parallel pipe networks where possible to ensure equitable water distribution to all farms and minimize friction losses through proper pipe sizing and layout. • Establish Regular Maintenance: Implement a proactive maintenance schedule including checking for leaks, flushing lateral lines, and inspecting seals and bearings to ensure continued efficiency and prevent system failure. Environmental Measures

	• Mitigate Energy Demand: Address the increased energy demand of pressurized systems by using renewable energy sources, such as solar power, to run the pumps. • Protect Wetlands and Fisheries: Ensure that water abstraction does not negatively impact environmental flows required for healthy ecosystems. This may involve installing fish ladders at dams and carefully managing water levels to protect aquatic habitats. • Minimize Water Contamination: Use modern irrigation to prevent surface runoff that can carry fertilizers and pesticides into local water bodies (eutrophication). Implement good waste management practices during construction and operation to avoid pollution. • Prevent Waterlogging and Salinity: The precise application of water in modern systems helps avoid the shallow water tables that cause waterlogging and soil salinization, but adequate drainage systems should also be planned where needed. Social and Institutional Measures • Promote Farmer Participation: Involve Water User Associations (WUAs) and farmers in the planning, design, operation, and management of the system from the beginning to foster a sense of ownership and ensure the system's long-term success. • Provide Extensive Training and Support: Offer technical assistance and educational programs to train farmers and operators on the new technologies, ensuring they have the skills to manage the modernized systems effectively. • Develop Appropriate Water Service Fees: Establish a fair and accepted system for paying water service fees to cover operation and maintenance costs, moving away from reliance on government subsidies. • Formalize Water Management Plans: Create clear institutional arrangements and regulations, including water rights and allocation plans, to ensure transparent and equitable water distribution, especially during droughts. • Address Land Use and Livelihoods: Consider the potential impacts of modernization on existing livelihoods (e.g., fisheries) and land use patterns (e.g., plot sizes). Ensure that the project takes local conditions and cultures into account to achieve a balanced outcome.
Adaptation Activity-5	5. Improved rural connectivity
Environmental Impacts	Negative Environmental Impacts • Altered Hydrology and Flood Dynamics: Elevated embankment in floodplains can act as barriers to natural surface water flow, changing flow velocity and direction. This can push floodwater to unprotected areas downstream and prevent the natural spread of nutrient-rich alluvium across the floodplain, which affects soil fertility for agriculture. • Habitat Fragmentation and Loss: Embankment construction destroys and fragments natural habitats, which is a major threat to

	biodiversity. This creates barriers to animal movement and migration patterns, which can lead to genetic isolation of populations, increased wildlife mortality from traffic, and a decline in species diversity. • Water and Soil Pollution: ○ Runoff: Stormwater runoff from embankment is a major source of water pollution, carrying pollutants like oil, grease, heavy metals (zinc, copper, lead), and de-icing salts into nearby streams, rivers, and groundwater. ○ Erosion and Sedimentation: Embankment construction exposes soil, leading to increased erosion and heavy sedimentation in nearby aquatic ecosystems. This increases water turbidity, reduces dissolved oxygen, and harms sensitive aquatic flora and fauna. • Air and Noise Pollution: Increased traffic volume due to better connectivity leads to higher emissions of air pollutants (carbon monoxide, nitrogen oxides, particulate matter) and noise. Noise pollution can disrupt wildlife behavior and affect human health. • Facilitation of Human Disturbances: New roads, especially in previously remote or forested areas, provide easier access for human activities that cause further environmental damage, such as illegal logging, poaching, mining, and the introduction of invasive species. Potential Positive Impacts and Mitigation • Reduced Flood Damage & Increased Resilience: Flood-resilient design prevents the costly physical destruction of embankment and infrastructure caused by flood events, ensuring continuous access to markets, jobs, and emergency services. • Opportunity for Sustainable Design: Incorporating "green infrastructure" solutions, such as permeable pavements, rain gardens, and bioretention swales, can help manage surface runoff, improve water quality, and enhance biodiversity, potentially offsetting some negative impacts. • Improved Livelihoods and Economic Stability: Reliable, flood-free access to markets can significantly improve the socio-economic conditions and food security of local communities by ensuring the continuous supply of goods and services.
Mitigation Measures	• Avoid sensitive areas: Embankment alignments should avoid reserved forests, sanctuaries, wetlands, and other sensitive ecological areas. • Implement land restoration: After construction is complete, cleared areas (such as borrow pits and steep slopes) should be restored through measures like tree planting and stabilizing slopes to prevent erosion.

	• Manage water flow: Constructing proper drainage systems (e.g., cross drains, culverts, and storm water cut-off drains) helps prevent waterlogging, flooding, and soil erosion. • Control pollution: Regularly water down cleared areas during construction to reduce dust emissions and manage construction waste appropriately. • Incorporate climate resilience: Design and construct infrastructure with climate adaptation measures, such as construction of embankment at higher elevations in flood-prone areas and using climate-resilient engineering designs, to withstand extreme weather events. • Strengthen local governance and community input: Involve local communities, including women and marginalized groups, in the planning and implementation phases to ensure projects align with local needs and promote transparency and accountability. • Manage land acquisition fairly: Ensure transparent and fair processes for land acquisition, providing financial compensation at full replacement value for any lost land or property. • Adopt a systemic approach: Move from an infrastructure-focused approach to one that builds local capacities, institutions, and policies for sustainable access and maintenance. • Integrate with other sectors: Combine communication initiatives with other sectors like market linkages, disaster risk reduction, and digitalization to multiply the socio-economic impact. • Use new technologies for planning: Utilize advanced tools like GIS-based needs assessments and satellite imagery to identify and prioritize needs efficiently and monitor impact. • Establish dedicated maintenance plans: Develop clear, funded plans for the ongoing maintenance and repair of new infrastructure to ensure long-term sustainability.
Adaptation Activity-6	6. Acquire additional land as needed to accommodate expanded footprint of climate-resilient and adaptive infrastructure
Environmental Impacts	• Biodiversity Loss and Habitat Destruction: Clearing land for infrastructure development leads to the destruction of natural habitats, threatening plant and animal populations. Land-use change is the leading direct cause of biodiversity loss. • Greenhouse Gas Emissions: Deforestation and the conversion of natural landscapes release stored carbon into the atmosphere. Infrastructure construction also involves material extraction and processing, contributing significantly to GHG emissions. • Land and Soil Degradation: Construction activities and the introduction of impervious surfaces (like pavement and concrete) contribute to soil degradation and limit its capacity to filter runoff and support vegetation. • Water System Alteration and Pollution: Land development increases stormwater runoff, which can carry pollutants into water

	bodies and affect water quality. Altering natural landscapes and creating physical barriers can also compromise the ability of the land to absorb and attenuate water flows, potentially increasing flood risks elsewhere. • Heat Island Effect: Replacing natural vegetation with buildings and pavement in urban areas creates "heat islands," raising local temperatures and affecting regional climate patterns. • Competition for Land: Expanding infrastructure may compete with other essential land uses, such as agriculture, potentially leading to food security issues or the intensification of farming practices (e.g., increased fertilizer use) on remaining land, which in turn causes further pollution.
Mitigation Measures	• Nature-Based Solutions (NbS): Integrating green infrastructure, such as wetlands, mangroves, and urban green spaces, can offer a dual benefit: enhancing climate resilience while providing co-benefits for biodiversity and environmental health. • Integrated Planning: Effective strategies require holistic planning that integrates engineering solutions with environmental science and policy to minimize adverse impacts. This includes considering the entire lifecycle of infrastructure and prioritizing the use of sustainable materials and designs. • Policy and Governance: Well-managed land acquisition processes that are transparent and consider the long-term environmental and social impacts, including fair compensation and community involvement, are essential for sustainable development. • Integrated Land-Use Planning: Conduct comprehensive environmental and social impact assessments (ESIAs) to identify potential risks early in the process. Prioritize the use of brownfield sites (previously developed land) over greenfield sites to minimize the impact on natural ecosystems. • Avoid Sensitive Areas: Design the infrastructure to avoid ecologically sensitive areas, high-biodiversity regions, and protected natural habitats, such as wetlands and forests, whenever possible. • Minimize Footprint: Optimize project design to minimize the total land area required for the expanded infrastructure, ensuring efficiency in land use. • Nature-Based Solutions (NbS): Incorporate NbS, such as wetlands, mangroves, and green roofs, into project designs. These solutions can provide dual benefits like flood protection, water filtration, and habitat creation, potentially reducing the need for extensive conventional infrastructure and the associated land acquisition. • Stakeholder Engagement and Consent: Ensure full and effective participation of all relevant stakeholders, especially Indigenous Peoples and local communities (IPs and LCs), throughout the planning and implementation stages. This includes incorporating local knowledge, securing land rights and tenure, and obtaining their

	Free, Prior, and Informed Consent (FPIC) when their land is involved. • Livelihood Restoration and Compensation: Develop fair and transparent compensation programs and alternative livelihood opportunities for displaced populations or those whose land-based incomes are affected. This might include training in new sustainable farming practices or diversifying income sources. • Community Benefit Sharing: Create value chains and other opportunities that directly benefit local communities and countries, such as job creation in ecosystem restoration or sustainable land management activities. • Grievance Mechanisms: Establish clear and accessible grievance redress mechanisms for affected communities to raise concerns and seek resolution. • Biodiversity Offsetting and Restoration: When habitat destruction is unavoidable, compensate by creating or enhancing habitats elsewhere, aiming for an equivalent or greater biodiversity value. This can involve reforestation, wetland restoration, and creating wildlife corridors. • Erosion and Sediment Control: Implement strict measures during the construction phase, such as silt fences and prompt revegetation of disturbed soil, to prevent soil degradation and water pollution. • Sustainable Water Management: Implement rainwater harvesting and greywater recycling systems to reduce strain on local water resources, and manage stormwater runoff effectively to prevent contamination of water bodies. • Waste Management: Develop a comprehensive Materials and Waste Management Strategy to minimize waste generation, promote recycling/reuse of construction materials, and ensure proper disposal of hazardous materials.
Adaptation Activity-7	7. Incorporate climate adaptation in training and capacity building and support to WMCAs
Environmental Impacts	Positive Impacts: Improved Water Resource Management: Training allows WMCAs to effectively manage local water bodies and infrastructure (e.g., canals, small-scale infrastructure), leading to better agricultural production and enhanced aquaculture activities. Environmental Management Integration: Specific training in environmental management and assessment ensures that subprojects (like building or improving infrastructure) are "friendly to the surrounding environment". This helps avoid or minimize negative environmental impacts and manage social safeguards, such as land use. Climate Resilience: Training and capacity building help WMCAs address local climate challenges like salinity intrusion, erratic rainfall, and high tidal surges by implementing specific adaptation measures within water management, ultimately reducing the community's vulnerability to climate impacts.

	Sustainable Practices: The long-term capacity built within these associations ensures the sustainability of infrastructure and management practices, supporting a more resilient local environment. Potential Negative Impacts: Increased Burden/Strain on WMCAs: New training and responsibilities (e.g., data collection, managing new subprojects) might overextend WMCAs' time and resources, particularly for women who already face systemic inequalities and time constraints. Mismatched Interventions/Lack of Relevance: Training might propose adaptation strategies that are not locally relevant or culturally appropriate (e.g., interventions requiring land ownership in areas where women have limited or no land access). Financial Risk/Maladaptation: Promoting new but potentially risky adaptation measures (e.g., new crop varieties or technologies) without adequate financial safety nets could increase the financial vulnerability of low-income women if the measures fail. Knowledge Gaps/Misinformation: Complex scientific information on climate projections may not be easily understood or trusted, leading to knowledge gaps or misinterpretation. Reinforcing Gender Inequality: New initiatives could inadvertently widen existing inequalities if only certain groups (e.g., men or women with specific assets) benefit from the training or if decision-making remains male-dominated. Lack of Long-term Support and Institutional Capacity: Interventions may be short-term or lack sustained institutional support, limiting their long-term effectiveness and impact.
Mitigation Measures	Mitigation measures focus on gender-sensitive, context-specific, and integrated approaches that build on existing strengths and ensure ownership. Integrate with Existing Activities: Mainstream climate content into existing microfinance operations and meeting structures rather than creating entirely separate, additional programs. Ensure the time commitment is realistic and manageable. Ensure Community Ownership & Co design: Involve WMCA members in the design and development of the training content to ensure it addresses their specific, self-identified needs and livelihoods. This also requires understanding the local cultural and political contexts. Provide Flexible Financial Tools and Support: Complement training with access to flexible credit products, savings, insurance mechanisms, and grants to manage climate-related risks and facilitate successful adoption of new methods. Tailored and Practical Education: Provide context-specific and practical information using local knowledge and accessible communication methods. Focus on practical skills like using early warning systems and climate-smart agriculture techniques that directly translate to their daily lives.

	Adopt Gender-Sensitive Approaches: Ensure equitable participation and access to training and resources for all members. Focus on empowering women in decision-making processes regarding climate actions and financial management within their communities. Foster Strong Institutional Links and Long-term Planning: Build strong links between WMCAs, local governments, and financial institutions to ensure sustained support, resource updates, and the institutionalization of climate resilience strategies.
Adaptation Activity-8	8. Support climate-smart agriculture practices and agribusiness development
Environmental Impacts	Positive Environmental Impacts: • Reduced Greenhouse Gases (GHGs): Practices like fertilizer deep placement (FDP) and microdosing cut nitrous oxide (N₂O) emissions, while alternative wetting/drying (AWD) in rice fields lowers methane. • Increased Carbon Sequestration: Soil health improvements, agroforestry, and crop residue retention store more carbon in the soil. • Water Efficiency: Smart irrigation (micro-irrigation, sensors) and drought-resistant crops conserve water. • Biodiversity & Soil Health: Crop diversification, integrated pest management (IPM), and no-till farming improve soil organic matter and reduce chemical pollution. Potential Negative Impacts & Challenges: • Technology Pitfalls: "Smart farming" can sometimes lead to <i>increased</i> fertilizer/pesticide use if not precisely managed, creating pollution. • Vague Definitions: The term "climate-smart" can be loosely applied, making it hard to track real impacts and ensure genuine benefit. • Implementation Hurdles: Costs, lack of access to services, and multi-year benefits for practices like no-till can hinder adoption.
Mitigation Measures	1. Soil Health & Carbon Sequestration: • Conservation Agriculture: No-till/minimum tillage, permanent soil cover (mulch/cover crops), and crop rotation to reduce disturbance, increase organic matter, and retain moisture. • Agroforestry: Integrating trees with crops/livestock for carbon storage, biodiversity, and resilience. • Biochar/Organic Amendments: Adding biochar and organic matter to soil to improve fertility and sequester carbon. 2. Water & Nutrient Management: • Precision Irrigation: Drip irrigation, Alternate Wetting & Drying (AWD) for rice, sensors to optimize water use.

	• Nutrient Smart: Soil health cards, leaf color charts, precision fertilizer application (e.g., briquetted urea) to reduce nitrous oxide emissions. 3. Crop & Livestock Systems: • Resilient Crops: Cultivating drought, heat, or flood-resistant varieties. • Integrated Pest Management (IPM): Eco-friendly pest/weed control. • Livestock Management: Improved fodder and manure management. 4. Technology & Information: • ICT & Weather Advisories: Using mobile tech, sensors, and AI for real-time climate info and tailored advice (e.g., weather-index insurance). 5. Policy & Agribusiness Support: • Shift Subsidies: Reallocate harmful agricultural subsidies (e.g., fossil fuels, input-based) towards CSA investments. Market Access: Develop value chains that reward sustainable practices.
Adaptation Activity-9	9. Support climate smart aquaculture practices and business development

Environmental Impacts	• Enhanced Food Security & Nutrition: CSA increases sustainable fish production, providing high-quality protein and essential nutrients, reducing reliance on wild fish stocks, and improving household diets. • Poverty Reduction & Income Growth: Integrated systems (aquaculture-agriculture) and better market access raise farm profitability, diversify income streams, and lift smallholders out of poverty. • Climate Resilience & Adaptation: Practices like water management, disease control, and early warning systems help farmers withstand climate shocks (droughts, floods). • Environmental Sustainability: CSA reduces greenhouse gas (GHG) emissions, optimizes natural resource use (water, feed), and minimizes pollution. • Economic Development: A thriving, climate-smart sector attracts investment, creates jobs, and supports broader economic growth. • Access to Finance & Markets: Providing credit, better market infrastructure, and links to higher-value markets improves economic viability. • Capacity Building: Training in new techniques (e.g., Recirculating Aquaculture Systems - RAS, Integrated Multi-Trophic Aquaculture - IMTA) and business skills is crucial. • Technology & Innovation: Supporting adoption of efficient technologies (e.g., boreholes, pond covers) and improved feed management. • Policy & Institutional Support: Developing supportive policies, extension services, and farmer cooperatives strengthens the sector. • Gender Equality: Specific focus on women, who are vital in aquaculture but often lack resources, ensures equitable growth and social equity. • Inclusive Growth: Ensuring benefits reach the most vulnerable,
Mitigation Measures	• Integrated Multi-Trophic Aquaculture (IMTA): Co-cultivating species from different trophic levels (e.g., fish, shellfish, seaweed) allows waste products from one species to be used as nutrients for another, which closes nutrient loops, minimizes pollution, and improves water quality. • Recirculating Aquaculture Systems (RAS): These closed-loop systems filter and reuse up to 99% of water, significantly reducing water consumption and controlling waste discharge into surrounding ecosystems. • Sustainable Feed and Nutrition: Developing and using alternative feed sources like plant-based proteins, algae, or insect-based ingredients can reduce the reliance on wild-caught fish meal and fish oil, thus alleviating pressure on wild fish stocks. • Renewable Energy Integration: Incorporating solar, wind, or bioenergy into aquaculture operations reduces the carbon footprint,

	enhances energy self-sufficiency, and improves operational resilience in remote areas. • Habitat Preservation and Restoration: Protecting and restoring natural coastal ecosystems, such as mangroves, can provide natural buffers against storm surges and erosion, directly protecting aquaculture facilities and infrastructure. • Waste Management and Valorization: Implementing effective waste treatment, such as constructed wetlands or biodigestion, transforms solid waste and sludge into valuable by-products like fertilizers, promoting circular economy principles. • Precision Aquaculture: Utilizing smart technologies, sensors, and data analytics can optimize feeding regimes, monitor water quality, and manage resources more efficiently, minimizing environmental impact and waste. • Risk Assessment and Spatial Planning: Utilizing tools like Geographic Information Systems (GIS) for site selection helps identify and avoid environmentally sensitive areas and locate farms in areas less vulnerable to climate-related risks like floods or sea-level rise. • Access to Finance and Insurance: Facilitating access to credit and developing climate-smart insurance products (e.g., for stock mortality due to climate events) can help farmers recover from losses and invest in resilient practices. • Capacity Building and Knowledge Sharing: Providing training and educational programs, especially for smallholder farmers and women, builds practical understanding of climate-smart innovations, best practices, and business management skills. • Cross-Sectoral Collaboration: Fostering partnerships among the aquaculture, agriculture, conservation, and finance sectors helps optimize resource use (e.g., using crop residues for fish feed) and ensure policies are coherent and mutually supportive. • Gender-Responsive Approaches: Designing and implementing programs that ensure women and marginalized groups are fully included in planning and decision-making processes helps promote social equity and inclusive growth. • Certification and Traceability: Adhering to international certification programs (e.g., Aquaculture Stewardship Council or Best Aquaculture Practices) and improving supply chain traceability builds consumer trust and enhances market access for sustainably produced products. • Community Engagement: Involving local communities in the planning and implementation of aquaculture projects ensures social acceptability, respects local customs, and promotes shared ownership and benefits.
Adaptation Activity-10	Pilots (Modern pump pipe pressure irrigation systems, 300 ha pilot, such as drip/sprinkler)

Environmental Impacts	Modern pressure irrigation systems (drip and sprinkler) in a 300-hectare pilot offer significant environmental benefits in water and soil management, but introduce potential negative impacts related to energy consumption and regional water resource dynamics. The overall impact depends heavily on management practices and the local context. Positive Environmental Impacts • Water Conservation: Drip and sprinkler systems significantly improve water use efficiency compared to traditional surface irrigation by minimizing evaporation, runoff, and deep percolation losses. This reduces pressure on freshwater sources. • Improved Soil Quality: These systems help prevent soil erosion and degradation. The precise application of water and fertilizers reduces the risk of salinization (salt buildup) and nutrient leaching, provided the systems are managed correctly to avoid under- or over-irrigation. • Reduced Chemical Pollution: More precise application of fertilizers and pesticides directly to the root zone minimizes the amount of agrochemicals that run off into local water bodies, reducing water pollution and eutrophication. • Enhanced Crop Health & Growth: By maintaining consistent soil moisture, these systems promote healthier, more extensive root systems and canopy cover, which can enhance photosynthesis and potentially increase carbon sequestration in the soil. • Weed and Disease Reduction: Delivering water only to the crop root zone limits the spread of weeds that rely on surface moisture, and minimizes moisture on leaves and stems, reducing the incidence of certain fungal diseases. Negative Environmental Impacts and Risks • Groundwater Depletion: While efficient at the farm level, the water "saved" is often reallocated to irrigate more land or more water-intensive crops (the "irrigation paradox"), which can lead to the over-extraction and depletion of aquifers if not regulated at the basin level. • Increased Energy Consumption & GHG Emissions: Pressure irrigation systems require energy for pumping water, which contributes to increased energy consumption and associated greenhouse gas (GHG) emissions, especially if the power source is fossil fuel-based. • Altered Hydrological Cycle: Large-scale water withdrawal can reduce downstream river flows and alter natural water flow patterns, potentially causing the disappearance of wetlands, coastal erosion, and saltwater intrusion in deltas and estuaries. • Salinity near Root Zones: Drip irrigation can lead to the buildup of salts at the perimeter of the wetted area. This requires careful management and occasional leaching to prevent toxic salt levels that can damage crops.
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	• Infrastructure Production Impact: The production of pipes and components for these systems contributes to the overall carbon footprint and resource use of the project. Key Considerations for a 300 ha Pilot For a 300-hectare pilot project, a comprehensive environmental assessment should be conducted with a focus on: • Water Resource Assessment: Ensuring the water source (river, aquifer) can sustain the withdrawal rate without negative off-site impacts. • Management & Training: The success of modern systems in mitigating negative impacts relies on proper implementation, regular maintenance, and adequate training for farmers to prevent issues like clogging and improper water application. • Energy Source: Utilizing clean or renewable energy sources (e.g., solar-powered pumps) can significantly reduce the project's carbon footprint. • Integrated Planning: Considering the entire river basin or watershed to avoid the "irrigation paradox" and manage water resources sustainably.
Mitigation Measures	To mitigate the environmental impacts of a 300-hectare pilot modern pump pipe pressure irrigation system (drip/sprinkler), a combination of advanced technology, sound design, and active management practices should be implemented. Key measures focus on water, soil, energy, and ecosystem management. Water Resource and Quality Management • Precision Application: Implement smart irrigation systems that use soil moisture sensors, weather data, and real-time monitoring to apply water only when and where necessary. This prevents over-irrigation, minimizes water loss, and reduces downstream impacts. • Water Source Protection: Prevent backflow into the main water source by installing appropriate backflow preventers to avoid contamination. • Wastewater Recycling: Explore water recycling and reuse systems, especially in water-scarce regions, to significantly reduce the demand for fresh water. • Downstream Flow Maintenance: Ensure that sufficient water flows are maintained downstream of any water abstraction points (like dams or wells) to support aquatic ecosystems and other users. • Water Quality Monitoring: Regularly monitor the quality of both the irrigation water source and return flows to address potential issues like nutrient runoff or salinity. Soil Quality and Land Management • Proper Drainage: Design and implement adequate drainage systems to prevent waterlogging and soil salinization, which are

	common issues in irrigated areas. For saline water disposal, designate specific land areas or build separate disposal channels. • Erosion Control: Minimize land clearing during construction and implement measures like cut-off drains and energy dissipation structures to control water flow speed and prevent soil erosion. • Soil Monitoring: Conduct regular soil analysis to monitor changes in salinity, pH, and nutrient levels, allowing for timely management interventions. • Nutrient Management: Use the irrigation system for precise nutrient delivery (fertigation) to ensure fertilizers reach the root zone efficiently, reducing the risk of nutrient leaching into groundwater. Energy Efficiency and Biodiversity • Energy Optimization: Use high-quality, energy-efficient pumps, valves, and fittings to maintain optimal pressure and flow, which reduces overall energy consumption and greenhouse gas emissions. • Renewable Energy: Explore the use of renewable energy sources (e.g., solar power) to operate the pumping units, further reducing the carbon footprint of the project. • Biodiversity Conservation: Minimize site clearance to protect natural habitats and afforest disturbed areas with native species. Designate land for wetlands and river corridors to support local biodiversity. Management and Social Aspects • Training and Capacity Building: Provide comprehensive training for farmers and operators on efficient system management, maintenance, and sustainable practices to maximize benefits and minimize negative effects. • Community Participation: Involve local communities and users in the planning, design, and operation phases of the project to ensure that plans are optimal and local needs and land/water rights are considered. • Maintenance Plan: Implement a rigorous maintenance and monitoring schedule, including regular flushing of drip lines to prevent clogging and use of automated monitoring systems to detect leaks promptly.
Adaptation Activity-10	Pilots Nature based solutions (bioengineering) to pilot use of geogrids and/ or plantations allowing strengthening of embankments and deepening of Khals to reduce vulnerability to flooding and water logging
Environmental Impacts	The combined use of bioengineering (plantations) with geogrids for embankment strengthening and the deepening of Khals (canals/drainage channels) offers significant environmental benefits, though potential negative impacts require careful management.

	Positive Environmental Impacts • Enhanced Biodiversity and Habitat Creation: Plantations on the embankments and within the riparian zones create new habitats for various species, contributing to local biodiversity. Restored or newly created wetlands can become hotspots for flora and fauna. • Improved Water Quality: Vegetation and associated ecosystems can act as natural filters, improving water quality by removing nutrients and pollutants (e.g., nitrogen and phosphorus) from runoff before they enter the main water bodies. • Soil Stabilization and Erosion Control: The root systems of plants provide natural soil reinforcement, which, combined with the mechanical strength of geogrids, effectively prevents soil and bank erosion, siltation, and landslides. This protects aquatic habitats from sediment accumulation. • Climate Change Mitigation: The vegetation sequesters carbon dioxide, contributing to climate change mitigation efforts. • Groundwater Recharge: Green infrastructure solutions can allow for better groundwater recharge compared to impermeable "grey" infrastructure. • Sustainable Infrastructure: Using biodegradable geosynthetics (where applicable) and integrating living plant materials into engineered structures can lead to more durable, resource-efficient, and long-lasting infrastructure, reducing the need for frequent maintenance and material replacement. Potential Negative Environmental Impacts and Considerations • Short-Term Trade-offs: The initial construction and implementation phase might involve short-term trade-offs, such as temporary disruption of local ecosystems or displacement of species. • Impacts of Deepening Khals: The physical process of deepening Khals may cause temporary bed erosion or damage existing vegetation and habitats if not managed correctly. This process could also alter local hydrology. • Material Production Impacts: While the solutions are largely "nature-based," the production and transport of manufactured components like geogrids and concrete for related structures (e.g., kerb stones) incur their own environmental footprints. Choosing materials with lower embodied environmental impact (e.g., natural fiber geotextiles) can mitigate this. • Plant Species Selection: The success and environmental impact depend heavily on selecting appropriate, flood-tolerant, native plant species that can thrive in the local conditions and provide effective stabilization without becoming invasive. • Performance Uncertainty: There are some knowledge gaps regarding the performance of nature-based interventions during <i>extreme</i> storm events compared to traditional grey
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	infrastructure, which might necessitate a combined "hybrid" approach to manage risk perception.
Mitigation Measures	Mitigation measures for the environmental impacts of using geogrids and/or plantations in bioengineering solutions for embankment strengthening and <i>Khals</i> (channels) deepening involve a combination of careful planning, use of appropriate materials, and post-project monitoring to ensure ecosystem integrity is maintained or restored. Mitigation Measures for Embankment Strengthening and Khals Deepening The primary goal is to balance the engineering requirements of flood control with the preservation and enhancement of local biodiversity and ecosystem services. Planning and Design Phase • Comprehensive Site Assessment: Conduct thorough environmental impact assessments (EIAs) before implementation to understand the existing hydrology, soil characteristics, and biodiversity of the area. • Hybrid Approach Integration: Design "hybrid" solutions that integrate traditional "grey" infrastructure (like geogrids) with "green" bioengineering elements (plantations) to minimize the grey footprint while ensuring structural stability. • Species Selection: Use native, soil-binding, and fast-growing plant species that are well-adapted to the local environment (e.g., specific grasses, bamboo, certain tree species). This promotes high root density for enhanced soil shear strength and reduces the need for constant maintenance. • Minimize Channel Alteration: Plan the deepening of <i>khals</i> to follow natural alignments where possible, avoiding unnecessary straightening or widening that can dramatically alter hydrological regimes and destroy habitats. • Establish Buffer Zones: Include adequate buffer zones around the project area to protect adjacent natural habitats and allow for natural regeneration processes. Implementation Phase • Timing of Works: Schedule construction and planting activities during favorable weather conditions (e.g., the wet season) to maximize plant survival rates and minimize soil erosion during the establishment phase. • Minimize Machinery Use in Sensitive Areas: Limit the use of heavy machinery in sensitive riparian and aquatic zones to reduce physical disturbance, soil compaction, and potential water pollution from fuel/oil spills. • Proper Material Use: ○ Geogrids/Geotextiles: Use geotextile materials (e.g., sand-filled geotextile mattresses, bags) that provide environmental benefits, such as enhanced water infiltration and reduced

	sedimentation, as an alternative to hard, impermeable surfaces like concrete. ○ Natural Materials: Prioritize natural and biodegradable materials (e.g., coir logs, brush mattresses, wattle fences) for bioengineering elements, integrating them with geogrids where extra reinforcement is needed. • Soil and Water Management: Implement robust erosion and sediment control measures during construction to prevent siltation of downstream water bodies and maintain water quality. Operation and Maintenance Phase • Monitoring and Adaptive Management: Continuously monitor the performance of the bioengineering solutions, including plant growth, slope stability, and changes in local biodiversity. Be prepared to implement corrective measures if initial interventions fail or are damaged by extreme weather events. • Community Engagement: Engage local communities in the maintenance of the embankments and planted areas. Training local farmers and residents ensures sustainable management and helps them understand the co-benefits (e.g., improved water quality, potential for fodder or other plant resources). • Control of Invasive Species: Monitor planted areas to prevent the introduction and spread of invasive plant species that could displace native vegetation and disrupt the local ecosystem.
Adaptation Activity-10	Pilots Pilots for modern agribusiness and aquaculture to reduce post-harvest crop losses due to exposure to increased temperatures and rainfall
Environmental Impacts	Pilots for modern agribusiness and aquaculture aimed at reducing post-harvest losses due to increased temperatures and rainfall have varied environmental impacts, generally offering significant benefits in resource efficiency and waste reduction but posing potential challenges related to energy consumption and ecosystem changes. Positive Environmental Impacts • Reduced Greenhouse Gas (GHG) Emissions: By preventing food loss, these pilots prevent the waste of labor, land, water, fertilizer, and energy used in production, processing, and transport, thereby avoiding unnecessary GHG emissions from food that would not reach consumers. • Efficient Resource Use: Technologies such as smart irrigation, precision fertilization, and closed-loop hydroponic systems reduce the overall consumption of water, fertilizers, and pesticides, minimizing runoff and the pollution of local water bodies. • Conservation of Land and Biodiversity: Innovations like vertical farming and improved land use efficiency help curb urban sprawl and deforestation, preserving natural ecosystems and biodiversity habitats. • Improved Water Quality: Responsible aquaculture practices, such as integrated farming systems and better wastewater management,

	help minimize the release of excess nutrients and pollutants into surrounding water, which can otherwise lead to harmful algal blooms and hypoxia (depleted oxygen levels). • Enhanced Soil Health: Agribusiness practices promoted by these pilots, such as conservation tillage and cover cropping (facilitated by precision agriculture data), improve soil structure, reduce erosion, and sequester carbon, building climate resilience. Potential Negative Environmental Impacts • Increased Energy Consumption: Technologies involving cold chain systems, controlled environment agriculture (CEA), and artificial intelligence require significant energy inputs, potentially leading to higher carbon emissions if not powered by renewable sources. • Introduction of Non-Native Species/Pathogens: In aquaculture, the mixing of farmed fish with wild populations during floods or equipment failures can lead to the transmission of diseases and parasites or the introduction of non-native species, impacting wild stock sustainability. • Waste Management Challenges: While technologies reduce food waste, the disposal of certain technological components, processing byproducts, and the potential increase in plastic packaging for enhanced shelf-life require effective waste management protocols. • Pressure on Wild Resources: In aquaculture, a reliance on fishmeal and fish oil for feed puts pressure on wild capture fisheries, which can be exacerbated by climate change impacts on wild fish stocks.
Mitigation Measures	Mitigation measures for the environmental impacts of modern agribusiness and aquaculture, aimed at reducing post-harvest losses due to increased temperatures and rainfall, focus on climate-smart technologies, improved infrastructure, and sustainable management practices. Agribusiness (Crop Losses) To mitigate environmental impacts while addressing crop losses from temperature and rainfall, the following measures are crucial: • Improved Post-Harvest Infrastructure: ○ Climate-controlled storage: Utilizing modern facilities with advanced temperature and humidity control to extend shelf life and prevent spoilage. ○ Renewable energy for storage: Integrating solar-powered cold storage or solar drying systems to reduce reliance on fossil fuels and lower the carbon footprint of preservation. ○ Enhanced drying techniques: Using raised drying racks for cleaner, faster drying of grains and other crops, which prevents contamination and mold growth often associated with damp weather. • Sustainable Practices and Technologies:

	○ Optimal harvesting time: Training farmers to harvest crops at the optimal maturity stage to maximize quality and shelf life, which minimizes loss from premature or overripe produce. ○ Efficient packaging: Using enhanced, often biodegradable or recyclable, packaging materials that provide proper ventilation and protection against physical damage and moisture fluctuations during transport. ○ Integrated Pest Management (IPM): Implementing a combination of biological, cultural, and chemical methods to control pests in an environmentally sustainable way, reducing reliance on harmful pesticides that can poison water and soil. ○ Water management: Employing efficient irrigation techniques like drip irrigation and practicing rainwater harvesting to use water resources efficiently and avoid contamination. ● Logistics and Policy: ○ Improved transportation: Investing in better road infrastructure and using appropriate, well-maintained transport (e.g., refrigerated trucks for perishables) to ensure timely delivery to market and reduce physical damage. ○ Policy support: Advocating for policies that provide financial incentives, such as tax exemptions on low-cost, innovative post-harvest technologies, to encourage widespread adoption among smallholder farmers. Aquaculture (Stock Losses) To mitigate environmental impacts in aquaculture while addressing losses from increased temperatures and extreme weather events, key measures include: ● Climate-Resilient Systems and Planning: ○ Integrated Multi-Trophic Aquaculture (IMTA): Co-cultivating species from different trophic levels (e.g., finfish, seaweed, shellfish) to recycle waste products, enhance water quality, and diversify production, thus improving system stability and reducing environmental impact. ○ Recirculating Aquaculture Systems (RAS): Utilizing closed-loop systems that filter and reuse water, which significantly decreases freshwater consumption and improves waste management and biosecurity. ○ Spatial planning and hazard mapping: Developing farm locations that account for climate-related risks like sea-level rise and extreme weather events to protect infrastructure and stock. ● Biological and Operational Adjustments: ○ Genetic improvement: Investing in selective breeding programs to develop fish and shellfish strains with enhanced tolerance to higher temperatures, variable salinity, and disease resistance.
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	○ Sustainable feed and nutrition: Improving feed conversion ratios through high-quality, highly digestible ingredients, and exploring alternative protein sources (like insect-based feeds) to minimize waste output and the carbon footprint of feed production. ○ Ecosystem-based management: Preserving and restoring coastal ecosystems like mangroves, which can buffer storm surges, stabilize shorelines, and protect aquaculture facilities from physical damage. ● Technological Integration: ○ Renewable energy integration: Incorporating solar, wind, or wave energy systems to power operations like aeration, pumping, and cold storage, reducing energy costs and emissions. ○ Monitoring technologies: Using sensors and data analytics to monitor water temperature, dissolved oxygen levels, and pathogen dynamics, enabling timely interventions and preventing stock losses.
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7 MITIGATION MEASURES OF THE ENVIRONMENTAL IMPACT

Mitigation measures for the environmental impact of the CDRSSWRMP in Bangladesh focus on sustainable infrastructure, community-led environmental management, and ecological protection. Key strategies include enhancing flood/drainage systems, promoting nature-based solutions like mangroves, and establishing Water Management Cooperative Associations (WMCAs) to ensure sustainable operations and reduce ecological degradation.

Key Environmental Impact Mitigation Measures:

- **Structural & Nature-Based Solutions:** Implementation of climate-resilient water management infrastructure, including embankments, sluice gates, and re-excavation of drainage canals to prevent waterlogging and reduce flood risks.
- **Mangrove Protection:** Utilization of mangrove plantations and other nature-based solutions to create protective barriers against coastal erosion and cyclones.
- **WMCA Institutional Support:** Establishing and strengthening Water Management Cooperative Associations (WMCAs) to manage, operate, and maintain infrastructure, which includes integrating environmental management into their O&M (Operation & Maintenance) planning.
- **Sustainable Water Management:** Developing water retention capacities in *haors*, *beels*, and *khaals* to improve irrigation water availability while maintaining ecological balance.
- **Environmental Monitoring:** Regular monitoring and reporting on environmental impacts at subproject locations to ensure compliance with sustainability standards.

- **Climate-Adapted Design:** Ensuring all infrastructure, such as the Bakkhali rubber dam modernization, is resilient to climate change, including floods and droughts.

These measures aim to boost agricultural productivity while minimizing the adverse environmental impacts of infrastructure development.

7.1 Best Possible Solution to the Problem of Environmental Pollution

The best solution for environmental pollution within the CDRSSWRMP (Climate and Disaster Resilient Small-Scale Water Resources Management Project) in Bangladesh is an integrated approach combining infrastructure resilience, participatory management by Water Management Cooperative Associations (WMCAs), and sustainable agricultural practices. This includes building climate-resilient water infrastructure, improving drainage, and promoting eco-friendly farming to mitigate pollution and adapt to climate change.

Key Components of the Solution:

- **Empowering Local Communities:** Strengthening WMCAs and community-based management is central to ensuring sustainable and localized solutions, allowing them to manage resources effectively and reduce local pollution sources.
- **Resilient Infrastructure:** Upgrading flood control, drainage, and irrigation systems to be climate-resilient, such as raising infrastructure or constructing durable, eco-friendly, and, where possible, floating, structures to handle waterlogging and flooding.
- **Sustainable Agriculture Practices:** Shifting to climate-smart agriculture, including the use of salt-tolerant crop varieties and agroforestry to protect soil quality and reduce the need for chemical inputs.
- **Water Quality Management:** Utilizing wastewater treatment and strengthening water resource management to combat pollution in water sources.
- **Waste Management:** Implementing strict waste management systems, including proper disposal and reducing plastic use to tackle pollution at the local level.
- **Policy and Monitoring:** Integrating environmental data and improving monitoring, as outlined in national initiatives like the Delta Plan-2100.

This approach, as outlined in IFAD's 2025 supervision report for the project, ensures that the project's infrastructure improvements are both effective in the long-term and environmentally sustainable.

7.2 Description of Each Recommended Mitigation Measures

The CDRSSWRMP implements four primary mitigation measures to enhance community resilience: **flood management** through infrastructure **drainage improvement and water conservation** in haors/Beels, and **command area development** for irrigation. These actions aim to reduce climate-related risks, improve agricultural productivity, and strengthen infrastructure, supported by the formation of Water Management Cooperative Associations (WMCAs).

Here is a description of each recommended mitigation measure based on the project documents:

- **Flood Management (Embankments/Sluice Gates):** This involves the rehabilitation and construction of flood embankments, sluice gates, and regulators. The goal is to reduce the depth and duration of farmland flooding, protecting agricultural production from excessive, unplanned inundation.

- **Drainage Improvement (Canal Re-excavation):** This measure focuses on re-excavating existing drainage canals to increase the capacity of drainage systems. It mitigates waterlogging, ensuring excess water drains away faster to benefit agriculture and cultured fisheries.
- **Water Conservation (Haor/Beel Development):** This involves enhancing the water retention capacity of existing haors, Beels (wetlands), and Khals (canals). By improving these natural water bodies, the project increases the availability of water for irrigation, particularly during the dry season.
- **Command Area Development (Irrigation Infrastructure):** This entails improving existing irrigation systems by providing better distribution systems (e.g., pipe networks, lined channels). This increases the efficiency and productivity of irrigation water, allowing more farmland to be cultivated sustainably.

Supporting Measures:

- **WMCA Strengthening:** The establishment and capacity building of Water Management Cooperative Associations (WMCAs) are crucial to manage, operate, and maintain these infrastructures sustainably.
- **Rural Connectivity Upgrading:** Upgrading on-farm and village roads (approximately 110 km) to be more climate-resilient.
- **Environmental/Sustainable Practices:** Promoting climate-resilient agriculture, such as using salt-tolerant varieties or improved aquaculture practices.

7.3 Nature Based Solution (Nbs)

Nature-based Solutions (NbS) in Bangladesh's Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) focus on integrating ecosystem restoration with infrastructure to build resilience. Key approaches include restoring coastal mangroves and wetlands, promoting sustainable agriculture, using bio-engineering for slope stabilization, and adopting community-led watershed management to manage water resources sustainably.

Key Nature-Based Solutions within the context of Bangladesh's water management:

- **Coastal & Wetland Ecosystem Restoration:** Mangroves are used as natural barriers against storm surges and sea-level rise. Restoring Haor ecosystems in the Northeast enhances biodiversity and water availability.
- **Bio-engineering for Infrastructure:** Using Vetiver grass, geotextiles, and other nature-based methods to stabilize riverbanks, embankments, and slope protection.
- **Sustainable Water Management:** Implementing retention ponds, re-excavation of canals, and wetland restoration to manage floodwaters and improve groundwater recharge.
- **Climate-Smart Agriculture:** Shifting to salt-tolerant crop varieties and agroforestry to protect soil quality and provide alternative livelihoods for communities in flood-prone areas.

These NbS, often combined with "grey" infrastructure, reduce disaster risk (Eco-DRR) and provide sustainable, cost-effective alternatives for rural community resilience.

7.4 Tree Plantation under CDRSSWRMP

The CDRSSWRMP in Bangladesh, initiated for 2021–2026 with ADB/IFAD funding, integrates tree plantation with infrastructure development to combat climate change, enhance environmental stability, and support livelihoods. It promotes nature-based solutions to strengthen, protect, and enhance the resilience of water-related infrastructure and coastal areas.

Key Aspects of Tree Plantation in CDRSSWRMP:

- **Objective:** The primary goal is to foster climate resilience by planting trees to protect coastlines and riverbanks from erosion, tidal surges, and saline intrusion.
- **Nature-Based Solutions:** The project focuses on utilizing nature-based solutions, such as planting trees to protect the slope of embankments and other infrastructure, alongside building hard, grey infrastructure.
- **Target Areas:** The interventions cover 42 districts, focusing on flood-prone and disaster-prone areas to reduce vulnerability.
- **Environmental & Livelihood Impact:** Beyond ecological protection, these initiatives aim to improve the livelihoods of rural households, including women, by supporting income-generating activities.
- **Species Selection:** Similar, parallel initiatives in Bangladesh promote planting a mix of timber, fruit, and medicinal trees suited to the local environment, such as Neem, Mahogany, and various fruit-bearing trees, to provide both ecological and economic benefits.

These efforts are part of a broader national push for massive-scale tree plantation to protect the country from climate change impacts.

Planting trees on riverbanks is a vital method for controlling erosion, improving water quality, and boosting biodiversity. Tree roots stabilize soil, while leaves and canopy help filter runoff, reduce pollutants, and slow floodwaters. This practice creates natural habitats, connects ecosystems, and enhances the overall health and resilience of the river environment.

Benefits of riverbank tree plantation

- **Soil stabilization:** Tree roots bind soil together, preventing erosion caused by water flow.
- **Improved water quality:** Trees act as a natural filter, catching pollutants, sediment, and excess nutrients from runoff before they enter the river.
- **Flood management:** By slowing the flow of surface water, trees and their root systems help manage flood risk.
- **Biodiversity support:** Riparian (riverbank) woodlands create habitats and food sources for various wildlife, including birds, bats, and fish.
- **Climate resilience:** Tree canopies provide shade, which helps cool water temperatures, making the river environment more resilient to climate change.
- **Increased amenity value:** Planting trees makes riverbanks more aesthetically pleasing and provides areas for recreation.

Key considerations

- **Native species:** It is best to use native trees and shrubs that are appropriate for the local area to ensure the project supports the local ecosystem.
- **Livestock exclusion:** Fencing off areas to prevent livestock from accessing the riverbank is crucial to allow trees to establish and to act as a natural buffer.
- **Careful planning:** Projects should be carefully planned, sometimes involving actions like relocating fish before work begins to minimize ecological impact.

7.5 Estimated Cost of All Proposed Mitigation Measures

The estimated cost for the CDRSSWRMP is **Taka 2,235.80 crore** (approximately USD 225 million). This project aims to implement comprehensive mitigation and adaptation measures to enhance climate resilience in water resources management, scheduled for completion by 31 December 2029.

Project Funding Breakdown

- **Total Project Cost:** Tk 2,235.80 crore (~USD 225 million).
- **Project Assistance (Loans/Grants):** Tk 16.1583 billion (ADB, IFAD, Netherlands).
- **Government Contribution:** Tk 4.2692 billion.

Proposed Mitigation and Resilience Measures

The project includes the following key measures for climate and disaster risk reduction:

- **Infrastructure Development:** Construction of climate-resilient small-scale water resources infrastructure, including rehabilitation and modernization of the Bakkhali Rubber Dam in Cox's Bazar.
- **Flood/Drought Management:** Improvement of drainage systems for 81,965 hectares and reduction of flooding risks for 87,000 hectares.
- **Rural Connectivity:** Construction of 110 kilometers of farm access roads with climate-resilient features.
- **Capacity Building:** Establishment of 150 new Water Management Cooperative Associations (WMCAs) and enhancement of 400 existing WMCAs for sustainable operation and maintenance.
- **Technology & Data:** Integration of digital transformation tools, such as operational dashboards with early warning systems for climate-induced events.

8 MONITORING PROGRAMME

8.1 Monitoring the Implementation of Mitigation Measures

Monitoring the implementation of mitigation measures under Bangladesh's CDRSSWRMP is primarily conducted by the Local Government Engineering Department (LGED) through its Integrated Water Resources Management Unit (IWRMU). The project targets increased climate-resilient agricultural productivity and sustainable infrastructure for 335,000 households across 220,000 hectares.

Key aspects of the monitoring framework include:

- **Implementation Oversight:** The Asian Development Bank and IFAD provide financing and oversight, with monitoring focused on compliance with social safeguards, resettlement frameworks, and environmental mitigation.
- **Performance Metrics:** Success is monitored through targets for increased crop yields, higher cropping intensities, and increased farm incomes.
- **Mitigation Measures:** Specific measures being monitored include the construction of climate-resilient small-scale water infrastructure, improved drainage, and water management systems to combat climate risks.
- **Reporting:** Semi-annual monitoring reports are produced to ensure adherence to loan covenants and to track the progress of subprojects.
- **Participatory Approach:** Monitoring involves ensuring that Water Management Cooperative Associations (WMCAs) are strengthened to sustainably manage the infrastructure, in line with participatory water management rules.

The project aims to reduce vulnerability in rural areas by focusing on 42 districts to combat risks like flooding and drought.

8.2 Environmental Impact Monitoring of Project

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh monitors environmental impacts by enforcing ADB's Safeguard Policies during the development of sustainable water management infrastructure. It focuses on enhancing climate resilience, improving drainage, managing flood/drought risks, and promoting sustainable agriculture across 220,000 ha to benefit 380,000 households.

Key aspects of the monitoring include:

- **Environmental Monitoring & Supervision:** Field monitoring checks if contractors and Water Management Cooperative Associations (WMCAs) are implementing environmental management measures specified in the contract.
- **Key Focus Areas:** Monitoring addresses climate impacts, water quality, degradation of natural resources, and, in some cases, the modernization of infrastructure like the Bakkhali rubber dam.
- **Institutional Framework:** The project strengthens the Local Government Engineering Department's (LGED) Integrated Water Resources Management Unit (IWRMU) to manage environmental safeguards.
- **Objectives:** To mitigate risks from increased salinity, improve drainage, and promote resilient, sustainable farming practices, reducing disaster-induced vulnerability.

The project, supported by IFAD, ADB, and the Netherlands government, focuses on participatory, stakeholder-driven water management, ensuring environmental sustainability.

9 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The Environmental Management Plan (EMP) outlines a structured approach to identifying, managing, and monitoring the environmental impacts associated with all phases of the

CDRSSWRMP—including pre-construction, construction, operation, and maintenance. It documents

- (i) the anticipated environmental impacts during each subproject phase;
- (ii) the corresponding mitigation and enhancement measures required to address these impacts; and
- (iii) the roles and responsibilities of implementing and monitoring entities.

The EMP was developed through a comprehensive assessment of baseline environmental conditions, extensive field visits, stakeholder consultations through PRA, and analysis of site-specific risks. Key considerations included the subprojects' proximity to agricultural land and settlements, the potential disturbance to aquatic habitats, safety of labor and surrounding communities, and the potential for conflicts around land use or material storage. The EMP integrates mitigation strategies such as proper siting of labor camps and stockpiles, water quality protection, labor and community health and safety protocols, grievance redress mechanisms, and inclusion of local stakeholders in monitoring activities. It ensures that the subproject proceeds in compliance with national environmental regulations and IFAD and ADB safeguard standards while implementation will help minimize negative impacts, enhance subproject benefits, and build long-term resilience among the beneficiaries. Phases of management process for the subproject's lifecycle:

Monitoring of EMP Implementation During Construction: During the construction phase (mainly during the dry period from November to May), monitoring of EMP implementation will be integrated into the workplans of PISC construction supervisors, environmental experts, and social safeguards personnel. Supervisors will frequently be on site, supported by technical experts through training, problem solving, oversight, and quality control. Social safeguard measures such as local hiring, gender inclusion, grievance redress, and stakeholder communication will be jointly monitored to ensure community wellbeing. A detailed account is described in the following sections.

First Operational Year Environmental Management and Monitoring: In the first year after construction completion, the Subproject and WMCAs will work closely to establish operational procedures and finalize the operation-phase EMP. This includes environmental monitoring and social accountability mechanisms, gender mainstreaming strategies, stakeholder feedback collection, and grievance redress implementation.

Post-Handover Operation Phase Environmental Monitoring: After the first operational year, the subproject infrastructure and responsibilities for its operation and maintenance including EMP implementation will be handed over to the WMCA. WMCAs will take over ongoing monitoring and implementation of environmental measures and social risk mitigation, supported by periodic LGED reviews.

Semi-Annual Environmental Monitoring Reports (EMRs): During implementation, the PMU, with assistance from the PISC, will prepare the Environmental Monitoring Report (EMR) every six months. Reports will include updates on environmental safeguard compliance, grievance redress activities, and community engagement. Each EMR will be submitted to IFAD and ADB for disclosure on their website and made available by LGED on its own platform.

9.1 Environmental Management of Different Subprojects

9.1.1 Before Construction

Essential preparatory activities will be undertaken to minimize environmental risks before construction begins. A labor shed and material storage area will be set up near the existing WMCA office to avoid extra land disturbance. Temporary signage and routing plans will manage worker and material movement, minimizing community disruption. Site preparation will follow strict health and safety protocols, with measures to prevent fuel or chemical leaks and unauthorized access. Environmental impacts will be minimal, limited to dust and minor runoff, which will be controlled using water spraying, silt fences, and bunds. All actions will follow site-specific protocols and be defined in contractor agreements, ensuring a responsible start to construction.

9.1.2 During Construction

The monitoring of environmental mitigation measures during construction will be carried out by PISC environmental experts in coordination with site supervisors. Dust suppression, noise control, waste management, and habitat protection strategies will be closely tracked through regular site visits and checklists.

Air Quality Impacts: Excavation, transport of materials, and machinery use are expected to generate dust and exhaust emissions. These impacts, while localized and short-term, will be mitigated by regular watering of dusty areas, covering of material during transport, and maintenance of equipment to reduce emissions.

Noise Pollution: Elevated noise levels from equipment and vehicle operation may affect nearby communities, particularly vulnerable populations. To address this, construction activities will be restricted to daylight hours and equipment fitted with proper mufflers.

Solid Waste Generation: Construction activities and worker camps will generate solid waste, including construction debris and domestic refuse. The contractor will be required to implement strict waste segregation, containment, and disposal protocols.

Vegetation and Habitat Loss: Limited excavation along the banks of Khals and river may result in vegetation clearance. Only essential areas will be cleared, and compensatory tree planting will be conducted.

Sustained Irrigation and Salinity Control: The dams' seasonal operation—annual inflation in November/December and deflation in April—will retain freshwater and prevent saline intrusion, supporting agriculture and maintaining ecological balance.

Water Quality: Water quality monitoring will be conducted at surface water sites and groundwater locations near the subproject area. Monitoring will occur quarterly, focusing on pH, dissolved oxygen, salinity, arsenic, nutrients, and pesticides. Sampling will be carried out by a contracted firm or NGO and analyzed in government approved laboratories. Water Quality Monitoring Plan (**Appendix-17**) will be followed to ensure compliance.

9.1.3 During Operation and Maintenance

Water Quality Management: There is a risk of water contamination from agricultural runoff, community waste, or accidental spills near canals and the reservoir. To mitigate this, regular water quality monitoring will be conducted, especially near the dam and along the main canal systems. Community awareness campaigns will discourage dumping of waste into water

bodies, and maintenance crews will be trained to prevent oil or chemical spills during routine operations.

Biodiversity and Ecosystem Conservation: Changes in water flow and sedimentation patterns can impact aquatic ecosystems, particularly fish populations and riparian vegetation. To minimize ecological disruption, the subprojects should maintain a minimum environmental flow and ensure that the fish pass remains operational and accessible, especially during migratory seasons. Monitoring of aquatic biodiversity will help detect any significant ecological changes.

Air and Noise Pollution: Operation of irrigation pumps and occasional use of machinery can generate localized air pollution and noise. These impacts are expected to be minor, but they will be mitigated by ensuring all equipment is regularly maintained and operated efficiently. Noise-generating activities, such as pump maintenance, will be restricted to daytime hours to avoid disturbing nearby residents.

Waste Management: During operation, waste may accumulate from routine maintenance activities or public use around the dam area and other subproject sites. Solid waste management will include placement of designated waste bins and routine collection and disposal. Liquid waste such as used oil or lubricants will be collected and disposed of in accordance with environmental standards to prevent contamination of soil and water.

Soil Erosion and Siltation: Uncontrolled surface runoff and canal seepage could lead to soil erosion or sediment buildup. This will be addressed by maintaining vegetation cover along embankments, applying erosion control techniques where necessary, and conducting regular inspections and dredging of canals to prevent siltation.

Occupational Health and Safety: Workers involved in dam operation and canal maintenance are exposed to potential hazards. To manage this, workers will receive ongoing training in health and safety practices, and personal protective equipment (PPE) will be provided and enforced. Emergency preparedness plans will be developed and periodically reviewed.

9.2 Summary of Environmental Management Plan with Mitigation Measures

The **Table 34** below sets out the environmental commitments that are to be fulfilled in the pre-construction phase, by the Contractor - supported by LGED and the project implementation support consultant (PISC) - during the construction phase, and in the operations phase. The table includes 3 columns (Topic/Potential Impact, Mitigation, Management and Enhancement Measure and Responsibility).

Table 34: Impact, Mitigation and Enhancement Measures During Project Phases

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
Pre-Construction / Design Phase		
Permits and approvals	Ensure Site Clearance Certificate (SCC) and Environmental Clearance Certificate (ECC) is applied for and in place.	PMU supported by the Consultant
EMP for Bidding Document	- Prepare subproject wise EMPs that reflect final detailed design and integrate any further environmental measures identified in the detailed design phase. - Include EMPs in Bidding Documents (BD).	PMU supported by the Consultant
Grievance Redress Mechanism	- Contractor to nominate key contact point(s) for grievances and complaints. - Contract to develop complaints register and complaints form.	Contractor

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
	• PMU to provide contractor with GRM contact details for signboards and contact cards. • Erect sign boards with project details and GRM procedures/ contact details at the entrance to each construction site/camp. • Contractor to raise awareness of all workers on how to respond when an affected person or member of the public has a complaint i.e. direct the person to the most senior site manager present at the time and provide contact card.	
Occupational Health and Safety	• Establish Incident Reporting (fatal accidents, medical treatment cases; first aid cases; restricted work injuries; near misses; environmental events) • Conduct work site/ construction site risk assessment to identify particularly risky work areas such as excavation and trench work, use of construction machinery, working in the drainage system and canals that receives wastewater, work in a noisy and dusty environment, working with electrical equipment, and identify appropriate procedures. • Develop corresponding Construction Health & Safety Plan	Contractor
Construction Phase		
Topography and Drainage	• Timing construction activities in the dry season to minimize disruption and changes of drainage pattern. • Start construction from the downstream to the upstream. • Affected areas will unless the level change is part of the improvement to the drainage systems, be restored to their original levels to prevent permanent impact to topography and drainage. Levelling and grading will unless the change is specified in the design to improve the drainage system, be undertaken with minimal disturbance to the existing contour and thereby maintaining the general slope of site. • Applying standard mitigation measures to ensure drainage capacity at construction site is maintained including bypass dewatering to pump flow around the worksite by using dewatering pumps upstream of the work section and temporary piping to the downstream.	Contractor
Soil Quality	• Timing construction activities in the dry season to minimize erosion and wash out. • Only strip topsoil when required. • Avoid stripping of topsoil, excavation and access road construction to be carried out in dry season to minimize erosion and run-off. • Store topsoil appropriately for reapplication. • Store fuel and any hazardous materials appropriately to minimize risk of spills. • Refuel on non-permeable surfaces and have spill containment material at the ready to minimize risk of pollution. • Avoid storage of waste materials on agricultural land. • During dewatering of construction site, discharge to the downstream of the drainage system and avoid discharge to adjacent agricultural land. • Limit duration of storage of waste material at construction sites to reduce impact to soil at temporary storage site.	Contractor

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
Surface Water and Groundwater	• Timing construction activities in the dry season to minimize wash out. • Store fuel and any hazardous materials appropriately to minimize risk of spills. • Refuel on non-permeable surface and have spill containment material at the ready to minimize risk of pollution. • Waste disposal in the rivers or other water bodies should be prohibited. • For the subprojects constructing in the water, use of silt screens hanging from floats in the water column will contain stirred up sediment and prevent it from traveling downstream. • Sand stockpiles stored on construction sites should be completely covered with tarpaulins when not in use to avoid material eroding during a rain event causing siltation of the drainage system.	Contractor
Land Use and Land Cover	• Restrict construction activities to take place only on allotted land. • Negotiate and agree any temporary use of land outside construction area with current users. • Only strip topsoil when required. • Store topsoil appropriately for reapplication. • Avoid storage of waste materials on agricultural land. • Restore land used temporarily during construction to previous or better state. • Landscaping, as included in a number of subprojects, to reestablish and improve land cover following construction.	Contractor
Air Quality	• Provide water spray vehicles to regularly water the unpaved ground, storage piles and other areas where airborne dust may originate. • Vehicles carrying dry construction material to be covered with tarpaulins or other suitable cover. Open load carrying dry construction material / potentially dust producing materials shall have properly fitting side and tailboards. • Clean and maintain access roads. • Plan sites to keep stockpiling of soils and sand, plant and machinery away from the densely populated residential areas and sensitive receptors. • Use temporary barriers to control dust around the construction sites near residential areas. • Minimize time that excavations and exposed soil are left open/exposed, backfill asap, and transport excavated soil as soon as possible to the sites for reuse or disposal. • Use new/properly maintained machinery and vehicles to reduce air emissions. • Use grid electricity as power source and to the extent possible restrict use of diesel generators to emergencies and power back-up. • No burning of debris, construction waste, vegetation or other materials should be allowed at the sites.	Contractor
Noise	• Construction activity near residential areas should be scheduled in daytime only, and noisy equipment should be prohibited from night operation. • Where possible, site noisy activities away from residences and sensitive receptors.	Contractor

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
	• Provide advance warning to the community on timing of noisy activities. • All powered mechanical equipment used in the works should be effectively sound reduced. Select equipment with consideration of having lowest noise levels and ensure equipment are regularly maintained to keep such levels during its operation. • Ensure mobile/temporary noise barriers, acoustic screens, enclosures are available for construction sites and excavations in populated areas. • The use of ear plugs, or ear muffs should be ensured for the construction workers, supervisors & engineers.	
Solid Waste	• Where existing road surface is removed it should not be dumped or landfilled but be prepared and re-used where appropriate. • Demolished concrete can be crushed and reused e.g. as aggregate for blinding of concrete structure, in base layer, or as gravel substitute. • Should focus on the generated non-metallic waste and need to ensure their appropriate reuse and recycling options. Construction and demolition waste to be stored separately and periodically collected. • Hazardous wastes to be properly labelled and stored at location with impermeable surface, cover, and secondary containment. Recycling options for waste oils to be explored locally. • Provide waste bins at sites away from water bodies, properly covered and protected from wind, rain, storms. • Processing of water hyacinth at local composting plants to be explored with operators including capacity and quality requirements of plant. • Reuse options for sediments to be explored along with need for further quality analyses to confirm quality. • Avoid temporary storage of waste on agricultural land. • Transport hazardous wastes, which cannot be recycled, to a designated disposal site approved by DOE. • Vehicles transporting solid waste should be covered with tarps or nets to prevent spilling waste along the route. • Train and instruct all personnel in waste disposal practices and procedures as a component of the environmental induction process. • Prohibit burning and dumping of solid waste by workers and at construction sites.	Contractor
Biodiversity	• Avoid clearance of mature trees and continuous shrubs to the extent possible; safeguard trees in close proximity to construction work. • Prohibit waste disposal in the rivers or other water bodies. • For the subprojects constructing in the water, use silt screens hanging from floats in the water column to contain stirred up sediment and prevent it from traveling downstream. • Time construction activities in the dry season to minimize erosion and wash out.	Contractor
Infrastructure and Services	• Carry out a thorough site investigation to ascertain the exact locations of the existing utility system within and around their project	Contractor

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
	site and mark their locations and plot the information on the drawings. • Submit plan and drawings for the relocation of the utilities and obtain permission from the agency concerned, employ suitable equipment and qualified personnel for utility relocation, make provision of water, electricity, or other utilities as necessary for the affected people in case of planned or accidental disruption. • Contractor to work together with the utilities and relevant agencies/departments to ensure that any expected disruption to public assets will be communicated prior to construction and alternative supply/provision is available in case of planned or accidental disruption. • Construction of alternative temporary crossing and access should be ensured prior to the demolition of old bridges. • Construction activities such as demolition of existing drains and construction of the new ones should be completed within the dry season to minimize flooding.	
Community Health and Safety	• Source expertise (local companies) and labour locally, wherever possible without comprising experience and training to minimize the impact of an influx of new people into the local community. Source services and supplies locally to generate turnover and benefits for local businesses and communities. • Ensure adequate living conditions with suitable services (water supply, sanitation, and power supplies) at housing for labour coming from outside. • Contractor to prepare and execute the health education plan for construction workers and document and report health education activities to prevent and control spread of communicable diseases.	Contractor
Occupational Health and Safety	General OHS measures: • Qualified Contractor Health and Safety Manager have to be engaged for the construction period. • Qualified Contractor Health and Safety responsible to be appointed from experienced staff for each site and at all times. • Selected or volunteer workers to be trained in first aid and first aiders to be available at each site and at all times. • All workers (including of subcontractors) to receive induction and refresher training in health and safety policies, use of PPE, and relevant procedures. Training to be documented. • First aid box and personal protective equipment (PPE) such as ear plugs, helmets, hand gloves, safety shoes, goggles, masks, etc. have to be provided to the workers while working at construction site. • In case of major accident, ambulance has to be made available to take the affected workers to the nearest hospital. • Daily toolbox meetings (including safety briefings) to be held at start of shift among construction teams on construction sites. • Construction sites to be fenced off with appropriate signage and lighting for nighttime visibility. • Proper health and safety signboards and appropriate information to the local people about the construction activities has to be provided.	Contractor

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
	- Workers operating the equipment and drivers driving the construction vehicles at construction site must be skilled and experienced. - Quality food and safe drinking water that meets the national standards have to be provided to the workers. - Separate accommodation and sanitary toilet facilities for male and female workers have to be available at labour camp. - Incidents/accidents to be recorded and investigated to identify corrective actions. - Regular health and safety audit to be conducted and results and follow-up measures documented. Specific OHS measures: - Demolition: Personal Protective Equipment (PPE) must be worn; Monitor noise, vibration and dust; Regular housekeeping; Manage traffic movement; Manage waste disposal. - Work with heavy machinery: Operators and drivers must be skilled and experienced; Stay out of the line-of-fire; Use effective communication signals; Identify and mark a danger zone; Identify entrances and exits of equipment zones; Perform routine maintenance. - Concrete pouring: Hazard communication; Respiratory protection; Ear protection; Skin protection. - All excavations in public places shall be suitably fenced off with suitable barricades established and appropriate signage; Excavated area should be supported by timbering and props with guard rails (omitted from left hand side for clarity) to prevent falls; Safe access should be provided by a tied ladder; Prevent vehicles from overrunning into the excavation by using properly secured stop-blocks;	
Operations Phase – Enhancement Measures		
Infrastructure and services Land use and land cover Drainage and surface water resources Landscape, visual and aesthetic impact	- Establish appropriate O&M organization for new facilities - Employ appropriately qualified O&M staff, notably for the pumping station. - Increase capacity of O&M organization at LGED to manage clogged drains. - Conduct regular monitoring (crack, damage, bank erosion, or other problem identification) and maintenance (when & where required) of the facilities. - Maintain and clean gross pollutant and silt trap at the upstream of Khals and at outlet to Khal. - Maintain the Khal reserve and consider extension for maintenance track/public access and to prevent encroachment. - Approach and discharge channel should maintain regularly to ensure discharge capacity. - Remove water hyacinth and dumped waste regularly from the Khals and ponds and at the sluice gates. - Remove septic tank connections to Khals and ponds. - Conduct regular monitoring and raise awareness to prevent waste dumping into the ponds and their surroundings.	LGED
Community health and safety	Khals should be cleaned on a regular basis to prevent stagnant water, mosquito breeding, and odor nuisance.	LGED

Topic/Potential Impact	Mitigation, Management and Enhancement Measure	Responsibility
	• Ponds should be cleaned on a regular basis to prevent mosquito breeding, odor and nuisance, and to maintain their storage capacity.	
Cultural resources	• The appointed authority for the O&M of the embankment to engage with the Mosque and Crematorium.	LGED

10 GRIEVANCE REDRESS MECHANISMS (GRM)

10.1 Objectives of the GRM

The GRM will be accessible to all internal, external, regional and international stakeholders, including affected people, community members, civil society, media, vulnerable people and other interested parties. External stakeholders can use the GRM to submit complaints, feedback, queries, suggestions, or even compliments related to the overall management and implementation of the CDRSSWRMP. The GRM is intended to address issues and complaints in an efficient, timely, and cost-effective manner.

The overall objectives of the GRM are:

- To create a mechanism through which affected people can communicate their dissatisfaction or grievances;
- To create a mechanism through which the project will be able to pick-up all the complaints;
- To create a mechanism through which the project will systematically, promptly and exhaustively respond to peoples' complaints;
- To create avenues through which affected people and the program can come together in order to solve problems and handle issues arising.
- To provide a transparent process for timely identification and resolution of issues affecting the project and people, including issues related to the environmental impact, resettlement and compensation program.
- To strengthen accountability to beneficiaries, including project affected people.
- To compensation payment,
- To failure to fulfill commitments,
- To poor management of construction activities,
- To accidents due to inappropriate planning of sub-project implementation
- To cultural conflicts between migrant workers and local communities,
- To disturbance due to excessive noise or other nuisance during construction or operation to unfair treatment of workers or unsafe working conditions.
- To gender Based Violence and gender issues
- To complain on labor influx
- To complain or comment from different public, private and international stakeholders
- To complain, comments or suggestions from various stakeholders, labors, contractor.

Given the low impact of the program, it is not very probable that people will become negatively impacted by the program. Any negative impact, however, needs to be mitigated promptly in

order to avoid unnecessary tensions and conflicts. The strategy to be adopted will promote involvement of the lowest level authorities since they are easily accessible to the people. The strategy will also include a combination of the legal requirements and socially/customarily acceptable practices. Handling of grievances will be the joint responsibility of PMU or its authorized representative and the LGED.

The objectives of the grievance resolution mechanism will be:

- Grievances which are not specific to the program like land disputes. For this kind of grievances mechanisms are already in place. (Grievance Redress System)
- Complaints and grievances directly related to program implementation which can directly be addressed by the program management. (Complaints handling)

A designated person in the PMU should be assigned as the grievance manager. All grievances need to be recorded properly. If problems cannot be solved at the project level the grievance manager must ensure that appropriate follow-up takes place and is also documented.

Websites and printed material produced to enhance the program's visibility should also present the grievance mechanism and contact details (phone number, address, responsible person).

In order to keep track of stakeholder involvement, questions related to this topic should be part of the annual E&S reporting of the program and each related project. In order to obtain a clear and realistic picture it is recommended to follow a participatory monitoring approach

10.2 Existing Grievance Redress Mechanisms of LGED

Based on information from LGED, the existing grievance and complaints handling at LGED are described as follows:

There is a complaint box under the office of the Executive Engineer. Complaints can only be submitted via the complaint box and not via other means. A log of complaints received are kept at the office of the Executive Engineer. There is no publicly advertised procedures of the complaints mechanism and there is no appeal process. LGED provides mediation in cases where the XEN deploys the concerned department or the appropriate person to investigate the complaint. In such cases LGED act as a mediator.

10.3 Public GRM During Construction

LGED will establish a Grievance Redress Mechanism (GRM) supported by PMU and PIU for the construction phase to address complaints and grievances and to ensure these are handled in a systematic way.

During the construction phase, all communication on grievances from the public will be channeled through PMU and PIU. LGED should ensure that sufficient staff resources are available to manage the GRM. It is suggested that a dedicated team is appointed to ensure that problems and complaints arising during the construction period as well as concerns or complaints over services are handled by the same team. Complaints in construction may for example be related to noise, dust, local flooding due to construction, traffic, access issues, and working conditions for contractor workers. Grievances may also relate to resettlement issues arising in the pre-construction or during construction, including assets missed during the resettlement survey, valuation of the affected assets, delay in compensation payment, etc.

The grievance mechanism is described in the **Figure 21** below. All grievances should be registered along with status of investigation into the issue and status of resolution, as applicable. The timeframes are important as they provide the complainant assurance of the complaints handling process and procedure and offers the general public transparency and accountability. The ability of the GRM to keep timeframes will be a key element in evaluation of the implementation of the GRM. LGED will appoint sufficient staff resources to ensure timeframes can be kept.

For each case a record sheet shall be filled in either by the complainant or by the PMU and PIU that receives the complaint. It should be possible to lodge grievances by phone, email, post, or through the LGED website. In addition, it may be considered to use an app, where people can lodge their complaints in order to make these more easily processable and directly link with location data. LGED should review the below suggested public grievance form before implementation.

10.4 Public GRM During Operation

It is suggested to strengthen LGED's public grievance and complaint mechanism in operation by making the existing complaints handling similar to the GRM described above. During operation grievances will typically relate to the quality of the services and can be an opportunity for LGED to collect information about maintenance needs.

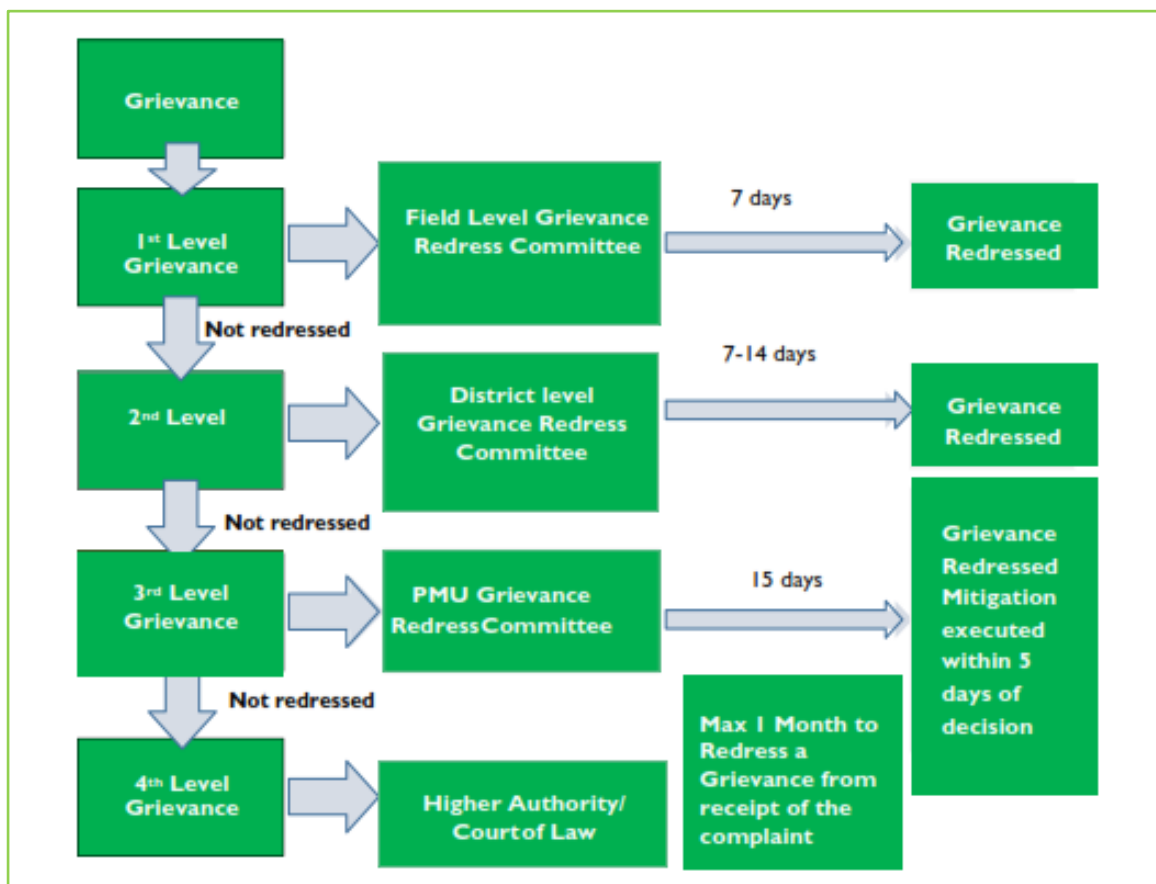


Figure 21: Grievance Redress Mechanism Process

10.5 GRM Contact Information of LGED

Information on the project and future stakeholder engagement programs will be available on the LGED's website and will be posted on information boards at LGED and at the construction sites. Information can be obtained from LGED's office.

10.6 GRM at PMU Level

If decisions made at the subproject level are deemed unacceptable by the complainants or aggrieved persons, the cases will be referred to the PMU. The GRC at this level will review the complaints and hearing details and decide the Project Director. If the decision at the PMU level remains unsatisfactory to the complainant, the case will be escalated to the Local Government Division (LGD) of the relevant ministry for further review and a final decision. Any decision accepted by an aggrieved person at any stage of the grievance process will be binding on LGED. It is important to note that the GRM does not override an individual's right to seek legal recourse in a court of law.

A PMU-level GRC has been adopted in the subproject and duly concurred by the IFAD/ADB. The committee will play a pivotal role in addressing and resolving grievances raised by affected persons. If any grievance remains unresolved at the subproject level, the case will be sent to the PMU level GRC where the Project Director will lead the committee and resolve the case. Among others, the committee includes the Social Officer (Member Secretary), the Environmental Officer of PMU CDRSSWRMPP as a member, and the Executive Engineer of PMU as a member (**Table 35**).

Table 35: Formation of Grievance Redress Committee at PMU Level

S.N.	Designated Officer	Designation
1	Project Director	Convener
2	Executive Engineer in Charge of Work/Contract Package	Member
3	Social Officer of CDRSSWRMPP, PMU	Member Secretary
4	Environmental Officer of CDRSSWRMPP of PMU	Member
5	Social Safeguard Specialist of CDRSSWRMPP	Member

10.7 GRM at PIU Level

The PIU-level GRM will address grievances related to:

- 1) **Project-Affected Persons (PAPs)** – Those impacted by land acquisition and displacement from private or public lands.
- 2) **Workers' Issues** – Concerns of workers employed by construction contractors.
- 3) **Gender-Based Violence (GBV)** – Incidents occurring at construction sites.

The CDRSSWRMPP of LGED will establish multiple Grievance Redress Committees (GRCs) under the subproject-level GRM at locations that are easily accessible to affected individuals

and workers. These GRCs will handle complaints regarding any irregularities in the application of provisions outlined in the Social, Environmental and Climate Assessment Procedures (SECAP) and other project-related concerns. The GRCs at the PIU levels will have the following memberships (**Table 36**).

Table 36 : Formation of GRC at PIU Level

S.N.	Designated Officer	Designation
1	Executive Engineer in charge of the Work/Contract Package	Convener (Non-voter)
2	An Elected Member of LGED (or Union Parishad/Upazila Parishad) / Nominated Officials by the LGED	Voting Member
3	An Elected Female Member of LGED (or Union Parishad/Upazila Parishad)/ Nominated Officials by the LGED	Voting Member
4	A female teacher at a local High School/College	Voting Member
5	A Representative of the affected persons	Voting Member
6	A Representative of any CSO working in the area	Voting Member
7	Social/Environmental Specialist of CDRSSWRMPP Consultant	Member Secretary & non-voter

Complaints Procedures with GRM

The subproject will establish a grievance redress mechanism (GRM) to address complaints and concerns related to the application of social and environmental safeguard guidelines, in line with both ADB and IFAD requirements. This mechanism aims to provide a quick, consensus-based resolution process to avoid costly and time-consuming legal action, while preserving the right of individuals to seek legal recourse if desired. Any complaints involving sexual harassment or sexual exploitation and abuse (SEA) will be referred to IFAD's Ethics Office for appropriate action.

To ensure effective resolution of complaints and community concerns, the Project will utilize the existing LGED Upazila and District Grievance Redress Committees (as illustrated in **Table 37**). These established bodies provide a structured, transparent, and accessible process for grievance submission, resolution, and appeal. Their use simplifies community engagement and streamlines grievance handling.

A Deputy Project Director (DPD) within the Project Management Unit (PMU) will serve as the designated GRM Focal Point, with overall responsibility for coordinating the functioning and oversight of the grievance process. The GRM focal point's key responsibilities include:

- Ensuring the dissemination of GRM information to WMCAs and all relevant stakeholders through LGED field staff, PISC consultants, and project NGO facilitators.
- Collecting and consolidating grievance records from District GRC member-secretaries.
- Publishing grievance data and resolutions within the PMU office and making them publicly accessible via the LGED website.
- Preparing biannual summaries of grievance cases for inclusion in the environmental and social safeguard monitoring reports submitted to IFAD and ADB.

- Authorizing and initiating the resolution process for grievances handled at Upazila and District levels.
- Approving GRC decisions and facilitating the implementation of project-funded remedial actions, including compensation when necessary.
- Monitoring GRC performance and periodically assessing the overall effectiveness of the GRM in addressing and preventing grievances.

Each Upazila and District GRC will maintain comprehensive records of grievance submissions and case resolutions. Each grievance log will include the complainant's contact information, date of submission, nature of the complaint, agreed corrective actions, implementation dates, and the final outcome.

Upazila GRC member-secretaries (LGED Upazila Engineers) will submit regular reports to their respective District GRC member-secretaries (LGED District Engineers), who will compile and forward the information to the PMU GRM focal point for recordkeeping and reporting.

Grievance Handling Process

- **Submission:** Grievances may be submitted by any individual or Water Management Cooperative Association (WMCA) directly to the Upazila GRC.
- **Initial Resolution:** Upon receiving a complaint, the Upazila GRC will hold an open hearing within 15 days. For cases involving small ethnic communities (SEC), indigenous peoples (IP), or vulnerable groups, a representative from the affected community must be present during the hearing.
- **Escalation:** If the grievance remains unresolved, it may be escalated to the District GRC, which must resolve the matter within 21 days of receipt.
- **Legal Recourse:** If no resolution is achieved at the district level, the complainant retains the right to seek legal redress through the formal court system.

This multi-tiered GRM structure ensures inclusive, transparent, and timely resolution of grievances, reinforcing accountability and promoting trust between the subproject and affected communities throughout the subproject lifecycle.

Table 37: Upazila and District Grievance Redress Committees

SL.	Organization	Title in Organization	Title in GRC
Upazila GRC*			
1	Upazila LGED Office	Upazila Engineer	Chair
2	Union Parishad	Chairman/Representative	Member
3	Construction Contractor	Representative of the Contractor of the respective SP	Member
4	Water Management Cooperative Association	Chair(s) of the respective SP	Member
5	Representative(s) of the Aps-one male and one female		Member
6	NGO	Representative of the Resettlement NGO	Member-Secretary
District GRC			
1	District LGED Office	Executive Engineer	Chair
2	Union Parishad	Chairman/Representative	Member
3	Construction Contractor	Representative of the Contractor of the respective SP	Member
4	Water Management Cooperative Association	Chair(s) of the respective SP	Member

SL.	Organization	Title in Organization	Title in GRC
5	Community(ies)	Representative(s) of the APs (SEC/IP Community(ies) and/or Vulnerable Group(s)) – one male and one female	Member
6	NGO	Representative of the Resettlement NGO	Member-Secretary
*Upazila GRC membership may vary at the call of the chair, depending on local circumstances and the grievance(s) under consideration. Source: ADB (2021) Indigenous Peoples Planning Framework, BAN: Climate and Disaster Resilient Small-Scale Water Resources Management Project			

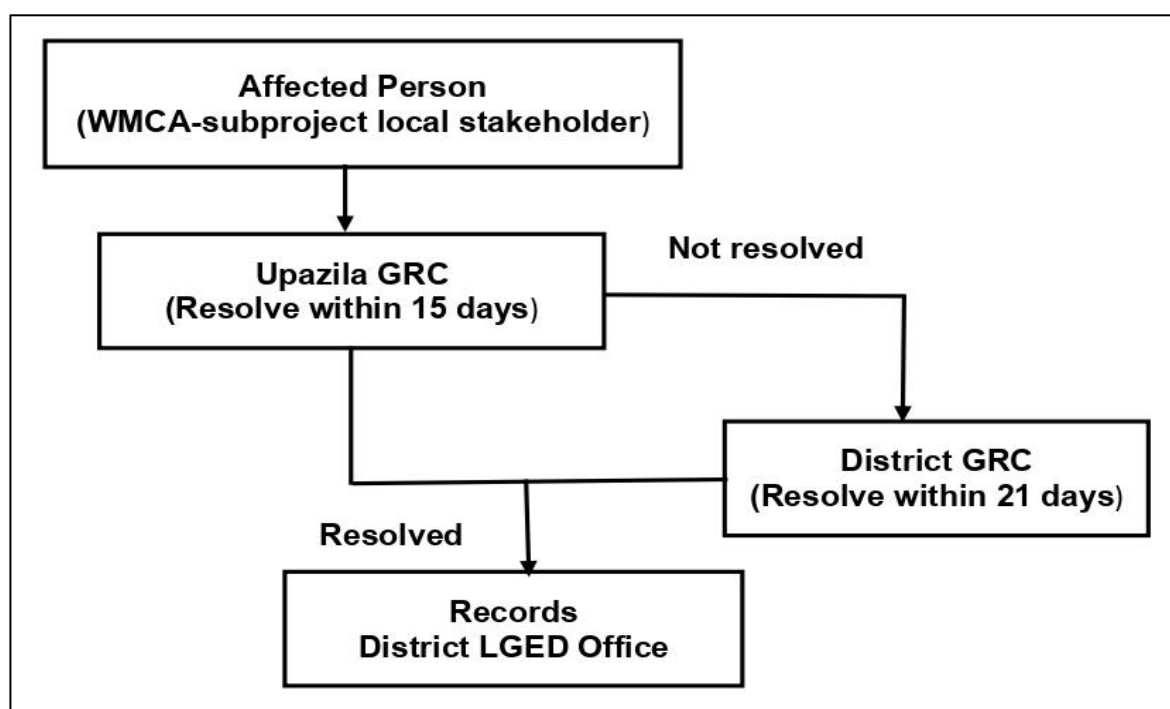


Figure 22: GRM Process Flow Diagram

11 PUBLIC CONSULTATION /STAKEHOLDER CONSULTATION

11.1 Scope of the Public Consultation

The Public consultation process included both qualitative and quantitative method. The qualitative method included focus group discussion (FGD) with subproject area people, stake holders and members of local government institutions and key informants' interview (KII) with relevant persons who are in decision making and information giving situation. Quantitative method includes baseline survey in the earmarked subproject area.

11.2 Objectives of Public Consultation

The public consultation as a means of integration of local people's concerns is considered very important by the government and the donor agencies. The Department of Environment also recognizes the importance of social and environmental factors for successful implementation of

the proposed project. So, the safeguard team undertook comprehensive process of public consultation. Feedback from the consultation process is expected to play important role in the development of the social and environmental programs.

The broader objective of public consultation is to inform local inhabitants/stakeholders to make them aware of the project and to gather their opinion/suggestions about the proposed project, development and processing plan as well as to incorporate their suggestions during project planning and implementation stage.

The specific objectives of public consultation are to:

- Create awareness of stakeholders (local people) and provide them general information of the project as a part of the project awareness campaign
- Learn about problem faced by community living in subproject area
- Facilitate the local community (people) to participate in the project planning
- Learn from the community (people) and share with them their perception of the CDRSSWRM project
- Know people's suggestions from the local community (people) for solution of problems/ constraints of the project
- Assess project impacts both positive and negative in nature as envisaged by the community
- Collect additional information and ideas of the project from the local community
- Explore local community's ideas on mitigation/minimization of negative impacts, if any

11.3 Methodology of Public Consultation

The public consultation includes focus group discussion with local people and professionals including businessman, transport workers etc. Focus group discussion was carried out by facilitators and consultants with the help of set of check list designed to obtain information from the participants. In discussion initially, all presents were introduced and all presents were informed of activities that have been going on under CDRSSWRMP.

11.4 Focus Group Discussions

Focus Group Discussions (FGDs) for the Environmental Impact Assessment (EIA) under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh are essential for identifying local environmental impacts and ensuring community participation. These sessions, often targeting vulnerable groups, farmers, and women, are used to assess potential impacts of water resource infrastructure, such as changes in water flow, land use, and ecosystem services. FGDs ensure compliance with national environmental regulations and international safeguard policies (e.g., Asian Development Bank).

11.4.1 Key Focus Areas for FGDs in CDRSSWRMP

- Water Management Impacts: Discussing changes in water availability, drainage, and irrigation needs.
- Climate Resilience: Assessing local knowledge on flood or drought risk management.

- **Environmental Concerns:** Identifying potential negative impacts on natural resources, such as fisheries or water quality, due to construction.
- **Social Safeguards:** Understanding community concerns regarding involuntary resettlement or loss of livelihood.
- **Mitigation Measures:** Gathering suggestions for practical and sustainable solutions to environmental issues.

Stakeholders Involved:

- Local community members (farmers, women, marginalized groups).
- Local Government Engineering Department (LGED) representatives.
- Environmental specialists or researchers.

Procedure:

- **Structure:** Small, focused groups with a moderator following a structured questionnaire to ensure consistent data collection.
- **Timing:** Conducted during the project planning phase to inform the EIA.
- **Result:** The feedback is used to update the environmental management plan to mitigate negative effects.

11.4.2 Khal re-excavation FGD

Focus Group Discussions (FGDs) for Khal (canal) re-excavation under the "Climate and Disaster Resilient Small-Scale Water Resources Management Project" (CDRSSWRMP) in Bangladesh focus on participatory planning, assessing waterlogging, and ensuring irrigation access. These sessions involve local farmers, community members, and Water Management Cooperative Associations (WMCAs) to identify sedimentation issues and plan rehabilitation.

11.4.3 Key Aspects of FGDs for CDRSSWRMP Khal Re-excavation

- **Objective:** To identify specific, locally-relevant, small-scale water resources management needs that address climate change-induced risks like flooding or drought, ensuring that rehabilitation is sustainable and participatory.
- **Targeted Participants:** Local farmers, community stakeholders, marginalized groups, and members of existing WMCAs.
- **Key Discussion Points:**
 - **Drainage and Irrigation:** Identifying blockages in Khals causing waterlogging or lack of water for irrigation, such as fish farm obstructions.
 - **Impact Assessment:** Understanding how re-excavation will increase crop production and improve livelihoods.
 - **Infrastructural Needs:** Discussing the need for accompanying structures like regulators, sluice gates, or check dams to manage water flow.
 - **Environmental and Social Safeguards:** Addressing potential impacts of the construction and ensuring equitable benefits for all, including vulnerable groups.

- **Project Context:** The CDRSSWRMP, often supported by Asian Development Bank (ADB) and implemented by the Local Government Engineering Department (LGED) or Bangladesh Water Development Board (BWDB), prioritizes climate resilience in water management.

These discussions are essential for gathering local knowledge, validating project designs, and ensuring community ownership of the restored water bodies.

11.4.4 Embankment heightening FGD

Focus Group Discussions (FGDs) regarding embankment height under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, implemented by the Local Government Engineering Department (LGED), are essential to ensuring community participation, addressing local knowledge gaps, and ensuring the sustainability of flood control infrastructure.

Based on typical project methodologies, here is a structured approach to conducting an FGD for embankment height under this initiative:

1. Key Objectives of the FGD

- **Determine Optimal Height:** To gather local historical knowledge on flood levels, surge heights, and drainage congestion to determine the necessary embankment height.
- **Assess Vulnerability:** Identify points where existing embankments are too low, breached, or damaged.
- **Address Land Ownership:** Discuss potential impacts of raising height on land acquisition and livelihoods (e.g., land loss for widening).
- **Enhance Local Ownership:** Build consensus on maintenance and protection of the structure.

2. Suggested FGD Participants (Target Group)

To ensure inclusivity and accurate data, the FGD should include:

- Smallholder farmers and landowners adjacent to the embankment.
- Women-headed households and vulnerable community members (who often face greater risks during breaches).
- Union Parishad (local government) representatives.
- Fishermen (impacted by water flow regulation).
- Local community leaders and elderly individuals with knowledge of historical flood levels.

3. Key Discussion Topics and Questions

- **Historical Flood Levels:** "What was the highest flood level in the last 10–20 years?"
- **Existing Embankment Performance:** "Did the current embankment protect your homes/crops during the last surge/flood?"
- **Proposed Height Adequacy:** "Do you believe the proposed height/design (e.g., 15 feet minimum) is enough to protect against future climate change (sea level rise/heavy rain)?"

- Drainage and Water Logging: "Does raising the embankment block internal drainage, causing waterlogging?"
- Access and Mobility: "Will the increased height affect access roads? Can the top be used as a road/path?"
- Maintenance: "Who will be responsible for maintaining the slope and repairing cracks?"

4. Technical Considerations Raised in FGDs

- Structural Integrity: The need for widening the base (e.g., 100 feet base) to support increased height.
- Slope Protection: Using geo-bags, bamboo bundles, or planting trees for erosion control.
- Sluice Gates: Ensuring functional gates for managing internal drainage to prevent waterlogging.

5. Expected Outcomes

- Validated height requirements based on local, on-ground reality.
- Community-agreed action plans for maintenance.
- Identification of vulnerable spots requiring special protection methods.

This participatory approach under CDRSSWRMP helps transition from simply building, to maintaining sustainable, climate-resilient water infrastructure.

11.4.5 FGD for WMCA formation

Focus Group Discussions (FGDs) for Water Management Cooperative Association (WMCA) formation under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) are critical participatory tools designed to ensure that the project's infrastructure and management plans are inclusive, effective, and sustainable.

The project, implemented by the Local Government Engineering Department (LGED), aims to establish 150 new inclusive WMCAs and strengthen 230 existing ones.

Purpose of FGDs in WMCA Formation

- Ensuring Inclusion: Identifying and involving all stakeholders, particularly women, youth, small ethnic communities, and functionally landless households.
- Assessing Needs: Understanding local water management issues and infrastructure needs (e.g., for flooding or drought).
- Institutional Capacity Building: Assessing the capacity for management and preparing members to take ownership of the infrastructure.
- Cooperative Formation: Facilitating the registration process and building trust among stakeholders.

Key Themes for FGDs

Based on the project's focus on climate resilience and community management, FGDs generally cover:

1. **Water Management Challenges:** Identifying historical flood/drought impacts, agricultural constraints, and current water usage patterns.
2. **Existing Local Organizations:** Assessing previous experiences with water cooperatives or other user groups.
3. **Inclusivity & Participation:** Determining how to involve vulnerable groups, functionally landless people, and women in decision-making and management committees.
4. **Ownership and Management Structure:** Discussing the roles, responsibilities, and benefits of joining a registered WMCA.
5. **Performance Enhancement (PE) Needs:** For existing subprojects, discussing necessary repairs or new infrastructure needs to improve resilience.

Target Participants

- Smallholder farmers.
- Functionally landless households (benefiting from fishery/agribusiness).
- Women and youth representatives.
- Local community leaders.

The CDRSSWRMP, aimed at boosting agricultural productivity across 42 districts, relies on these discussions to ensure the infrastructure developed is robust against climate change and managed directly by the community.

11.5 Public Consultation Findings

11.5.1 Location of Public Consultations

Focus group discussions at several locations were conducted to make the study more participatory and evincing opinions of the people for those the project is meant. The locations of holding FGDs are given in **Appendix-1**.

Public consultations were organized and conducted at 42 districts, throughout the subproject locations are shown in the **Appendix-4**. The environmental safeguard team conducted a series of discussions with local level people, inhabitants and people of different professions within the subproject area.

11.5.2 Tools and Techniques used for Consultation

In conducting the public consultation meetings, a checklist was used by the consultants to enable the participants to comprehend the issues easily, so that they could participate in the discussions more effectively and expressed their opinions and views objectively. The Participants were shown the sketch map where different activities are proposed to be done. This participatory approach was well accepted by all participants. During consultations, social, environmental as well as cross-cutting issues were discussed in detail, including potential impacts of the project activities on environmental and social parameters, identification of sensitive issues, risks, potential threats, public concerns and expectations from the project. The list of participants with their occupation was prepared and their signature obtained.

The checklist used for consultation includes the following issues:

- Importance of subproject implementation

- Probable measures which might alleviate the problems
- Problems will be faced by the subproject area community
- Importance of protection measures against social impacts
- Importance of protection measures against natural calamities
- Importance of protection measures against environmental impacts

11.5.3 Consultation with Community and Stakeholders

In line with the requirements of public consultation, the identified stakeholders of the subproject area, were consulted through participation and discussion for their views/ perceptions, needs, problems and suggestions.

11.5.4 Opinions of Community About Problems

The subproject area is beset with various problems. Erosion of the inland rivers, Khals and embankment are nagging problems. Water demands are being formed in another area but the subproject site requires significant time to be productive and productive agricultural fields, developed agricultural area and infrastructure are lost to erosion. The discussion with the subproject area people revealed that the problems of water are different from the other area though they have some common problems.

In addition to the local problems the participants discussed both positive and negative aspects of the interventions under CDRSSWRMP, the overall opinion of the stakeholders expressed during consultation was positive towards start-up of proposed infrastructure construction.

11.5.5 Summary of Public Consultation and Disclosure

Since this subproject is considered under the Climate and Disaster Resilient Small Scaler Water Resources Management Project (CDRSSWRMP), consultations were carried out during the site visiting process starting in December 2025.

The stakeholders such as affected people, beneficiaries and other direct and indirect users of the subproject including women were consulted to obtain data and their concerns related to the proposed subproject. The discussions can be summaries as follow:

- A compelling issue that was raised by the pond users was the need for the pond to be de-silted rehabilitation work.
- The issue was discussed in length and this was agreed as an important issue.
- It was claimed that the field canals here had not been excavated for a good number of years
- Agreement was that further consultations will be carried out during design of the proposed activities.

Besides these consultations, additional consultations will be carried out during implementation. This will involve:

- Focus group discussion with the pond community
- Public will be briefed about the project, purpose and design and outcomes via a documented community consultation session
- The community consultation session will be organized immediately after the contractor is mobilized.

- The contractor will take note of all impacts, especially safety hazards that will be of concern to the residents and take necessary measures as stipulated in the EMP to mitigate them.
- The contractor will maintain a log of any grievances/complaints and actions taken to resolve them.
- A copy of the EMP will be available always at the project supervision office on site.

11.5.6 Key Informant Interview (KII)

The Climate and Disaster Resilient Small Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh involves Key Informant Interviews (KII) as part of its assessment to increase climate-resilient agricultural productivity (**Appendix-5**). The project, co-financed by IFAD, ADB, and the Government of the Netherlands, aims to benefit 335,000 farming households and 45,000 landless/vulnerable households across 220,000 hectares.

Key Aspects of KIIs for CDRSSWRMP:

- **Purpose:** To assess existing infrastructure, identify challenges (e.g., riverbank erosion, salinity, waterlogging), and opportunities for improving water and sanitation systems.
- **Targeted Respondents:** Key Informants often include LGED Executive Engineers, Water Supervisors, Upazila Fisheries Officers, Agriculture Officers, and community leaders.
- **Focus Areas:**
 - **Agricultural Impact:** Changes in farming, rainfall, and temperature.
 - **Infrastructure:** Assessing existing water resources, pumps, regulators, Khals.
 - **Resilience Strategies:** Community coping mechanisms against climate shocks.
- **Implementation Partner:** Field assessments for such project are conducted by PISC in collaboration with government agencies like the Local Government Engineering Department (LGED), Department of Agriculture Extension and Department of Fisheries.

These interviews are conducted to gather localized data to ensure the project's interventions are sustainable and, in line with international standards.

Table 38: FGD and PCM Done with GPS Coordinates& No. of participants

SL.	Districts	Upazila	Subproject	GPS Coordinates		Number of participants		
				Longitude (E)	Latitude (N)	Male	Female	Total
1	Barguna	Taltali	Nalbunia	90°02'59.37" E	21°56'36.09" N	42	9	51
2	Barishal	Sadar	Chandpura SP	90°27'30.17" E	22°40'28.71" N	19	12	31
3	Bhola	Char Fasson	Nilkamal WMCA	90°38'14.64" E	22°13'44.20" N	20	10	30
4	Patuakhali	Sadar	Paler Danga SP	90.40298 ⁰ E	22.38934 ⁰ N	30	15	45
5	Jhalokathi	Nalcity	Rajpasa SP	90°19'18.9" E	22°35'49.9" N	12	0	12
6	Pirojpur	Nazirpur	Amtola SP	89°56'17.68" E	22°44'16.86" N	31	0	31
7	Chandpur	Faridganj	Rupsha Rumur Khal	91° 0'6.24" E	24°27'32.18" N	17	0	17
8	Laxmipur	Sadar	Bhuluar Khal CAD SP	90°49.5' E	22°57' N	8	4	12
9	Noakhali	Ashwadia	Olipur SP	91° 8'46.18" E	22°50'40.65" N	36	4	40
10	Chattogram	Satkania	Mirzakhil Darbar Sharif	92°01'43.75" E	22°02'37.49" N	33	1	34
11	Cox's Bazar	Sadar+Ramu	Bakkhali Rubber Dam	92°00'00" E	21°22'00" N	37	0	37
12	Cumilla	Meghna	Rajitpur Boroshapmara	90°42'25.35" E	23°37'23.81" N	13	0	13
13	Khulna	Dacope	Bajua Chara Khal	89°32'31.84"E	22°33'19.07" N	35	2	37
14	Bagerhat	Sadar	Dier Khal SP	89.922916 ⁰ E	22.634419 ⁰ N	33	0	33
15	Jashore	Sadar	Dolpur Mukteshway	89°8'2.64" E	24°58'46.86" N	15	2	17
16	Narail	Sadar	Khatnur Beel	89°16'49.92"E	24°58'46.86" N			
17	Satkhira	Tala	Chakarkhali Beel SP	89.247671 ⁰ E	22.745316 ⁰ N	21	2	23
18	Chuadanga	Sadar	Mominpur	90° 25'48" E	22° 37'48" N	18	13	31
19	Meherpur	Mujibnagar	Dadpur-Gopalpur	88°44'42.28" E	23°45'30.99" N	20	0	20
20	Bogura	Adamdighi	Bosonbari Khal	89.765600 ⁰ E	24.8196510 ⁰ N	24	12	36
21	Chapai Nawabgonj	Shibganj	Hogla-Damosh SP	88°17'50.90" E	24°45'38.47" N	5	4	9
22	Natore	Baraigram	Rawta Astikpara	89°09'57.97" E	24°11'20.43" N	18	2	20
23	Pabna	Sadar	Beelvaduria Khal	89°13'52.90" E	24° 3'8.02" N	24	0	24
24	Rajshahi	Mohonpur	Dhuroil SP	88.8067081 ⁰ E	24.5707729 ⁰ N	24	0	24
25	Sirajganj	Ullapara	Monohara SP	89°33'53.04" E	24°17'14.33" N	15	0	15
26	Joypurhat	Akkelpur	Chri Khal SP	89°01'45.15" E	25°01'40.79" N	14	20	34
27	Naogaon	Dhamoirhat	Kazipur SP	88.8237860 ⁰ E	25.0766585 ⁰ N	24	12	36
28	Gaibandha	Gobindoganj	Madarpur-Choutpur	89°19'3.33" E	25°9'45.94" N	30	0	30
29	Dinajpur	Bochagonj	Tangaon River Rubber Dam	88°25'4.70" E	25°40'20.50" N	19	13	32
30	Nilphamari	Sadar	Duhuli Chonkhar	88.9462 ⁰ E	25.9489 ⁰ N	15	0	15
31	Panchagar	Debigonj	Akandapara	88.7360227 ⁰ E	26.2510746 ⁰ N	24	12	36
32	Rangpur	Mithapukur	Hieler Beel	89°06'12" E	25°28'32" N	14	0	14
33	Thakurgaon	Sadar	Anjila Khal	88°26'42" E	26°19'39" N	12	8	20
34	Kurigram	Nageshwari	Kachakata Boro Charar per	89°47'48.42" E	26° 0'47.56" N	20	0	20
35	Lalmonirhat	Kaliganj	Bhateshwar SP	84° 06' E	25° 28' N	12	0	12
36	Gopalganj	Kashiani	Pathor Ghata -Ratoil-Chapta	89°44'4.89" E	23°11'49.41" N	54	0	54
37	Kishoreganj	Sadar	Hazipur Porabari SP	90°35'33.19" E	24°26'47.25" N	20	12	32
38	Habiganj	Nobiganj	Darveshpur Khal	91°35'58.23" E	24°37'57.31" N	33	4	37
39	Moulvibazar	Sreemangal	Boro Chara SP	91°37'12" E	24°24'29" N	18	18	36
40	Sunamganj	Sadar	Noiganag Chhara	90° 25'48" E	22° 37'48" N	34	0	34
41	Sylhet	Gowainghat	Shialichara WMCA	90° 25'48" E	22° 37'48" N	21	0	21
42	Netrokona	Kendua	Bipinganj	90°37'49.56" E	25°08'22.23" N	16	24	40

11.5.7 Public Consultation Meeting on Different Interventions and Safeguard Issue

Public consultation meeting was held in 42 districts subproject areas under the Climate and Disaster Resilience small scale Water Resources Management Project (CDRSSWRMP). The participants in public consultation meeting were farmers, fishermen, women, landless individuals, Upazila engineers of LGED, Upazila agricultural officers, Upazila fisheries officers.

The team members of consultant team were team Coordinators, water resource engineers, agriculturists, sociologist, gender specialist, fisheries specialist and environmental specialist/ environmental expert.

Table 39: Findings of Public Consultation on Khal Re-excavations

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
#	Existing water related problems in the subproject areas in 42 districts	Existing water related problem in the subproject area such as flood, drainage congestion, water logging, scarcity of irrigation water including its source/ reason. Water logging situation due to heavy rainfall in rainy season for a couple of months are the main constraints of the subprojects.	
1	Engineering point of view (Physical works)	The water carrying and drainage capacity of Khals have reduced significantly due to siltation. During dry season, little water remains in the Khal. The Khal is very badly silted up and local people are cultivating on the Khal lands. Re-excavation of the Khal will be beneficial. Availability of surface water will increase due to re-excavation of the subproject Khals. Local people said that if the Khal is re-excavated, there will be no problem with land because the land is Khas. Participants in the meeting demanded to re-excavate all Khals for drainage improvement and adequate water for irrigation in monsoon and dry season respectively.	Physical works necessary to solve the problems are Re-excavations of proposed Khals. Participants emphasized the need for re-excavation of Khals. Participants want re-excavation of the Khals to increase water in the Khals for HYV Boro, Rabi and vegetables cultivation.
2	Agriculture	Re-excavating of Khals would enhance water availability, improving agricultural productivity, increase cropping patterns and cropping intensity, increase in both cereal and non-cereal crop production. Positive impact on local employment due to improved agricultural activities and production. Rabi crops are limited to low value pulses that are grown with little or no irrigation. Farmers cannot cultivate high value Rabi crops and vegetables that need irrigation and also and HYV Boro rice. People will cultivate HYV Boro rice and winter-summer vegetables will increase as availability of irrigation water will increase. Re-excavation of Khals will increase water availability and dry season agriculture and agri-production will increase. These will generate more local employment. So,	Local people suggested for re-excavation of the Khals for mitigating the problems. Re-excavation of proposed Khals would provide improving agricultural productivity during the monsoon and dry season.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		landless persons have supported re-excavation of Khals. The coastal Khals receive tidal inflow. These Khals are silted due to which drainage impedes badly and adequate tidal inflow does not come. Slow drainage delays transplanting of both T Aman and Boro rice. Again, young T Aman rice and mature HYV Boro rice sometimes get inundated and damaged due to heavy rainfall. Surface water is the only source of HYV Boro irrigation in the subproject area. Therefore, HYV Boro paddy is damaged by drought stress for inadequate availability of tidal inflow in the Khal. Some Khals have tidal influence. These Khals have been silted up and farmers incurring crop damage for slow drainage of water and inadequate availability of tidal inflow. Crop production limitations in the agricultural land that has been arisen due to bad siltation in Khal. Local people suggested for re-excavation of the Khals for mitigating the problems. Present irrigation in some proposed subproject area is mainly supported by Low Lift Pumps (LLPs). The irrigation cost for HYV Boro rice is about BDT 120 per decimal per season. The following problems and farmers' needs were assessed through interactive discussions with local people and UP representatives after the field visit: The main problems of water management (WM) and Agriculture in the subproject area include: (1) During the monsoon season, some land cannot be cultivated due to rainwater flooding, and HYV Aman on some high-land depends on irrigation water. (2) During the dry season, there is a severe shortage of irrigation water in the Khals, which makes HYV Boro rice cultivation difficult and reduces yield by about 40–50%. As a result, farmers in the Chandpur subproject area have to depend on the CIP irrigation scheme, leading to higher irrigation costs.	
3	Fisheries	The Khals provide a habitat for natural fishes. However, the habitat is unsustainable as the water in the Khal is insufficient in the dry	Re-excavation would provide a year-round fish habitat,

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		season. Fishes migrate from the river to the internal Khals of the subproject area in monsoon season. But habitat of the fishes in the Khals is poor as the Khals dry up soon after monsoon. If the Khals are re-excavated, fish habitat will remain throughout the year and fishes will increase in the Khals whole of the year. Practically, there is no full-time fishermen community in the subproject area because catch from Khals and local rivers are not adequate for livelihood. Natural fisheries in the subproject Khals will improve as habitat will improve due to re-excavation. Fish cultivation in small seasonal ponds, ditches may be possible. There are no full-time fisher families in some area. Those who fish in Khal waters are only part time fishers. However, if Khals of the subproject area are re-excavated with sufficient depth, fish availability in the Khals will improve because fish habitat will remain for longer period - may be year-round. Open water fish catch from Khals will also benefit landless persons as they may fish there. Community members and fishers expect that the project will have overall positive impacts, provided that fish habitat management is included in the implementation plan. They suggested joint management of fisheries resources between WMCA and the local fisheries cooperative. Fisheries-related benefits will be occurred through improved water management. Although minor and temporary adverse impacts may occur during construction, these can be effectively mitigated through appropriate timing, spoil management, and participatory fisheries enhancement measures. The project area should be monitored during both construction and operation phases to ensure that drainage improvement and fisheries management objectives are achieved sustainably. There is no established full-time fishing community. So, only the part-time fisher will be benefited to catch from the Khal and River.	increasing fish populations.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
4	Environment (Drainage & Water Retention, Re-excavated Spoil Earth Management)	Participants emphasized on safe re-excavation of Khals for not deterioration of environment. No adverse impact on environment was identified. Impact on water environment will be positive. The issue related to efficient management of spoil earth that result from re-excavation of Khals is of concern because improper and unmanaged disposal of spoil earth are found to find very soon ways into the excavated Khals. Besides the usual measures of (a) spreading spoil earth on farm lands on or near the Khal banks, (b) making spoil banks taking measures like (i) adequate berms to prevent falling/washing down of spoil into the Khal and (ii) adequate gaps for drainage of crop lands, etc., alternative use of the spoil earth, say, making farm access roads within subproject area for ease of movement of farmers and transportation of equipment, materials and harvest, filling of playgrounds of Schools and Madrasas, sites of Mosques and Graveyards, etc. within reasonable distances have been discussed with UP Representatives and local people. It was said that such alternative use will surely be possible but the details, including costs and management requirements, will be assessed in the later stages. The subproject area is not located within any declared conserved wetland such as the Tanguar Haor or within any legally protected ecologically critical area (ECA). However, the project area serves as an important seasonal capture fishery, functioning as a floodplain Beel that provides fish breeding, feeding, and nursery habitats during the monsoon season. Positive impacts: ○ Improved drainage efficiency will reduce prolonged waterlogging, benefitting agricultural productivity. ○ Re-excavation will enhance water retention capacity and improve aquatic habitat quality during the dry season. Adverse impacts: ○ Short-term disturbance of aquatic habitat and fish spawning ground during excavation.	Re-excavation of Khals and avoid spoil dumping in Khals and agriculture land. Maintain safe working environment with PPE for workers. Local people expressed strong support for the project, recognizing its long-term benefits for improved drainage, agriculture, and fisheries. They requested timely excavation work and proper spoil management to minimize damage to crop fields.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		○ Possible temporary increase in turbidity and sedimentation affecting fish and aquatic organisms. Mitigation Measures: • Schedule excavation activities during the dry season (December–April) to avoid fish breeding season. • Maintain fish migration routes by ensuring proper inlets/outlets during re-excavation. • Encourage community-based fish habitat restoration through brush piling (katha) and creation of fish refuges. • Include post-construction stocking of native species to restore fish population. There is no forest or conserved forest area within or adjacent to the proposed sub-project site. The area is entirely composed of agricultural land, village settlements, and seasonal wetland habitat. Potential Impacts: No impact is identified or anticipated. Mitigation Measures: Mitigation is not applicable. There are no known archaeological or historical structures within or near the sub-project area. Local inquiries and LGED field verification confirmed the absence of any heritage sites that might be impacted. Potential Impacts: No impact is identified or anticipated. Mitigation Measures: Mitigation is not applicable. During the re-excavation of Khal, short-term environmental impacts may occur, including: • Temporary obstruction of water flow during excavation. • Minor deposition of excavated spoil on adjacent agricultural land. • Noise and dust generation from excavation machinery. • Temporary restriction on fishing during the construction period. Mitigation Measures:	

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		- Excavated spoil to be dumped on designated sites away from cropland and watercourses. - Construction to be completed before the monsoon season to avoid disruption. - Provide advance notice to fishermen and local users before commencing work. Potential long-term impacts include: Positive Impacts: - Enhanced water flow and drainage will reduce stagnant water conditions and improve overall aquatic productivity. - Increased dry-season water availability for domestic, agricultural, and small-scale aquaculture use. - Reduced flooding in nearby settlements and farmlands. Adverse Impacts: - Possible lowering of water levels in certain adjacent lowlands during dry months due to improved drainage. - Reduction of floodplain inundation area may affect natural fish breeding and migration patterns. Mitigation and Enhancement Measures: - Develop community fish sanctuaries in deeper segments of the Khal to preserve fish refuges. - Introduce integrated floodplain management involving WMCA and local fishermen's groups. - Maintain minimum water retention during dry months through temporary regulators or water control structures. - Conduct monitoring of fish catch and species diversity annually to assess ecological improvement.	
5	Climate change	Local opinion about measures required for climate change impacts such as increased rainfall, cyclone, tidal surge, etc. were considered. General opinion has been that the Khals may be made deeper so that drainage of water entering the subproject area from rivers/water from heavy rains can be drained out quickly from the subproject low lands areas.	Khal re-excavation, widen and heighten

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
6	Social (land acquisition and resettlement)	Benefit of the subproject will be directed to about 94% of subproject HH who are dependent on agriculture and fishery. No adverse social issues were noted. There is no local conflict about the subproject. Labor is available for the earthwork. If the sub-project is implemented, beneficiaries agree to join a Water Management Co-operative Association (WMCA) and to follow the project's rules and regulations. They will arrange the land for the office building construction. The UP chairman and local peoples said that due to the silted-up of the Khal, there is no proper drain out of water during the rainy season and water shortage is problem in dry session of the area. As a result, the crop production has been reduced. 82% people engage in agriculture, and 18% people engage in agriculture, non-agriculture and other occupations.	Re-excavation of Khals
7	Gender (Women's Participation)	Women usually do not work in crop fields. But increased agriculture and production increases family income when women's condition improves. As household works increase with increased agriculture and production, scope of employment of poor women in domestic works increase. Although women generally do not work but implementation of the Sub-project will create opportunity for women employment. Women have requested for creating scope and training for small culture fisheries programs in private ponds, ditches, etc. where they can contribute. Women's Group participants supported the subproject as Khal re-excavation will increase agricultural activities and production which will increase family income. If post-harvest and domestic works increase, poor women will be employed in such jobs. Women have requested for support and training on suitable jobs for them like tailoring, homestead vegetable growing, culture fishery in ponds, ditches, etc. Women expressed interest on training for small-scale aquaculture and fish farming in private ponds and ditches, enabling them to contribute to the local economy.	Women group recommended for re-excavation of Khal and also requested for creating scope of training for small culture fisheries.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
8	Meeting with landless people	Most of the Landless persons are agriculture labours and they hope to be benefitted as more works will be created in agricultural sector. They will be able to catch fish from the Khal in large quantity. Most of the Landless persons are agriculture labours and they hope to be benefitted as more works will be created as agricultural activities and crop production will increase as irrigation water will increase in the Khals. They can catch some fishes from the Khals if availability of fish increases.	Re-excavation of Khals
9	Any other issues found during the reconnaissance (Local People's Endorsement)	All the subproject beneficiaries met and discussed are in favor of the subproject implementation and no opposition to the subproject was seen or sensed. They expressed their willingness to form a WMCA by becoming Member and pay contribution as needed for O&M of the subproject infrastructure.	Re-excavation of Khals
10	Meeting with UP members	After completing all the Visit Points and FGDs, the Team hold a discussion and data collection meeting at the UP. UP Members and local people were present in the meeting. The Team collected Data for the feasibility study checklist by discussion with the participants. Team met chairman and members of the union parishad and explained purpose of the visit. The Team interacted with farmers and local people, as was readily available at each visit point, about the recent natural disasters specially on water and agriculture related problems and possible solutions they expect.	Re-excavation of Khals
11	Meeting with Upazila other offices	The Team, after completing all field activities, met Upazila Agricultural Officer and Upazila Fisheries Officer at their offices at Upazila and briefed them about the feasibility study of the proposed subproject. The feasibility study team informed the Upazila Agriculture Officer that the concerned SAAO has provided with necessary data on agriculture and crops, land types, farmer categories, etc of the subproject area. The team also collected data on fisheries.	Re-excavation of Khals

Table 40: Findings of Public Consultation on Re-sectioning of Embankment

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
#	Existing water related problems in the subproject's areas in 42 districts under CDRSSWRMP	Existing water related problem in the subproject area such as flood, drainage congestion, water logging, scarcity of irrigation water including its source/ reason. Water logging situation due to heavy rainfall in rainy season for a couple of months are the main constraints of the subprojects.	
1	Engineering aspects	Re-sectioning of an embankment involves re-shaping, widening, or strengthening an existing earth structure to improve its stability, safety, or functional capacity, often necessitated by erosion, subsidence, or upgrading requirements. It is a critical civil engineering intervention for maintaining infrastructure integrity, particularly in flood-prone areas.	Physical works necessary to solve the problems are Re-sectioning of embankment Participants emphasized the need for re-sectioning of embankment.
2	Agriculture	Re-sectioning of embankments under the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) enhances agricultural productivity by creating climate-resilient water management systems. This process directly increases farming income, boosts crop yields, and stabilizes soil to enhance long-term fertility. Agricultural benefits include: • Reduced Flood Risk: Strengthened embankments prevent floodwater from submerging crops, protecting root zones and reducing losses. • Increased Cropping Intensity: Improved water control and irrigation infrastructure allow for better water management in both flood-prone and drought-prone regions, enabling farmers to grow more crops annually. • Salinity Control: Proper embankment management reduces soil salinity, maintaining long-term soil fertility. • Increased Farmer Income: Enhanced crop yields (ranging from 30% to 70% in some cases) directly contribute to higher income for agricultural households. • Asset Protection: Re-sectioning protects crucial agricultural infrastructure and land from erosion and monsoon damages. The project, which is designed to benefit farming households in specific areas, aims to enhance agricultural productivity and profitability, providing a sustainable solution	Local people suggested for re-sectioning of embankment. Re-sectioning of proposed embankment would provide improving agricultural productivity during the monsoon and dry season.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		for food security in the face of climate change.	
3	Fisheries	Re-sectioning of embankments provides significant fisheries benefits by restoring floodplain connectivity, increasing perennial water retention, and reducing fish mortality during droughts. These enhancements support biodiversity, increase fish habitat, and improve the livelihoods of local fishing communities through better water management. - Enhanced Habitat: The re-sectioning process, often combined with canal excavation, increases water capacity and creates stable aquatic environments (perennial water bodies) that serve as dry-season fish refuges. - Improved Connectivity: Proper designing ensures that fisheries are not cut off from floodplains during wet seasons, allowing for natural breeding, migration, and nutrient flow. - Increased Productivity: By maintaining a healthier water environment, these interventions lead to increased fish biodiversity and higher, more sustainable fish production in the area. - Sustainable Livelihoods: Enhanced water management supports community-based fisheries management, protecting the income of local, often poorer, fishing households against climate-driven disasters. These improvements are part of a broader strategy, which includes building climate-resilient water infrastructure, to ensure that agriculture and fisheries can coexist and flourish despite increased flooding or drought conditions.	Fisheries group recommended for re-sectioning of embankment which will provide a year-round fish habitat, increasing fish populations.
4	Environment	Re-sectioning of embankments provides critical environmental benefits by reducing erosion, preventing saline water intrusion, and enhancing ecosystem resilience in flood-prone areas. This protective infrastructure supports climate adaptation through sustainable water management and, when integrated with nature-based solutions,	Participants emphasized on safe re-sectioning of embankment for not deterioration of environment.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		strengthens community resilience against disasters. Environmental benefits of this intervention include: • Reduced Erosion and Sedimentation: Re-sectioning strengthens existing embankments against riverbank erosion, protecting land from damage and reducing sedimentation in water bodies. • Salinity Management: By upgrading embankments, the project limits the influx of saline water into agricultural land during storm surges and tidal flooding, preserving long-term soil fertility and reducing crop loss. • Enhanced Water Resource Management: The improvements facilitate controlled, consistent access to surface water for agriculture, reducing the need for groundwater extraction and improving water conservation. • Nature-Based Integration: The project often incorporates tree planting and greening of embankments to increase stability, conserve biodiversity, and act as carbon sinks. • Improved Adaptive Capacity: By lowering the risk of flooding and disaster, the improved infrastructure protects local ecosystems and allows rural communities to better adapt to climate-related hazards.	Re-sectioning of embankment and avoid spoil dumping in agriculture land. Maintain safe working environment with PPE for workers. Local people expressed strong support for the project, recognizing its long-term benefits for improved drainage, agriculture, and fisheries. They requested timely excavation work and proper spoil management to minimize damage to crop fields.
5	Climate change	Re-sectioning embankments primarily strengthens community resilience against climate change by fortifying infrastructure to withstand intensified floods, storm surges, and sea-level rise. This process increases embankment height and width, effectively mitigating erosion and reducing saline water intrusion into agricultural lands. Climate Change Benefits: • Enhanced Flood & Surge Protection: Re-sectioning improves the stability and height of embankments, protecting coastal and flood-prone Haor regions from rising water levels and more frequent cyclones.	Embankment re-sectioning, widen and heighten

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		- Increased Agricultural Resilience: By preventing saline water intrusion and reducing flood inundation, the improved structures protect crops, enhancing food security and agricultural productivity in vulnerable areas. - Reduced Vulnerability: The initiative safeguards local infrastructure (such as roads) and communities, reducing the economic damage caused by climate-induced disasters. - Adaptation to Increased Rainfall: By redesigning cross-sections, embankments are better equipped to handle higher discharges and increased water pressure during extreme weather events. The project, supported by partners like IFAD and the ADB, integrates these structural enhancements with nature-based solutions to build long-term disaster preparedness, particularly in Bangladesh's coastal zone.	
6	Social	Resectioning embankments focuses on strengthening coastal protection through community-led approaches, directly affecting local livelihoods, land use, and disaster resilience. Key social aspects include involuntary resettlement, rehabilitation of squatters, local employment generation through earthwork, and user participation in maintenance. Social Aspects of Embankment Re-sectioning: - Land Acquisition and Resettlement: Re-sectioning (widening and raising) often requires additional land, impacting landowners and encroachers (squatters) on the existing embankment slope. Mitigation involves implementing a Resettlement Action Plan (RAP) to compensate for land loss, structures, and crops. - Participatory Management: The project emphasizes community-led management, involving local water management associations (WMCAs) in designing, constructing, and maintaining embankments.	Recommendations for Social Management: Regular Maintenance: Establishing local committees for regular repair and maintenance to ensure long-term functionality. Compensation and Training: Providing cash grants and skill training for people affected by resettlement to rehabilitate their livelihoods. Conflict Resolution: Strengthening the role of WMCAs to resolve disputes over embankment use, such as grazing or farming, that can weaken the structure.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		• Livelihood Improvement: The project aims to improve agriculture within the polder by reducing saline intrusion, which helps farmers switch from shrimp farming back to paddy cultivation, promoting local food security. • Social Forestry and Income Generation: Participatory social forestry is to be implemented on the foreshore slopes, providing income opportunities for landless, marginalized groups and women. • Improved Safety and Reduced Risk: Enhanced embankments (typically to 15 feet high and 12 feet wide) provide greater protection against storm surges and floods, leading to increased safety for the residents. • Challenges: Key challenges include managing the resistance of those losing land, ensuring the equitable distribution of benefits, and preventing illegal occupation of rehabilitated embankments.	
7	Gender (Women's Participation)	Under the CDRSSWRMP, women's engagement in embankment re-sectioning is structured to maximize local participation, particularly through Women's Adaptation Labs and labor-intensive earthworks. Key requirements include: • Active Recruitment: Prioritizing women, particularly from disadvantaged households, for earthwork, embankment maintenance, and protective planting. • Decision-Making Roles: Ensuring women are represented in Community-Based Organizations (CBOs) and Water Management Groups (WMGs) to influence design and maintenance planning. • Training & Compensation: Providing training for women volunteers in early warning, disaster response, and safe, well-lit working conditions for embankment management. Key Impacts and Mitigation Measures • Impact - Time Poverty: Construction work may increase women's existing house hold workloads.	Women group recommended for re-sectioning of embankment and also requested for creating scope of training for small culture fisheries.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		<i>Mitigation:</i> Flexible work hours, hiring local women to minimize commute times, and implementing labor-saving tools. - Impact - Safety and Harassment: Vulnerability to gender-based violence (GBV) during work or in temporary shelters. <i>Mitigation:</i> Establishing strict code of conduct for workers, ensuring separate, lockable, and well-lit sanitary facilities for women, and implementing complaint mechanisms. - Impact - Economic Exclusion: Inequitable pay or lack of access to decision-making regarding compensation. <i>Mitigation:</i> Ensuring direct, equal pay for equal work, providing mobile banking for payment, and mandatory gender training for contractors. Impact - Loss of Access to Land: Re-sectioning may affect small-scale agricultural activities on slopes. <i>Mitigation:</i> Including women in compensation planning and focusing on alternative livelihood training (e.g., homestead gardening, poultry).	
8	Meeting with landless people	Most of the Landless persons are agriculture labours and they hope to be benefitted as more works will be created in agricultural sector. They will be able to catch fish from the khal in large quantity. Most of the Landless persons are agriculture labours and they hope to be benefitted as more works will be created as agricultural activities and crop production will increase as irrigation water will increase in the Khals. They can catch some fishes from the Khals if availability of fish increases.	Re-sectioning of embankment
9	Any other issues found during the reconnaissance (Local People's Endorsement)	All the subproject beneficiaries met and discussed are in favor of the subproject implementation and no opposition to the subproject was seen or sensed. They expressed their willingness to form a WMCA by becoming Member and pay contribution as needed for O&M of the subproject infrastructure.	Re-sectioning of embankment

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
10	Meeting with UP members	The Team hold a discussion and data collection meeting at the UP. UP Members and local people were present in the meeting. The Team collected data for the feasibility study checklist by discussion with the participants. Team met chairman and members of the union parishad and explained purpose of the visit. The team interacted with farmers and local people, as was readily available at each meeting point, about the recent natural disasters specially on water and agriculture related problems and possible solutions they expect.	Re-sectioning of embankment
11	Meeting with Upazila other offices	The team met Upazila Agricultural Officer and Upazila Fisheries Officer at their offices at Upazila and briefed them about the feasibility study of the proposed subproject. The feasibility study team informed the Upazila Agriculture Officer that the concerned officer has provided with necessary data on agriculture and crops, land types, farmer categories, etc. of the subproject area. The study team also collected data on fisheries, fisherman community and private ponds in the subproject area from records of the Upazila Fishery Office.	Re-sectioning of embankment

Table 41: Findings of Public Consultation on Bakkhali Rubber Dam Rehabilitation

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
#	Existing water related problems in the subproject's areas in 42 districts under CDRSSWRMP	Existing water related problem in the subproject area such as flood, drainage congestion, water logging, scarcity of irrigation water including its source/ reason. Water logging situation due to heavy rainfall in rainy season for a couple of months are the main constraints of the subprojects.	

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
1	Engineering point of view (Physical works)	The IFAD-supported project emphasizes sustainable management through Water Management Cooperative Associations (WMCAs). This involves not just structural repair but also strengthening the community-based Operation & Maintenance (O&M) committee to ensure 100% O&M cost recovery. As part of the CDRSSWRMP, the reconstruction strengthens the structure against extreme flood and drought events to enhance water management for Boro rice cultivation.	The reconstruction strengthens the structure against extreme flood and drought events to enhance water management for Boro rice cultivation.
2	Agriculture	The Bakkhali Rubber Dam will boost agriculture by providing critical dry-season irrigation, enabling year-round cropping (Boro rice/diversified crops). The project mitigates environmental impacts through improved water management, canal excavation, and modernizing the dam to prevent failure and manage floods. The dam enables irrigation during the dry season, significantly increasing agricultural productivity (yields of Boro rice), reducing, or often eliminating, the need for chemical fertilizers in some areas, and creating new farming opportunities. Over 78% of users report increased crop production, and 27% report expansion of farmland due to secured water access.	The participants recommended for construction of modern rubber dam at Bakkhali river for increasing agricultural productivity.
3	Fisheries	The Bakkhali Rubber Dam, modernized under the CDRSSWRMP (Climate and Disaster Resilient Small-Scale Water Resources Management Project), provides significant fisheries benefits by conserving freshwater, increasing dry-season water availability, and enabling structured aquaculture. It supports livelihood diversification for local communities, enhancing fish production despite altering local geo-morphological patterns. The rubber dam creates a reservoir, maintaining water levels at optimum heights for inland fisheries production. The sustained water allows for increased fish culture initiatives, enhancing food security and income opportunities for communities. The project helps boost fishers' and vulnerable households' livelihood opportunities by enhancing resilience against droughts and providing consistent water	As the rubber dam creates a reservoir, maintaining water levels at optimum heights for inland fisheries production, they recommended to construct a rubber dam in that area.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
		flow. The large reservoir created by the dam provides a breeding ground, boosting the available fish population, which supports local fishing livelihoods.	
4	Environment	The Bakkhali River rubber dam provides significant environmental benefits by storing freshwater for irrigation (33% reduced groundwater reliance), lowering irrigation costs, and boosting fish populations, enhancing agricultural productivity. The dam facilitates freshwater storage, allowing farmers to reduce reliance on groundwater and utilize stored water for agriculture. The stored water has facilitated an increase in fish populations and strengthened aquaculture. As a rubber dam offers more flexible water management than concrete dams, with minimal structural impact, which is crucial for managing the specific 83.62 ha (upstream) and 75 ha (downstream) sediment-affected areas. Reduced environmental flow (e-flow) in the downstream area, especially during the dry season, has altered the brackish ecology and caused, or worsened, salinity intrusion issues.	
5	Climate change	The Bakkhali Rubber Dam (BRD) in Cox's Bazar, currently undergoing modernization, faces climate risks like increased salinity intrusion, sea-level rise, and intense flooding. Mitigation efforts include emergency rehabilitation, strengthening Water Management Cooperatives (WMCAs), and improving drainage to reduce flood risks and boost agricultural productivity. The existing structure is vulnerable to severe tidal surges and increased riverbank erosion. Higher temperatures and increased sediment load affect rubber bag durability and pump efficiency. Emergency rehabilitation of the existing rubber dam to withstand current and future climate stresses. Promoting climate-resilient farming techniques (e.g., salinity-tolerant crop varieties) to ensure food security despite changing water conditions.	The Bakkhali Rubber Dam (BRD) in Cox's Bazar, needs to functionalize through construction of new one.

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
6	Social	The Bakkhali Rubber Dam in Cox's Bazar has significantly boosted local agriculture by providing irrigation for over 6,000 hectares, increasing farmer income, and reducing groundwater dependence. However, it created issues like upstream waterlogging, downstream salinity reduction, and siltation. Mitigation under CDRSSWRMP (2024-2030) involves urgent rehabilitation, modernization, improved water management, and enhanced stakeholder participation to ensure sustainable, climate-resilient benefits. Approximately 45% of surveyed locals reported a rise in income due to improved irrigation, allowing for multiple cropping cycles. By storing freshwater in the river, the dam decreases reliance on underground water sources, preserving the water table. The accumulation of silt upstream has altered the river's morphological structure, leading to waterlogging in some areas and disrupting traditional agricultural practices. The dam hinders boat navigation, affecting the traditional transportation of goods and people. The project includes the immediate repair of existing rubber bags and the modernization of the dam machinery to ensure efficient, long-term operations. The initiative involves excavating/re-excavating surrounding canals to improve water distribution and mitigate the waterlogging issues reported upstream. The project improves flood control, drainage, and irrigation systems, providing a comprehensive approach to managing water-related disasters in the region.	Establishing and strengthening participatory WMCAs to improve operation and maintenance (O&M), including monitoring for leakage and siltation.
7	Gender	The project establishes new, and strengthens existing, WMCAs to manage water distribution. These groups are designed to be inclusive, ensuring participation of women and poor, landless farmers in decision-making.	Modernization of Bakkhali Rubber Dam and formation of WMCA involving women group

Sl. No	Issues of consultation	Stakeholders' feedback	Recommendations
8	Meeting with landless people	Most of the Landless persons are agriculture labours and they hope to be benefitted as more works will be created in agricultural sector. They will be able to catch fish from the river in large quantity. Most of the landless persons are agriculture labours and they hope to be benefitted as more works will be created as agricultural activities and crop production will increase as irrigation water will increase in the river. They can catch some fishes from the river if availability of fish increases.	Modernization of Bakkhali Rubber Dam
9	Any other issues found during the reconnaissance (Local People's Endorsement)	All the subproject beneficiaries met and discussed are in favor of the subproject implementation and no opposition to the subproject was seen or sensed. They expressed their willingness to form a WMCA by becoming Member and pay contribution as needed for O&M of the subproject infrastructure.	Modernization of Bakkhali Rubber Dam
10	Meeting with UP members	The Team hold a discussion and data collection meeting at the UP. UP Members and local people were present in the meeting. The Team collected Data for the feasibility study checklist by discussion with the participants. Team met chairman and members of the union parishad and explained purpose of the visit. The Team interacted with farmers and local people, as was readily available at each visit point, about the recent natural disasters specially on water and agriculture related problems and possible solutions they expect.	Modernization of Bakkhali Rubber Dam
11	Meeting with Upazila other offices	The Team, after completing all field activities, met Upazila Agricultural Officer and Upazila Fisheries Officer at their offices at Upazila and briefed them about the feasibility study of the proposed subproject. The team also collected data on fisheries, fisherman community and private ponds in the subproject area from records of the Upazila Fishery Office.	Modernization of Bakkhali Rubber Dam

12 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT PLAN

12.1 Health and Safety Measures During Construction

The Contractor independently of any liability arising from the legislation shall undertake all measures, as required, to prevent accidents during construction works, as well as for the health protection and provision of first aid to employees on site. The Contractor will also comply with all the relevant local regulations and provisions for ensuring health and safety during the construction phase. The works will be carried out safely and in accordance with the Laws, Directives and other provisions relating to health and safety of the staff.

During the construction all measures will be taken to prevent accidents to personnel and all third parties and to provide first aid to them. More specifically:

- All working positions will be equipped with drinking water and sanitation facilities (showers, toilets etc.)
- First aid stations must be available
- Positioning of signs and glowing signs which inform, warn or forbid certain actions regarding dangers in the site
- Dispensation to all staff working in the site of appropriate Personal Protection Equipment (PPE) such as helmets, goggles, masks etc.
- In case of works taking place during night, adequate lighting must be ensured in the relevant areas.

Signage will be provided for works in public spaces, bearing reflecting signs. During night there will also be light signals, which will be noticeable from a distance equal to the maximum breaking distance of vehicles at the public place where the site is located. Appropriate first aid materials will be available on site.

12.2 Health and Safety Measures During Operation

Health and safety of workers is essential and a crucial parameter of proper operation. Workers will wear special clothing during work; shoes, galoshes, raincoats, helmets, gloves, masks etc., which will be washed and ironed at the site. A fully equipped first aid kit and a stretcher will be available at site.

During maintenance machinery operators must take the following measures:

- Keep machinery clean.
- Do not crush sealed containers.
- Do not leave machinery unattended.
- Keep the steps of the machinery clean.
- Use steps and handles of the machinery.
- Never get on or off the machine during movement.
- Clean machinery before repair and maintenance.
- Keep a daily record of the machinery's operation.
- Always inspect machinery before the commencement of works.
- Inspect the place of works before the commencement of works.
- Keep the buckets and blades of machinery close to the ground.
- Lower buckets and blades of machinery to the ground during parking.
- Begin to operate machinery only after they are seated at the driver's seat.

13 CAPACITY DEVELOPMENT TRAINING

The Climate and Disaster Resilient Small-Scale Water Resources Management Project in Bangladesh includes significant environmental capacity development training, focused on empowering Water Management Cooperative Associations (WMCAs) and Local Government Engineering Department (LGED) staff to manage water resources sustainably in the face of climate change.

Key Aspects of Environmental Training & Capacity Building:

- **Target Audience:** The training targets WMCA members, local government representatives, and staff from the LGED's Integrated Water Resources Management Unit (IWRMU).
- **Focus Areas:** Training covers climate-resilient water management infrastructure, environmental management capacity, and the operation and maintenance of small-scale water resources to reduce poverty and increase agricultural productivity.
- **Operational Approach:** Training is designed to improve the knowledge base of stakeholders regarding climate change impacts, risk, and vulnerability of ecosystems and biodiversity.
- **Implementation:** The project is supported by the Asian Development Bank (ADB) and the International Fund for Agricultural Development (IFAD), running until 31 December 2029.
- **Outcome:** The training aims to foster sustainable, stakeholder-driven water management systems that can cope with climate variability, such as floods and droughts.

13.1 PMU Level Environmental Training

The CDRSSWRMP includes dedicated training for the Project Management Unit (PMU) on environmental safeguards, strengthening the capacity of the Local Government Engineering Department (LGED) to manage climate-resilient water resources.

Key Aspects of CDRSSWRMP Environmental Training & PMU Focus:

- **Context:** The project, approved in late 2023 and running until 2029, is implemented by the LGED. A PMU has been established in Dhaka, with 42 PIUs at the district level.
- **Environmental Safeguards:** The PMU is responsible for implementing Initial Environmental Examination (IEE) and Environmental Management Plan (EMP) requirements to mitigate impacts, particularly for subprojects involving water management infrastructure.
- **Training Scope:** Training focuses on strengthening institutional capacity for sustainable program implementation, including environmental compliance, climate change adaptation, and disaster resilience, as highlighted in related LGED/IFAD initiatives.
- **Key Topics:** PMU and PIU training covers environmental risk assessment, climate change science, resilience in agricultural production, and sustainable water management.
- **Implementation Partner:** The Integrated Water Resources Management Unit (IWRMU) of LGED is responsible for planning, implementing, and monitoring these environmental trainings.

13.2 PIU Level Environmental Training

The Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP) in Bangladesh, supported by IFAD, ADB, and the Government of the Netherlands, includes specific training for Project Implementation Units (PIUs) to ensure environmental compliance and management. The project focuses on strengthening capacity within the Local Government Engineering Department (LGED) to manage environmental risks associated with small-scale water infrastructure.

Essential Aspects of PIU Level Environmental Training & Capacity Building:

- **Focus Area:** Training covers the implementation of the Environmental Management Plan (EMP), Environmental Impact Assessment (EIA), and adherence to the Environmental Management Framework (EMF).
- **Target Audience:** Staff within the PIUs, which are typically established under the LGED to implement subprojects at the local level.
- **Implementation Status:** As of late 2025, capacity-building, including for environmental aspects, was being strengthened due to initial scheduling delays and the need for robust operational and maintenance mechanisms to ensure long-term sustainability.
- **Core Components:** The training includes monitoring environmental parameters, implementing grievance redress mechanisms (GRM), and ensuring compliance with both national regulations (DoE) and international safeguard policies (e.g., ADB Safeguard Policy Statement).
- **Institutional Strengthening:** In addition to PIU-level training, the project involves strengthening local Water Management Cooperative Associations (WMCAs) in environmental monitoring.

13.3 Subproject Level (WMCA Level) Environmental Training

Subproject-level (WMCA level) environmental training under the Climate and Disaster Resilient Small-Scale Water Resources Management Project in Bangladesh focuses on building capacity for sustainable operation and maintenance (O&M) of water infrastructures. Managed by the Local Government Engineering Department (LGED), this training ensures Water Management Cooperative Associations (WMCAs) can implement environmental mitigation measures, manage climate-resilient, small-scale water resources, and comply with safety standards.

Key aspects of the WMCA-level environmental training include:

- **Capacity Building:** Training WMCA management committees on O&M plans, routine maintenance, and environmental safeguards to ensure long-term sustainability of infrastructure.
- **Environmental Safeguards:** Training focuses on mitigating environmental impacts during construction and operation, including, but not limited to, water quality management and ecosystem protection.
- **Climate Resilience:** Training on adopting nature-based solutions and managing climate-smart, low-cost investments.
- **Grievance Redress (GRM):** Ensuring WMCAs understand and implement mechanisms to manage local environmental and social concerns.

- **Target Group:** Direct training for WMCA leaders and members responsible for managing subprojects.

The initiative aims to strengthen 230 existing WMCAs and establish 150 new ones, covering 42 districts in Bangladesh.

Table 42: Training Program for Environmental Management

Target Group	Training Subject	Methods	Timeframe
Design and Construction Phase			
All concerned PIU project staff	Environmental Overview: Environmental regulations, and national standards, process of impact assessment and identification of mitigation measures, importance of EMP and monitoring, and monitoring methodology.	Lectures or Presentation	Before beginning of the implementation of the project
Environmental engineers, field officers, contractors, PISC	Implementation of EMPs: Basic features of an EMP, Planning, designing and execution of environmental mitigation and enhancement measures, monitoring and evaluation of environmental conditions during construction and operation	Workshops and Seminars	Before the construction begins
Environmental Engineers, field officers, contractors, PISC	Environmentally Sound Construction Practices: Construction waste management and minimization in construction, pollution control devices and methods for construction sites and equipment, Environmental clauses in contract documents and their implications, Environmental monitoring during construction	Seminars, Lectures and Site visits	Before the construction begins
Project staff dealing in social/ lands matters	Social awareness: Monitoring consultants/organizations specializing in social management and monitoring can provide training on social awareness and land acquisition and resettlement issues	Seminars, Lectures and Site visits	Before the construction begins
Environmental engineers, field officers, contractors, PISC	Monitoring Environmental Performance during Construction: Monitoring of Air, Water, Noise, Solid Waste, Sediments and effect on biodiversity and fisheries. Evaluation and Review of results, Performance indicators and their applicability, possible corrective actions, reporting requirements and mechanisms.	Seminars, Lectures and Site visits	During initial phases of construction
Contractor's staff, construction labourers	Occupational Safety and Health: Monitoring consultants/ organizations specializing in occupational, health and safety issues can provide training on this issue.	Workshops and seminars	During initial phases of construction
Construction labourers	Waste handling and sanitation at construction sites/ construction camps	Workshops and presentation	During initial phases of construction
During Operation Phase			
Environmental engineers, field officers, contractors	Long-term Environmental Issues in Project Management: Designing and implementing environmental surveys for ambient air, sediments and water quality, data storage, retrieval and analysis, contract documents and environmental clauses, risk assessment and management, contingency planning and management and value addition	Workshops and seminars	During the operation phase or defect liability period

It would be essential to understand the legislative framework and enhance capacity of PIU for analysing the applicability of various environmental legislations and clearances, approvals and compliance monitoring requirements.

14 CONCLUSION AND RECOMMENDATIONS

14.1 Conclusion

Water Management for agriculture is important in our country. The Environmental Impact Assessment (EIA) has provided a comprehensive evaluation of the potential impacts associated with the project covering 42 districts, while also identifying opportunities for maximizing its positive outcomes. The findings of the EIA demonstrate that the project is both environmentally feasible and socially beneficial, provided that the mitigation measures outlined in the Environmental Management Plan (EMP) are fully implemented. Environmental impacts during construction—such as dust, noise, temporary waste generation, and risks to water quality—are largely short-term and manageable. In the operational phase, the project will require consistent oversight to ensure the sustainability of ecological functions, including maintaining environmental flows and safeguarding aquatic biodiversity through the proper functioning of the fish habitat.

Rubber dams, while offering benefits like flexible water management and reduced environmental impact compared to concrete dams, can still have some environmental effects. These include potential impacts on groundwater levels, soil salinity, and riverbank erosion, particularly if not properly managed. However, they are generally considered a more sustainable option due to their minimal disturbance during installation and removal, and their ability to adapt to changing water levels. The Bakkhali Rubber Dam Improvement Subproject has undertaken as part of the Climate and Disaster Resilient Small-Scale Water Resources Management Project (CDRSSWRMP), represents a critical investment in climate-adaptive infrastructure aimed at strengthening water security, agricultural productivity, and rural resilience in a fragile region of Bangladesh.

Socio-environmentally, the project is expected to deliver transformative benefits to the local population, particularly through improved irrigation access, increased cropping intensity, and strengthened community-based water governance. The institutional role of the Water Management Cooperative Association (WMCA) is central to sustaining these outcomes. However, the assessment also recognizes potential risks, including unequal access to water, safety concerns around infrastructure, and the risk of excluding women and vulnerable groups from decision-making processes. These risks can be effectively mitigated through targeted community engagement, inclusive governance, and a proactive grievance redress mechanism.

The performance of Bakkhali Rubber Dam subproject in terms of socio-economic, agriculture and hydraulic indicators can be considered satisfactory. Considering both the capital and the lower operation and management costs of irrigation development, Rubber Dam technology is more economically viable than the previous traditional technology and if found technology feasible, the technology is recommended in the small and medium river subprojects of Bangladesh. To consider all sides of rubber dam subproject we can say that rubber dam subproject on Bakkhali River will have a great step to change socio-economic condition of that region.

In brief, the project has strong alignment with Bangladesh's national development strategies, environmental protection regulations, and international safeguard principles. If implemented with diligence and supported by inclusive institutional arrangements, the subproject has the potential to become a model for resilient and community-driven small-scale water resource management in the face of growing climate challenges.

The process described in this document has assessed the environmental impacts of all elements of the infrastructure proposed under the CDRSSWRMP. Potential negative impacts were identified in relation to construction and operation of the improved infrastructure. Mitigation measures have been developed to reduce all negative impacts to acceptable levels. These were discussed with specialists responsible for the engineering aspects, and as a result some measures have already been included in the outline designs for the infrastructure. This means that the number of impacts and their significance have already been reduced by amending the design.

This EIA report has been prepared following the guidelines of DOE (ECR 2023). Regardless of these and various other actions taken during the EIA process and in developing the subproject, there will still be impacts on the environment when the infrastructure is built and when it is operating. This is mainly because of the invasive nature of excavation work; because of these factors the most significant impacts are on the physical environment, the human environment, and the cultural heritage.

Fertilizer supplies essential nutrients directly to plants, fostering faster growth and higher yields. It enables intensified, high-density farming, meeting global food demands. It causes cost-effective productivity, often provides a cheaper, immediate solution for increasing agricultural output per area. Fertilizer has negative impacts like soil degradation. Continuous use causes soil compaction, acidification, and destruction of beneficial soil microorganisms. Excess phosphorus and nitrogen run off into water bodies, causes algal blooms, toxic chemical accumulation, and water contamination. It disrupts natural nutrient cycles and decreases organic matter, requiring even higher fertilizer doses over time. Nitrogen-based fertilizers release nitrous oxide, a powerful greenhouse gas that contributes to climate change. Chemical residues can accumulate in crops, causing heavy metal toxicity (e.g., Cadmium, Arsenic). High salt index fertilizers can cause "salt burns" on crops and disrupt soil structure.

Pesticides contaminate water sources through agricultural runoff, spray drift, and leaching, causing severe damage to aquatic ecosystems and human health. They kill aquatic plants and insects, induce harmful algal blooms, disrupt fish development, and contaminate drinking water supplies, often remaining in the environment for long periods. Pesticides are toxic to fish and aquatic life, killing non-target organisms and reducing biodiversity. They can kill beneficial pollinators and predators, disrupting the food chain and natural balance. Pesticides travel from soil into groundwater (leaching) and surface waters (runoff), polluting drinking water supplies. Certain chemicals, such as organochlorines, can remain stable and accumulate in the environment, leading to bioaccumulation in the food chain. Exposure can cause severe developmental issues in aquatic life, such as spasms and respiratory difficulties. Rain or irrigation washes pesticides from agricultural fields and lawns into nearby rivers and lakes. Pesticides sprayed on crops can drift through the air and land directly on water surfaces. Dumping pesticides down drains or improper storage causes leaks and contamination.

Finally, stakeholders were involved in developing the EIA through face-to-face discussions on site and a public meeting held in the subproject area, after which views expressed were incorporated into the EIA and the planning and development of the subproject. The EIA will be made available for public opinion and will be disclosed to a wider audience via the DOE website and LGED website. The consultation process will be continued and expanded during subproject implementation, when a nationally-recognized NGO will be appointed to handle this key element to ensure that stakeholders are fully engaged in the subproject and have the opportunity to participate in its development and implementation.

The studies concluded that the subprojects of CDRSSWRMP will not have diverse, irreversible, or unprecedented adverse environmental impacts. The identified risks can be effectively managed through the strict implementation of the Environmental Management Plan (EMP).

14.2 Recommendations

The project should maintain ecological flow in the river system and ensure the regular functioning of the fish habitat to preserve aquatic biodiversity. Partnerships with the Department of Agricultural Extension and the Department of Fisheries should be leveraged to promote climate-resilient agricultural practices and sustainable fishery management. Integrating these efforts into the ongoing institutional framework under the CDRSSWRMP will help translate the project's objectives into lasting environmental, economic, and social benefits. Strong inter-agency coordination, ongoing community participation, and a culture of adaptive management will be key to realizing the long-term success of the project interventions improvement initiative.

To achieve its intended outcomes, the project must fully implement the Environmental Management Plan (EMP) and conduct regular monitoring every six months, with separate reporting for environmental performance. Strengthening the capacity of the Water Management Cooperative Association (WMCA) is crucial for the sustainable operation and equitable management of water resources. Continued stakeholder engagement, a functioning and inclusive grievance redress mechanism (GRM), and adherence to occupational and community safety standards will be essential to ensure broad-based support and risk mitigation.

The Project Management Unit (PMU) and Project Implementation Support Consultant (PISC) will be responsible for monitoring. The PISC will submit semi-annual environmental monitoring reports (EMRs) to PMU and the PMU will send the semi-annual environmental monitoring reports to ADB and IFAD. ADB and IFAD will post the environmental monitoring reports on their website. Quarterly EMR incorporated into project QPR. Contractors' monthly environmental monitoring to be submitted by contractors to PISC.

The yearly environmental compliance reports will be submitted to DOE for renewal of the SCC/ECC with necessary renewal fee submission through government challan. Therefore, the proposed project is unlikely to cause significant adverse impacts and net environmental benefits to stakeholders will be positive. The potential impacts that are associated with design, construction and operation can be mitigated to standard levels without difficulty through proper engineering design and the incorporation or application of recommended mitigation measures and procedures.

The EMP of this EIA is site specific including monitoring plan. During construction, the contractor will prepare Contractor's Environmental Management Plan, which will include contractor's responsibility in implementing EMP. The plan should be reviewed and approved by the employer at least 10 days before commencement of construction.

A copy of the EMP will be kept on-site during the construction period at all times. The EMP shall be made binding on the contractor operating on the site, and will be included in the contractual clauses. Non-compliance with, or any deviation from, the conditions set out in this document shall constitute a failure in compliance.

LGED has fully endorsed the EMP and is committed to implement all the mitigation measures. PMU of LGED will also ensure that the work is carried out in an environmentally acceptable manner and the monitoring and reporting are completed in a compliant and timely fashion, acceptable to DOE. As per Government of Bangladesh ECA, 1995 and ECR, 2023, the project is categorized as "Red"; and ECC must be obtained from DoE.

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11. The other two BDP hotspots are the Urban Hotspot (seven districts, corresponding to the eight metropolitan areas less Gazipur) and Chittagong Hill Tracts (CHT) Hotspot (three districts).
12. BDP mapped 58 of Bangladesh's 64 districts to the six hotspots and five districts to a "Relatively Less Hazard Prone Area" (RLHPA). One district, Narsingdi, was left unassigned. Of the five districts assigned to the RLHPA, one district, Nilphamari, is also assigned to the Barind+Drought-Prone Hotspot. The non-assignment of Narsingdi and RLHPA+hotspot assignment to RLHPA of Nilphamari look like errors (inconsistent with BDP hotspot scheme logic).
13. The four-district difference between the four Project hotspots (54 districts) and the six BDP hotspots (58 districts) comprises the three CHT districts and Dhaka district.
14. BDP mapped each Urban district except Dhaka to one or two additional Project hotspots (Sylhet to Haor+Flash Flood-Prone; Barisal, Chottogram, and Khulna to Coastal; Rajshahi and Rangpur to Barind+Drought-Prone; and Barisal, Khulna, and Rajshahi to River+Estuaries)
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16 APPENDICES (Appendix-1 to Appendix-19 is in Vol-II)

Appendix-1 Photographs of focus group discussion under CDRSSWRMP

Appendix-2 Photographs of field visit under CDRSSWRMP

Appendix-3 Photographs of existing infrastructures and interventions

Appendix-4 Photographs of public consultation meeting (PCM)

Appendix-5 Photographs of KII (Key Informant Interview)

Appendix-6 Google maps, Index maps, physical maps

Appendix-7 Attendance sheets of FGD and stakeholders' consultations

Appendix-8 List of NOCs Collected from Union Parishad

Appendix-9: Field Environmental Assessment Checklist of CDRSSWRMP

Appendix-10 Questionnaire for Environmental Field Data Collection

Appendix 11: Field Climate Risk Screening Assessment Checklist of CDRSSWRMP

Appendix-12 Field Environmental Monitoring Checklist-CDRSSWRMP

Appendix-13 TOR Approval Letter of DOE

Appendix-14 Approved Terms of References of EIA study of CDRSSWRMP

Appendix-15 Environmental quality parameter standard value of DOE

Appendix-16 Mitigation of Impacts of Environmental Components During O&M

Appendix-17 Water Quality Monitoring Plan Summary Under CDRSSWRMP

Appendix-18 Stakeholders/Public Consultation Meeting meetings

Appendix-19 Public Consultation Meeting Published in Newspaper