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Impact Assessment of Structural Interventions in Haor Ecosystem and Innovations for Solution

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Impact Assessment of Structural Interventions in Haor Ecosystem and Innovations for Solution

Main Report

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Impact Assessment of Structural Interventions in Haor Ecosystem and Innovations for Solution

This volume consists of three reports:

1. **Impact Assessment of Structural Interventions in Haor Ecosystem**
2. **Eco-Friendly Guideline for Structural Interventions in the Haor Region**
3. **Strategic Environmental Assessment in the Haor Region**

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Report on

Impact Assessment of Structural Interventions in Haor Ecosystem

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Abbreviations and Acronyms

AEZ	Agro-Ecological Zones
AH	Asian Highway
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BDP	Bangladesh Delta Plan
BIWTA	Bangladesh Inland Water Transport Authority
BIDS	Bangladesh Institute of Development Studies
BINA	Bangladesh Institute of Nuclear Agriculture
BMD	Bangladesh Meteorological Department
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
CEGIS	Center for Environmental and Geographic Information Services
CNRS	Center for Natural Resource Studies
CALIP	Climate Adaptation and Livelihood Protection
CAD	Command Area Development
CIP	Country Investment Plan
DAE	Department of Agricultural Extension
DBHWD	Department of Bangladesh Haor and Wetlands Development
DoF	Department of Fisheries
DLS	Department of Livestock
DPP	Development of Project Proforma
DAP	Di-Ammonium Phosphate
DEM	Digital Elevation Model
DM	Disaster Management
EIP	Early Implementation Project
EPWAPDA	East Pakistan Water and Power Development Authority
ECA	Ecologically Critical Area
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FY	Financial Year
FAD	Fish Aggregating Device
FAP	Flood Action Plan
FC	Flood Control

FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FMD	Flood Management and Drainage
FGD	Focused Group Discussion
FMD	Foot and Mouth Diseases
GIS	Geographic Information System
GAP	Good Agricultural Practices
GoB	Government of Bangladesh
HILIP	Haor Infrastructure and livelihood Improvement Project
HMP	Haor Master Plan
HYV	High Yielding Varieties
IBA	Important Bird Area
IMD	Indian Meteorological Department
ICM	Integrated Crop Management
IPM	Integrated Pest Management
IFAD	International Fund for Agricultural Development
IUCN	International Union for Conservation of Nature
IRR	Irrigation
KKRMP	Kalni-Kushiyara River Management Project
KII	Key Informant Interview
LGED	Local Government Engineering Department
LPL	Lower Poverty Line
MoWR	Ministry of Water Resources
MPHA	Master Plan of Haor Area
MPO	Master Plan Organization
NWMP	National Water Management Plan
NAR	Net Attendance Ratio
NGO	Non-Government Organization
O&M	Operation and Maintenance
PSF	Pond Sand Filter
PIC	Project Implementation Committee
PA	Protected Area
PCM	Public Consultation Meeting
PPP	Public Private Partnership
RWS	Rainwater Harvesting System
R&I	Rehabilitation and Improvement

RS	Remote Sensing
RHD	Roads and Highways Department
SAT	Satellites
SRDI	Soil Resource Development Institute
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SDGs	Sustainable Development Goals
SIMT	System Improvement and Management Transfer
SRP	Systems Rehabilitation Project
WMIP	Water Management Improvement Project

Executive Summary

Haor area comprises mosaic of wetland habitat including rivers, streams, canals, large areas of seasonally flooded cultivated plains and beels, unique and rich ecosystem that naturally prevails and provides ecological safety net to all lives. It provides about 15% of total rice production, 20% of total fish habitat, 14% of total inland fish production, 35% of surface water for total irrigation. It is the habitat for 200 wetland plants, 11 amphibians, 257 birds, 29 mammals & 40 reptile species. The diverse nature of haors provide livelihood opportunities for about 20 million people actively supporting the sustainable economic condition of the country.

Bangladesh Water Development Board (BWDB) has implemented 118 FC/FCD/FCDI/IRR schemes from early ‘60s for water as well as flood management in haor area in a view to increase agricultural production, improvement of communication and saving life and properties from flash floods. Submergible embankments, regulator or sluices, culverts, irrigation inlets and drainage outlets, fish pass, rubber dam etc. have been constructed under these schemes. Interventions made under these schemes have both positive and negative impact on different components of haor ecosystem. This study aims to conduct environmental auditing of those schemes in terms of performance analysis of structures through evaluation of impact exerted by these interventions in haor ecosystem, compliance analysis and formulating mitigation measures. Evaluation of impact has been performed for BWDB schemes on the selected indicators of five relevant sectors namely: water resources and navigation; land, agriculture and livestock resources; fisheries resources, ecological resources and socio-economic resources.

In this regard, an inventory of structures has been made through collecting available data from secondary sources. Structural inventory has been made from available information on water management structures of Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED) and Roads and Highways Department (RHD). It has been found that, BWDB has constructed around 2,000 km of submersible embankments, 128 regulators, 65 sluices, 157 inlets, 21 outlets, 28 closures and 3 cross dams. LGED has constructed 24,948 km rural roads, 8 rubber dams, 123 regulators, 17 sluices, 23 inlets and outlets, 55 water retaining structures and RHD has constructed 430 km National Highways, 578 km Regional Highways, 937 km district road. There are 1,005 number of bridges and 2,074 number of culverts in the RHD road network of the haor region. Structures of Zila Parishad, Upazila Parishad, Union Parishad, Pouroshova and other NGOs are established in settlement area only. Therefore, structures of local government agencies and NGOs have not been included in the inventory preparation.

The directives regarding haor area in connection to infrastructural development mentioned in different literatures and the existing developments in the haor region have been reviewed to facilitate the environmental auditing under this study. A number of policies, acts, rules, strategies, plans, international conventions etc. relevant to above mentioned five sectors have been meticulously reviewed and the findings of the directives have been summarized under some thematic issues. Moreover, existing development in the haor region has also been reviewed as the Government of Bangladesh has taken several initiatives to manage water resources, flood, transportation system as well as poverty since early ‘60s in the haor areas.

Performing environmental auditing in all of the 118 BWDB schemes is a time consuming tasks. Due to time constraints, screening of existing 118 BWDB schemes has been performed on the basis of seven criterion i.e. schemes on ecologically important haor, types of haor, type of schemes, size of schemes, total percentage of intervened haors, water system and temporal and spatial distribution of schemes. Thirty schemes have been found which are explicitly representative of 118 schemes and spatially distributed over 6 districts (Sylhet, Sunamganj, Kishoreganj, Netrokona, Habiganj and Maulvibazar). Brahmanbaria has not been considered in screening process, because this district's hydrology has major influence of Comilla. In addition, three (3) control haors have been selected where no structural interventions has been made yet, but autonomous development has been taken place. Therefore, these control haors have facilitated evaluation of impact due to structural interventions only in haor ecosystem giving ideas about autonomous development.

Evaluation of impact has been performed for each of the selected indicators under five aforementioned sectors of thirty screened schemes. Glimpse of impact evaluation are as following:

Water Resources and Navigation

Satellite image analysis shows, in an average flood year around 2% and 10% of total FC/FCD/FCDI project area inundates in April and May respectively. But, in extreme year, around 15% and 50% of FC/FCD/FCDI project area inundates in April and May respectively. Risk of entrance of early flash floods reduced significantly due to implementation of BWDB projects by delaying entrance of water from mid-April to 15 May through constructing submergible embankments and compartmental dykes with 10 year return period design crest level. Lesson learns from 2017 event and frequency analysis of different stations along Surma-Kushiyara river system depicts that flood once in 5 year return period is normal in haor area and flood up to 10 year return period must be allowed in consideration with sustainable ecosystem of the haor area. Local people must have to be prepared for early flash floods greater than 10 year return period and authorized administration should have to formulate and implement pre and post disaster risk reduction program to tackle such havoc. Drainage situation has been deteriorated in most of the visited schemes due to high sedimentation. Boats ply over the years smoothly other than pre-monsoon season.

Land and Agriculture Resources

Implementation of BWDB schemes has made enabling environment for agriculture expansion. It is found that, in 2015-16, around 52% of the haor area is predominantly covered by Boro crops which is almost 100% higher than that of in early 70s. Around 98% of HYV Boro has been found in practise. Similarly, total cropped area has been increased in selected 30 haors due to decreasing of flood vulnerability through implementation of the project and agriculture extension services, though net cultivable area has been decreased in some haors due to expansion of settlement areas. The cropping intensity in the study area has been increased about 24% from pre-project situation due to crop diversification in the area. In haor area, Boro crops contribute around 63% of rice production. Currently (2015-16) this Boro production has been increased around 370% than early 70s due to implementation of interventions and agriculture extension services. In study area (30 haors), additional 0.39 million tons Boro rice is being produced annually in post project situation. But, crop damage area is increasing day by day due to reducing height of submersible embankment, malfunctioning of the sluice gates, regulators, pipe sluices and reduced water carrying as well as retention capacity of surrounding rivers, khals and beels. Annually 0.15 million ton Boro crop is being damaged due to flash flood and drainage congestion in the study area. After implementation of the project, the irrigation water demand has been increased due to cultivation of high water demanding HYV Boro instead of local Boro crop. On the other hand, the availability of surface water is being reduced due to siltation of surrounding rivers, khals and beels of the Haor area. Scarcity of irrigation water has been observed from early February to end of March in most of the year. Due to agriculture expansion and practising more HYV varieties, use of agro-chemical use has been increased. In addition, annually 75,390 tons of chemical fertilizers and 1060 tons or kilo litre pesticides are being used for cultivating crops and protecting crops from pest and diseases. Land degradation (1,361 ha) in terms of sand carpeting has been observed in Chandra Sonarthal haor, Kalner haor, Dhaleshwai river, Haizda Embankment, Mohadeo nadi, Naluar haor, Nautana khal, Updakhali haor area.

Fisheries Resources

The haor area comprises a wide variety of fishes including 143 indigenous and 12 exotic species along with a several species of freshwater prawns. An analysis between 1983 to 2014 reveal that, fish habitat area has been decreased by only 2%, but fish production has been increased around 9 times due to enabling environment by BWDB and autonomous development by fisheries extension agencies. The area of fish habitats altogether produce about 4.22 lac tons of fish in 2015 where 67.5% is capture fishery and the rest is from culture fishery. The production in floodplain and Beels has drastically increased from 2009-10 to 2014-15 due to floodplain stocking with carp fingerlings, Beel nursery programme, and the strengthening of conservation measures. The production trend of other habitats of the capture fishery was found more or less steady. On the other hand, production from pond fishery has gradually been increasing since 1996-97. In study area, gain of fish habitat area has been found in case of Bara Haor, Baram Haor, Chandra Sunarthal, Chaptir Haor, Chayer Haor, Hail Haor, Humaipur Haor, Jamkhola Haor, Nautana Haor, Pagner Haor, Singua River Project and Surma River System by about 19, 17, 1, 12, 214, 2060, 8, 1, 40, 14, 370, 1174 and 113 hectare respectively. Fish habitat has been lost in other selected haors of which Sari Goyain Project is worth mentioning. Fish habitat quality and water quality has been found degrading in all the projects due to incremental use of agrochemicals, pesticides and fertilizer and pollutant from different sources. Little imbalance has been found in fish species distribution over the area for all the haors. Lateral fish migration is highly obstructed in case of Kairdala Ratna Haor, Kalner Haor and Surma River System. But in case of Baram Haor, Jamkhola Haor, Nalua Haor and Tangua Haor, there is no significant implication of interventions on fish migration. Gain of fish production is commonly found in all the projects due to adoption of fisheries management like Beel fishery, Beel nursery, increasing fishing activities, fishing commercialization, stocking of culture fish species in Beel fishery, etc.

Ecological Resources

Construction of submergible embankment, water control structures and allied facilities with autonomous developments have negative impacts on wild floral and faunal communities. Most of the impacts are more or less similar for all the haors and none of the interventions are directly responsible for the changes of status of the ecological indicators. It is difficult to identify area specific and quantifying information on the indicators as local people are not very much concerned about biodiversity and wildlife habitats. On the other hand, around 40% perennial waterbodies has been decreased due to agriculture expansion. Therefore, natural vegetation coverage has been reduced due to crop cultivation and human habitation, increase of fuel demand. Karach, Pitali, Barun, Hijal etc have been reduced in the surrounding sites of homestead and kanda areas. Terrestrial faunal like small indian civet, fishing cat has been decreased/disappeared due to loss of habitat area. Habitat condition and diversity of aquatic flora has been decreased. The submerged vegetation has also been reduced to agriculture practice, leasing of beel for fisheries purposes. Wetland dependent mammal species (Eurasian Otter-Lutra lutra, Fishing Cat- Prionailurus viverrinus), turtle population (Spotted flap-shelled turtle- Lissemys punctata. water dependent frogs etc. have been reduced due to loss of connectivity between haor and river in some areas. Diversity and population of migratory waterfowl has been decreased due to habitat exploitation, hunting and toxic trapping. Reeds and swamp forest in most of the haor areas has been squeezed due to conversion into crop field, human settlement and cattle grazing etc. However, some positive impact has also been found. Secondary plantation and other conservation efforts have been taken place by different Go, NGO programs in few areas. Like, in Singua river system swamp trees like Hijal, Karach, Barun have taken place the reeds area and swamp forest coverage has been increased due to plantation. Therefore, provisioning services i.e. food; fuel wood, medicinal plants, genetic resources of flora and fauna has been boosted up.

Socio-economic Resources

The Haor system provides a wide range of economic and non-economic benefits to the local people as well as to the people of Bangladesh at large. In study area (30 haor), agriculture is recognized as the prime source of livelihood option and about 85% people mostly dependent on this prime source. It has been found that, agricultural production based income has risen to around BDT 32 billion due to the increased crop production. Agricultural labor employment opportunity has been increased by about 11% while agricultural wage based income has been increased by 37%. Safety and security of settlement area has been improved due to protection from flash flood. Seasonal labor migration has been increased while permanent migration has been decreased. The communication system has been improved due to the interventions like roads and submergible embankments. Increased affordability and accessibility has improved the quality and standard of life (i.e Health, Education and Sanitation etc). However, lack of participatory governance and monitoring system is creating obstacles in getting solution for the emerging problems on the livelihood issues in the Haor regions.

Compliance of the interventions with project objectives and compliance with Policy, Act, Rules, Strategy, Plan and International Conventions have been performed as a part of environmental auditing. Compliance with the relevant Policy, Act, Rules, Strategy, Plan and International Conventions has been checked if they were enacted prior to the initiation of a project. Since, 23 projects were implemented from 1957 to 1990 and only 7 projects were implemented from 1991 to 2006; a few projects were applicable for compliance assessment with the Policy, Act, Rules, Strategy, Plan and International Conventions that were formulated after the year 1991. All the 30 selected FC/FCD/FCDI projects under this study have complied with their objectives of controlling flood and increased crop production in the project area. Among thirty, 29 projects have complied with the directives of the Embankment & Drainage Act, 1952 regarding flood and drainage management. Directives of the Embankment and Drainage Act, 1952 regarding regular maintenance and rehabilitation need to comply by all the projects. Directives of the Protection and Conservation of Fish Act, 1950 regarding development of fish friendly infrastructure need to comply by all the projects. Directives of the Bangladesh Environment Conservation Act, 1995 is also needed to be complied by 4 projects.

Evaluation of impact and this compliance assessment have facilitated in identification of necessary mitigation measures to mitigate negative impacts through addressing the gaps for compliance with the project objective and policy directives. Moreover, 14 local workshops were held to validate ad disseminate of the study findings among local stakeholders. Overall findings of these 14 local workshops validate our study findings almost. In some cases, perceptions of local stakeholders have been deviated from our findings because of emphasizing on recent years occurrence more.

Following mitigation measures have been identified on the basis of recommendation made for thirty schemes individually and taking perceptions of local stakeholders through conducting 14 local workshops:

Water Resources and Navigation

- Re-excavation of internal Khals and Beels
- Regular maintenance dredging work in peripheral Rivers
- Maintain connectivity of inter and intra hydrological network of Haor
- Eco-friendly water regulation structures for smooth drainage and navigation
- Review of design crest level of submersible embankments through comprehensive study
- Regular and timely operation and maintenance work
- Construction of suitable structures over embankment to ensure navigability in pre-monsoon
- New submersible embankments in required locations
- Awareness raising program against public cuts
- Ensure participation of local stakeholders in Haor management.

Land and Agriculture Resources

- Strengthen and developed short duration and flood tolerant crop varieties
- Suitable variety selection according to land type
- Strengthening and introducing special system of agricultural practice during monsoon season
- Regular maintenance of earthen embankment and water control structure
- Re-excavation of rivers, khals and beels
- Encourage to use of organic fertilizers and leguminous crops
- Encourage to use of modern agricultural technology (IPM/ICM/GAP).

Fisheries Resources

- River dredging
- Re-excavation of internal Khals
- Fish friendly water control structures
- Re-excavation of Beels
- Promotion of Beel sanctuary.
- Promotion of Beel nursery program
- Ban unconventional fishing appliances
- Optimum use of agrochemicals and pesticides and fertilizer
- Stop discharging of untreated industrial effluent

- Promotion of community based fisheries.

Ecological Resources

- Conserve natural vegetation in fallow land, reedland and swamp forests
- Identify the core habitat for the threatened animals and take action to conserve the respective habitats
- Demark every beel's perennial boundaries and enforce law and order to ban agricultural extension and ban fully drying of wetland for fish catch
- Ban leasing or allotment systems for all the khash land with swamp forest and reedlands
- People awareness for wildlife conservation and optimum use of pesticides and fertilizers
- Implement Plantation programme along the river levees, embankment slopes, kandas and other khash lands with the attachment of plant specialist and involve local people for nursery raising
- Introduction of Eco friendly tourism according the relevant policy and laws
- Initiate commercial production of freshwater snails for meeting up duck feeds
- Implement proper land use planning including natural vegetation and wildlife conservation provision
- Consider design level for keeping minimum water depth inside beels and connecting khals throughout the year
- Consider structure design to ensure better movement of snail and other fishes
- Involvement of Forest Department for conserving every swamp forest.

Socio-economic Resources

- A functional PIC and monitoring should be formed and play proactive role considering the all stakeholders concern for O&M in the Haor region
- Local People's feedback should be taken before the implementation of any policy, plan and program in the Haor regions
- Alternative training and soft loan would be provided to enhance resilience for the development of entrepreneurship.

Chapter 1: Introduction

1.1 Background

Haors are bowl shaped depressions of considerable aerial extent and unique hydro-ecological characteristics lying between natural levees of the rivers or high lands. It is a mosaic of wetland habitat including rivers, streams, canals, large areas of seasonally flooded cultivated plains and beels, sporting rich ecosystem that naturally prevails and provides ecological safety net to all lives. The north-eastern haors cover an area close to 20,000 km^2, which is about 15% of the country and 44% of the total haor region and are distributed among the northeastern districts of Sylhet, Sunamganj, Maulvibazar, Habiganj, Netrokona, Brahmanbaria and Kishoregonj. Haors provide the most valuable and productive ecosystems on earth and offer important opportunities for sustainable development. The diverse nature of haors provide livelihood opportunities for the 20 million people that reside in the region and in doing so actively supports the sustainable economic condition of the country.

The livelihood of the people living in the haor area mainly depends on the production of Boro Rice across this region. In the financial year 2015-16, 3.3 million tons of Boro Rice was produced here which was 15% of total Boro production of the country. Overall rice production in the haor area for the FY 2015-16 was 5.21 million tons and it was about 15% of the total rice production of Bangladesh. Around 60% agricultural land of the haor region was irrigated by surface water which amounts to 35% of the country.

The haor area of Bangladesh is the habitat to 143 nos. of native fin fish and 8 nos. of exotic fish species. Some unique fish species such as Rani, Lasu, Ghonia, Mohashol, Nanid, Tila Shol etc. are found here. Approximately, 4.70 million hectares of area is fish habitats which is around 20% of the total fish habitat of the country. The total fisheries production in the FY 2015-16 was 3.08 Million Metric Tons in the haor area comprising of 14% of the total inland fisheries production of the country. Around 0.42 Million MT of capture fisheries comes from the haor area having a contribution of around 84% in the total capture fisheries production of the country.

The haor area is the habitat for 200 wetland plants, 11 amphibians, 257 birds, 29 mammals & 40 reptile species. Tanguar Haor is designated as Ramsar Site which seasonally harbor up to 60,000 migratory birds and possesses 206 species. It provides ecosystem services like flood control, ground water replenishment, sediment and nutrient retention, water purification, reservoirs of biodiversity, food production, cultural values, recreation and tourism etc.

Being a riverine country, water has always played a vital role in governing infrastructural development in Bangladesh. Haors, being submerged for half the year is thus also fundamentally attached to this notion. Every infrastructural intervention in the haor area is done keeping this imminent submergence in calculations. For example, a road network thus has to house not only bridges where required but also a predefined number of culverts that might remain dry for a portion of the year, sluice gates operate on periodic regulation of water allocation etc. Moreover, degradation of wetland resources in Bangladesh is also increasing due to rural infrastructures, water management structures, irrigation and flood management structures, and associated disturbances. Continuous degradation is creating threats for the living condition of local people and deteriorating their livelihoods, socio-economic condition and the wetland-based ecosystem. These great number of interventions although made keeping a probable submerged scenario in mind, exerts impact upon the dry period ecosystem and livelihood which necessitates a detailed study assessing their physical and environmental impact on the surroundings.

Bangladesh Water Development Board (BWDB) has implemented 118 FC/FCD/FCDI/IRR schemes from early '60s for water as well as flood management in haor area in a view to facilitate boosting up of agricultural production, improvement of communication and saving life and properties from distress of flash floods. Submergible embankments, regulator or sluices, culverts, irrigation inlets and drainage outlets, fish pass, rubber dam etc. have been constructed under these schemes. Interventions made under these schemes have both positive and negative impact on different components of haor ecosystem. An account of physical impacts exerted by these interventions is necessary in planning a long term management plan for the area. Monitoring the environmental management plans (EMP) for existing structures and reassessing wherever necessary will ensure smooth functioning of not only said structure but also of ambient environment. In this regard, environmental auditing of schemes of BWDB has been performed in this study in respect to impact assessment of infrastructural interventions on environment.

1.2 Objectives

The overall objectives of this study is to assess the impacts of existing major structural interventions on environment for conducting auditing of undertaken schemes by Bangladesh Water Development Board (BWDB) and also to formulate mitigation measures for mitigating negative impacts exerted by these schemes.

The specific objectives of the project are to:

- Develop of inventory of infrastructure in the haor ecosystem
- Assess the impacts of existing water management infrastructures in the haor ecosystem
- Conduct environmental auditing to determine the effectiveness of the Environmental Management Plan (EMP)
- Formulate mitigation measures to facilitate preparation of Environment Management Plan (EMP) in future.

1.3 Scope of Works

Scope of works of this study are as following:

- Review of relevant national and international policies, acts, rules and strategies to assess directives on different environmental issues may be arisen by development activities on haor ecosystem.
- Review of development initiatives undertaken by different implementing or regulatory agencies of Government of Bangladesh (GoB) notably Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Roads and highways Department (RHD) and Department of Bangladesh Haor and Wetlands Development (DBHWD).
- Collection of available data of water management infrastructures in haor area constructed by different agencies specifically Bangladesh Water Development Board (BWDB), Local government Engineering Department (LGED) and Roads and Highways Department (RHD) since early '60s.

- Preparation of inventory of infrastructures in haor ecosystem accumulating both basic and detailed information under different schemes
- Screening of schemes from 118 schemes of Bangladesh Water Development Board (BWDB) which are representatives of all of BWDB schemes in the haor area.
- Selection of important environmental indicators for different component of environment i.e water resources and navigation, land and agriculture resources, fisheries resources, ecological resources and socio-economic resources.
- Field level data collection for identified indicators using participatory approach i.e. Focused Group Discussions (FGDs), Public Consultation Meeting (PCM) and Key Informant Interview (KII) and for pre and post project condition of each of the screened schemes.
- Assessment of the impacts of existing water management infrastructures analyzing pre and post project condition situation of each of the identified indicators under each of the selected sectors.
- Assessment of compliance and gap against project and policy objectives for each of the screened schemes.
- Formulation of mitigation measures for assessed negative impacts exerted by interventions.
- Validation of assessed impacts and mitigation measures through conducting several local stakeholder workshops.
- Finalization of environmental audit report for whole haor region on the basis of assessed impact and formulated mitigation measures of screened schemes.
- Dissemination of findings of this study through a national workshop.

1.4 Study Area

Haor area comprises of seven districts namely Sylhet, Sunamganj, Maulvibazar, Habiganj, Netrokona, Brahmanbaria and Kishoregonj covering 20,000 sq.km area. Implementation agencies of Government of Bangladesh (GoB) like Bangladesh Water Development Board (BWDB), Local Governement Engineering Department (LGED), Roads and Highways Department (RHD) have taken several initiatives since early ‘60s in these seven districts. These seven districts are hydrologically interlinked and functioned as a unique ecosystem. Therefore, it is rationale to select this whole ecosystem as study area to ascertain cumulative impacts of interventions as well as to conduct environmental auditing undertaken by implementing agencies. Hence, study area of this study has been taken as whole haor area delineated by Haor Master Plan (2012).

1.5 Limitation

Like any such study the present one also has some limitations, which are:

- Available data of major water management structures in haor area has been collected based on secondary sources and field office visit

- Available data of major water management structures has been collected for Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED) and Roads and Highways Department only.
- Impact assessment has been performed using participatory approach and recall method, as it is not possible to draw a baseline of pre or post project condition other than this method which was implemented 40 to 20 years earlier.
- Environmental audit has been performed in respect to impact assessment of structural interventions, compliance analysis against project and policy objectives as there is no Environment Management Plan (EMP) available for implemented projects in haor area.

In addition, it is worth to mention that, time constraints are the major one limitations of the study, which basically triggers all of the above mentioned limitations.

Chapter 2:   Physical Setting of the Area

2.1 Introduction

This Study area covers the haor basin located at the north-eastern region of Bangladesh which is surrounded by the hill ranges of Meghalaya (India) on the north, the hills of Tripura and Mizoram (India) on the south, and the highlands of Manipur (India) on the east. Haors with their unique hydro-ecological characteristics are located in this region of Bangladesh covering about 4600 sq. km of area. They are bowl-shaped large tectonic depressions, receive surface runoff water by rivers and khals and become very extensive water body in the monsoon but dries up mostly in the post-monsoon period. The region is situated just below the hilly regions of the States of Assam, Meghalaya and Tripura of India (Figure 2.1), experiences some of the most severe hydrological events. The annual rainfall ranges from 2,200 mm along the western boundary to 5,800 mm in its northeast corner (MPHA, 2012). Surma, Kushiyara, Manu, Khowai, Someswari, etc. are major rivers in this region having catchments in the hills of India.

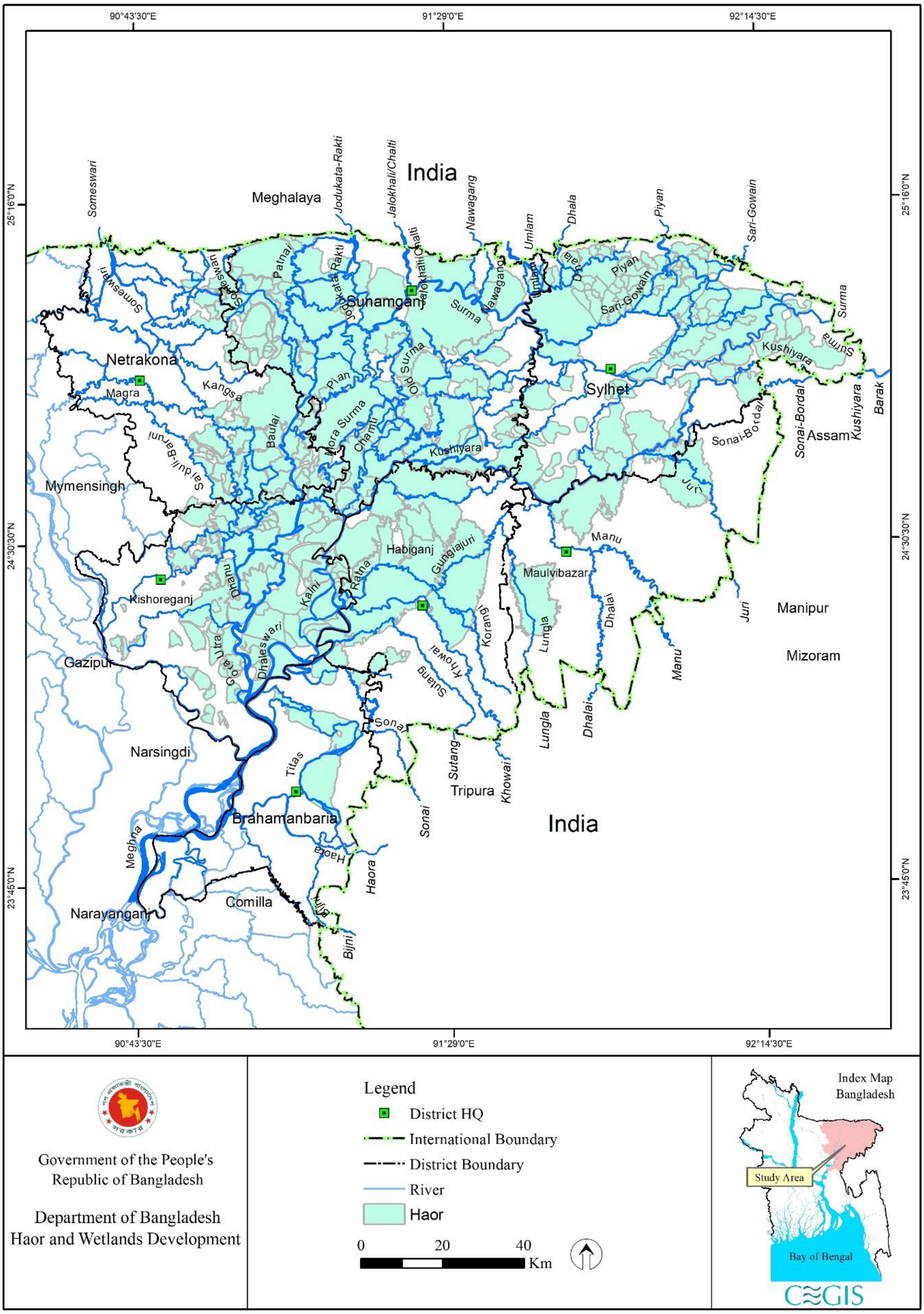


Figure 2.1: Haor area in the north-eastern region of Bangladesh

2.2 Topography

The primary haor region formed through the eastern continuation of the central broad Indo–Gangetic plains. Evolution of the Indian sub-continent has been the result of a collision between the northward moving Indian plate and the Stationary Eurasian Plate since the Cretaceous times. Parts of this plate has further fractured and sunk below the sea-level during Oligocene period. The Bengal Basin started to take shape post this event and started filling up with sediment through a process of deltaic sedimentation, eventually turning into a slowly subsiding tectonic basin. The Bengal Basin of modern times is primarily located within Bangladesh, with small parts in the West Bengal.

2.2.1 Digital Elevation Model (DEM)

The north-eastern haor region falls within the Bengal Basin engulfed by India on the north, east and southern borders. The Sylhet Trough is a sub-basin of the Bengal Basin and consists of 13-20 km thick alluvial and deltaic sediments underlain by much older gneiss and granite rocks. The basin is bounded by the Shillong Plateau in the north, the Indian Burmese ranges in the east and by the Indian Shield in the west. The north eastern haor region has been experiencing some profound subsidence in recent decades. The Sylhet Basin has subsided 10-12 m in the last several hundred years with an annual subsidence rate of 21 mm which appears to be arrived at by using Morgan and McIntire’s estimate of 10 m subsidence in 500 years. With an annual consideration of subsidence at 2-4 mm and a soil compaction rate of 1-2 mm/yr, the actual subsidence rate of the Sylhet Basin might be approximately 3-6 mm/yr. The southern and eastern parts of the Sylhet Basin are characterized by a series of north trending folds which have formed as a result of deformation from the Indo-Burmese ranges. The anticlines constitute the Tripura Hills along the southern border of the region.

The general topographical layout of the haor region is represented in Table 2.1 and has been derived from the digital elevation model (DEM) illustrated in Figure 2.2.

Table 2.1: Topography of the Haor Region

Elevation (m)	Area (km^2)	% Area
<= 1	4	0
1-5	6708	34
5-10	8948	46
10-50	3759	19
50 - 100	223	1
100 - 310	19	0

Source: NWRD

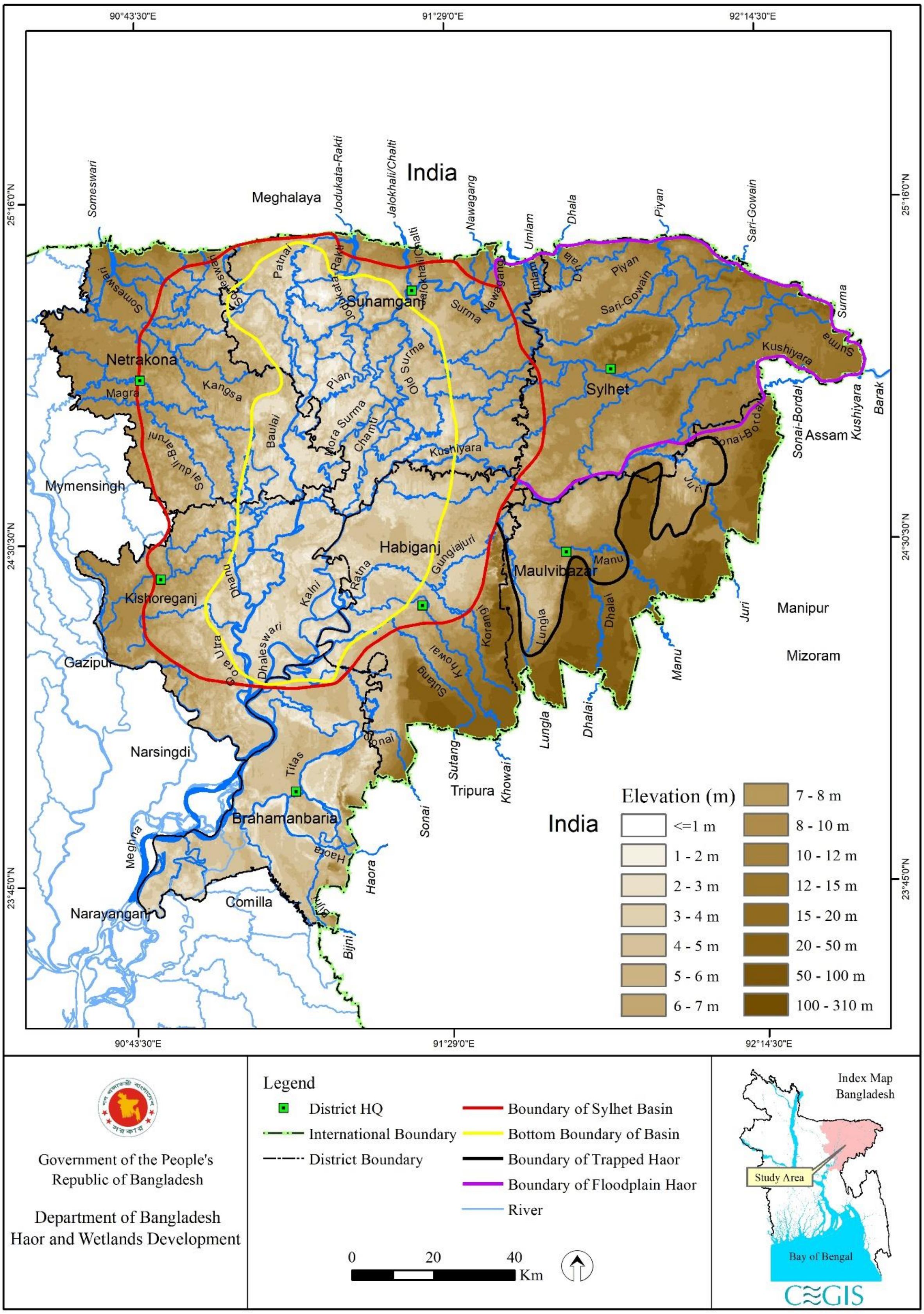


Figure 2.2: Illustration of Digital Elevation Model (DEM) for north-eastern Bangladesh

The statistics indicate the nature of land formation in the Haor region. It is observed that almost 35% of the region is below 5 m elevation whereas 80% of the region is within 10 m elevation. There are very small amounts of low hilly terrain scattered throughout the region. The north-eastern Sylhet Haor region engulfs the Sylhet Basin which covers an area of about 8724 km^2 from where the topography starts to slope down to form the bowl shaped terrain with a depressed area of about 4600 km^2. The average sloping for the region is 0.03-0.25 m/m in the western portion and 0.08-0.14 m/m in the eastern region.

2.2.2 Land Use and Soil

The region is bounded by the hilly ranges of Meghalaya (India) to the north, the hills of Tripura and Mizoram (India) to the south, and the highlands of Manipur (India) to the east. Netrokona District of Mymensingh Division lies to the west. Numerous intersecting floodplains of rivers in the hilly region of India provides abundant supply of water to these plains submerging the land during monsoon periods and causing flash flooding upto depths of 6m. Small permanent water bodies within the haors remain underwater for prolonged period of time. A lot of these *beels* are perennial and constitute lowermost parts of the depressions. Land type classification is based on the depth of inundation during monsoon season due to flooding of agricultural land. There are five land types classified by the MPO study: High land (F0 – above flood level), medium highland (F1 – flood depth of 0-90 cm), medium lowland (F2 – flood depth of 90-180 cm), Lowland (F3 – flood depth of 90-270 cm) and very lowland (F4 – flood depth in excess of 270 cm).

The haor region houses nine of the Agro-Ecological Zones (Figure 2.3). Among these AEZ are the, (1) the Sylhet Basin, (2) the Eastern Surma Kushiyara Floodplain, (3) the Old Meghna Estuarine Floodplain, (4) the Old Brahmaputra Floodplain, (5) the Middle Meghna River Floodplain, (6) the Young Brahmaputra and Jamuna Floodplain, (7) the Northern and Western Piedmont Plains, (8) the Northern and Eastern Hill and (9) the Akhaura Terrace. Among these, the main haor basin includes only three AEZs namely, the Sylhet Basin, the Eastern Surma Kushiyara Floodplain and the Old Meghna Estuarine Floodplain.

Waterways are extensively used for local riverine transportation and for carrying bamboo rafts especially during the monsoon season. The permanent water bodies support a rich and diverse aquatic habitat comprising unique assembly of flora. Apart from this, water bodies are mostly used for fishing management and extractable wetland resources which includes thatching materials, animals fodder, wild plant, fruits, food, fuel wood supplement and transport.

Soil within the haor system can vary in texture, drainage type, fertility and other parameters. The soils of the area are grey silty clay loams and clay loam on the higher parts that dry out seasonally and grey clays in the wet basin. About 74% of the top soil texture of the haor region is clay to clay loam, 21% loam and the rest are silty loam, sandy loam and sand. The soils have a moderate content of organic matter and soil reaction is mainly acidic. The transition from the wettest to the driest areas in the floodplains occurs over distances varying from several kilometers to several meters. Peat occupies some wet basin centers. About 44% of the area is covered with high to medium high organic matter where organic content is more than 3.4%. This helps the soil to soften making land preparation easy and increases its moisture holding capacity, retaining the nutrient status of soil. The rest of the area has low to very low organic matter content. The fertility level is medium to high.

Majority of water bodies and land within the region government owned (khas land) and are generally leased out on a yearly basis for fishing or other activities. During the winter season when the water level is lower, marginal land of the haor are cultivated with paddy.

Approximately 21% of cultivable area is subject to sub-par drainage, where floodwater retains for nearly 15 days whereas 61% of cultivable area are poorly drained and can remain submerged for up to eight months. About 10% of cultivable areas are very poorly drained, keeping the area almost perennially wet. The rest of the area (8%) experiences quick rainwater recession from soil surface and is thus well-drained. Apart from agricultural activities, the levees and the fallow land are used for cattle grazing. Most of the surrounding areas are used for rice cultivation with some vegetable growing. Table 2.2 and Figure 2.4 represents the landuse pattern of the haor area.

Table 2.2: Land Use within the Haor area

Land Type	Area (ha)	Area in %
Agriculture Land	13109	66
Settlement(homestead, pond and Road)	3724	19
Hill	1334	7
Forest(Excluding hill forest)	663	3
Perennial water bodies	484	2
River	419	2
Canal/Khal	264	1
Total	**19998**	**100**

Source: MPHA, 2012

Land use plans and agreements can be used by the public sector, private sector, local governments and other resource managers in formulating strategic level schemes about land and resource allocation and management. Therefore, land use must be planned in a way that the needs of future generations are met in a sustainable manner. For sustainability, a number of different forms of land use plans based on land suitability can be derived to give direction for the management and allocation of public lands and resources over a defined area.

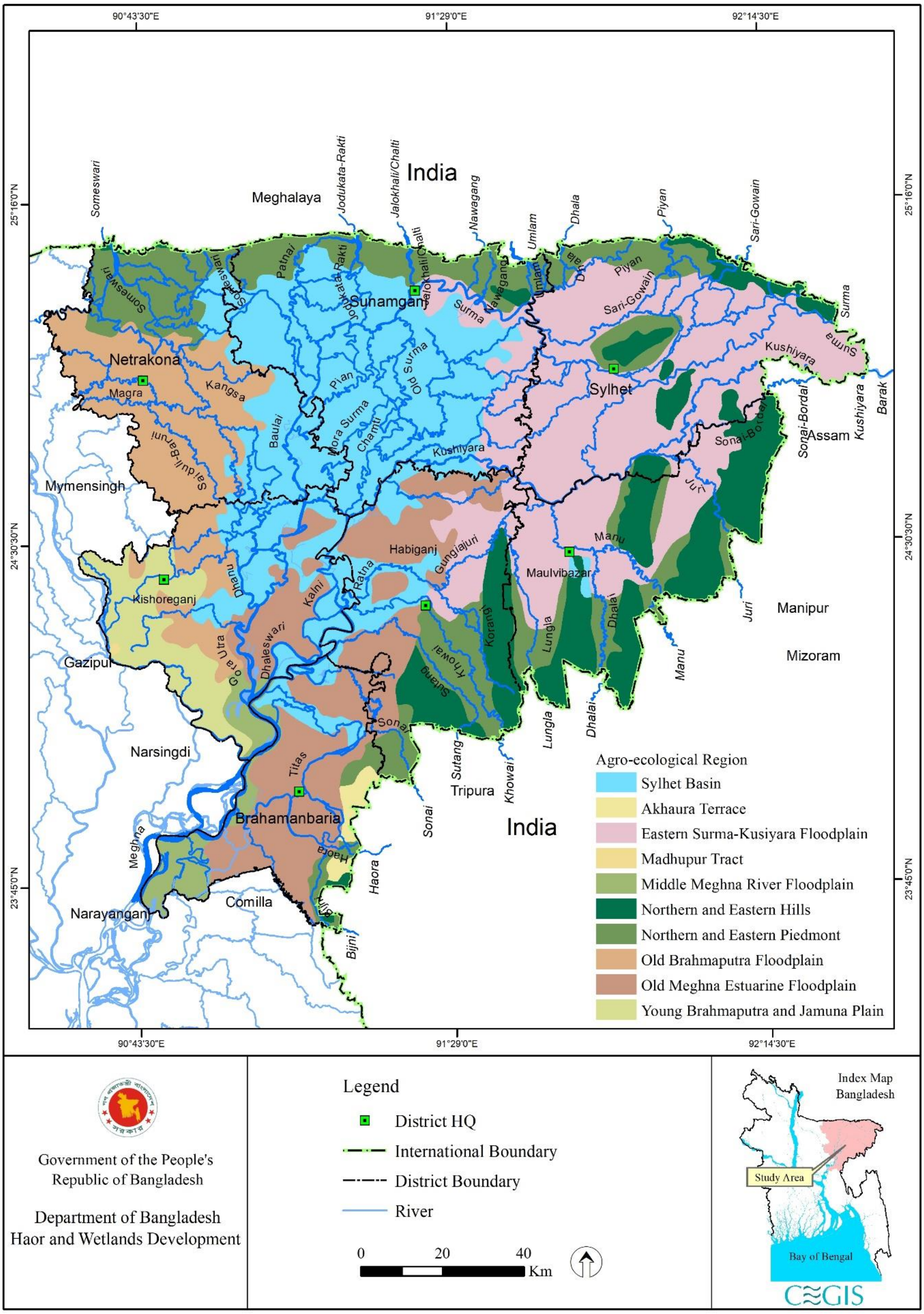


Figure 2.3: Agro-ecological zones within the haor area

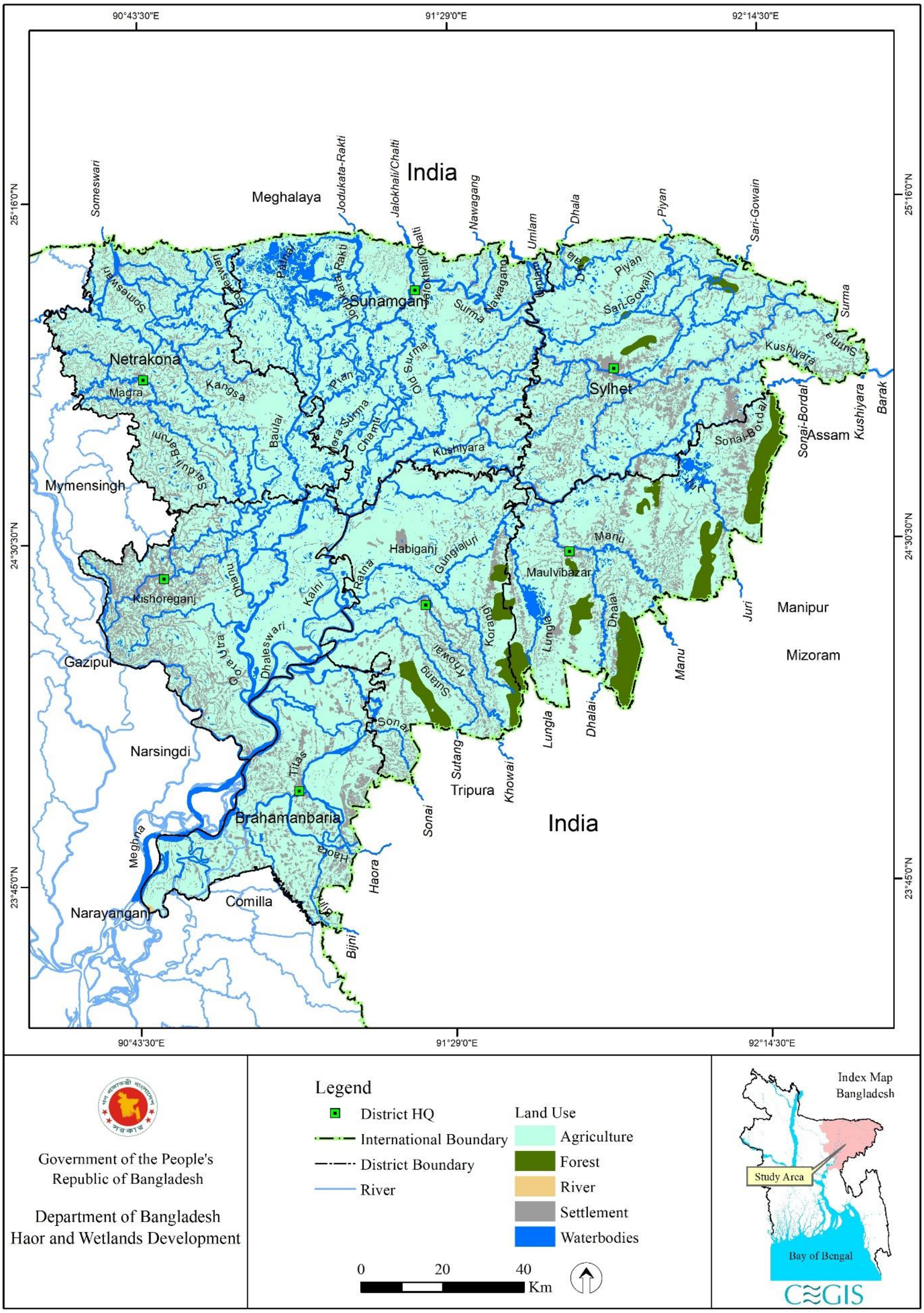


Figure 2.4: Land Use within the Haor area

2.3 Climate

Climate of the haor area is dominated by unique geographical characteristics of the region, which ultimately plays the main role in determining the spatial and temporal distribution of rainfall, evapotranspiration and hydrology of surface and groundwater. The North East Region is located entirely to the north of the Tropic of Cancer; hence, its monsoon climate is described as sub-tropical. The sub-tropical monsoon climate tends to have more sharply defined seasons than the tropical one. Some salient features of climate of the area are discussed here.

2.3.1 Rainfall

The southwest monsoon carries moist winds into the Haor Region from the Bay of Bengal along a circular route over the Chittagong region so that the winds actually approach the Region from the southeast. Rainfall in this season is abundant and it is often referred to as "the monsoon", meaning the rainy season. Typically, rainfall increases northeastwards across the Region and reaches a maximum on the southward-facing slopes of the Shillong Plateau in Meghalaya (India). Cherrapunji (India), located on these slopes, is well known as the wettest place on Earth, its annual rainfall often exceeds 12 m. Across the North East Region annual rainfall from around 2,400 mm in the southwest to around 5,500 mm in the northeast (Figure 2.5). It has been found that monsoon (June to September) contributes around 60% of annual rainfall whereas pre-monsoon adds about 20%.

Among seven districts of the haor area, Sunamganj has the highest annual rainfall. The highest mean annual rainfall varies within 3,600 mm and 7,800 mm in Sunamganj. The following table (Table 2.3) shows the range of the mean annual average rainfall in the seven districts of the haor area.

Table 2.3: Average rainfall at different districts (1960-2009)

Name of District	Range of Mean Annual Rainfall (mm)
Sunamganj	3,600-7,800
Sylhet	3,400-7,400
Netrakona	3,200-4,800
Maulvibazar	2,600-3,800
Habiganj	2,200-3,500
Kishorganj	2,000-3,400
Brahmanbaria	2,000-2,500

Source: NWRD

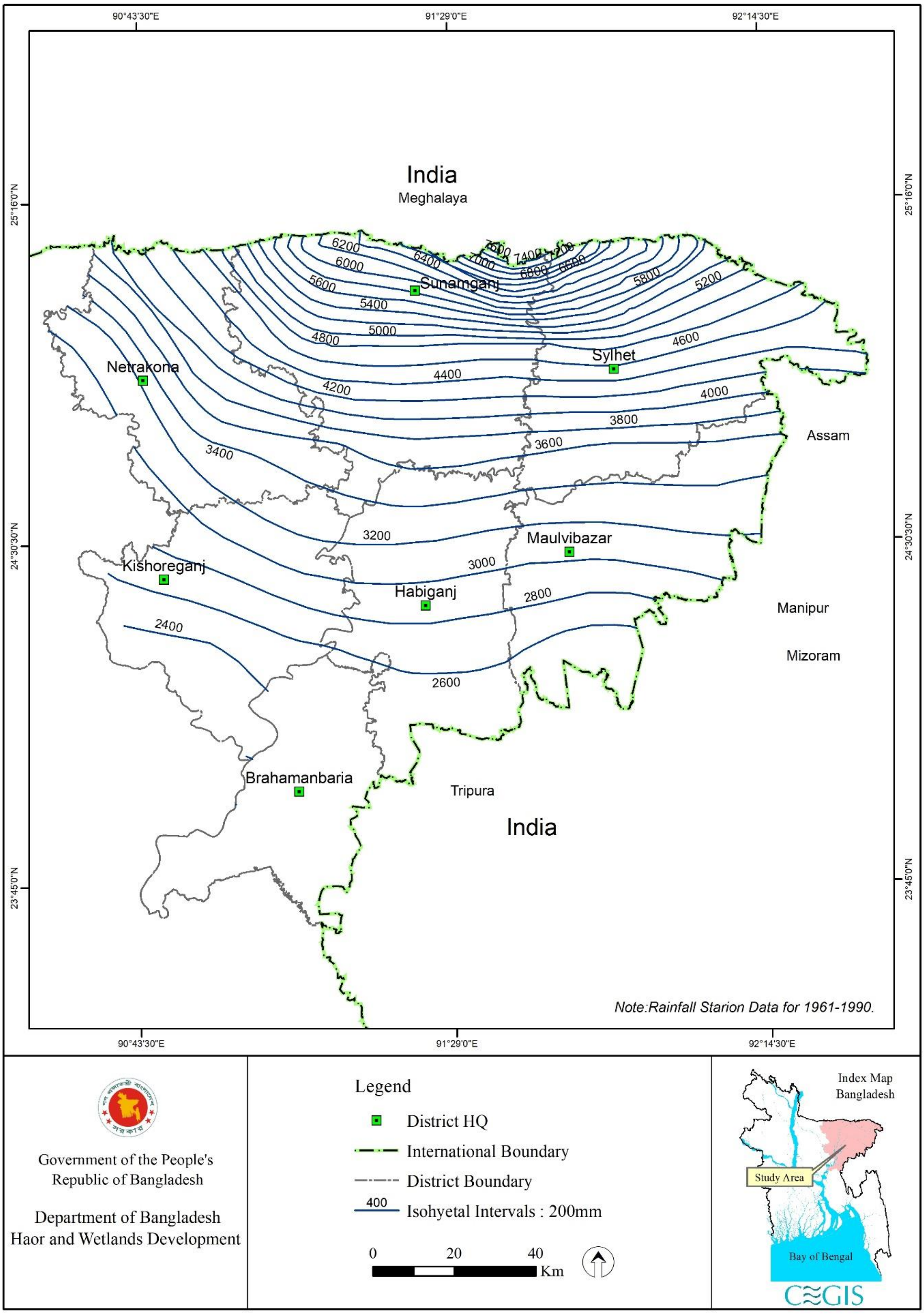


Figure 2.5: Mean annual rainfall of the haor area

Rainfall data from 1960 to 2009 are analysed to investigate the trend of annual rainfall. Previous data are extracted from the FAP 6 study. The analysis shows a continuous increasing trend of annual rainfall in this area. Table 2.4 shows the overall change in the North East Region as well as the haor area.

Table 2.4: Annual average rainfall in different periods

Period	Mean Annual Rainfall (mm)
1901-1930*	2,871
1931-1960*	2,987
1960-1990**	3,180
1960-2009**	3,230

**Source: FAP 6 for North East Region, **Source: BWDB for the haor area*

2.3.2 Temperature

Temperature data from 1960 to 2008 shows that the average maximum temperature is highest in Sreemangal (33.0 ^{0}C) in the month of April (Table 2.5). On the other hand, January was the coldest month (9.1 ^{0}C) considering the average minimum temperature (Table 2.6).

Table 2.5: Monthly average maximum temperature (^{0}C)

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sylhet	25.17	27.36	30.58	31.13	30.87	30.76	31.06	31.57	31.32	30.81	29.08	26.41
Sreemangal	25.30	27.99	31.69	33.02	32.33	31.83	31.93	32.25	32.09	31.21	29.02	26.46
Mymensingh	24.50	27.25	31.05	32.40	31.76	31.30	31.20	31.61	31.46	31.17	29.24	26.08
Comilla	25.31	27.98	31.31	32.60	32.73	31.56	31.02	31.42	31.73	31.32	29.51	26.53

Source: NWRD

Table 2.6: Monthly average minimum temperature (^{0}C)

Station name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sylhet	12.55	14.42	18.22	21.10	22.76	24.50	25.07	25.15	24.56	22.57	18.25	14.22
Sreemangal	9.09	11.70	16.88	21.02	22.88	24.54	25.01	25.03	24.43	21.73	15.99	11.01
Mymensingh	11.87	14.39	18.47	22.15	23.44	25.37	25.86	25.98	25.46	23.39	18.30	13.47
Comilla	12.14	15.22	19.69	22.93	24.22	25.21	25.38	25.35	25.20	23.48	18.74	13.57

Source: NWRD

Analysis of annual average temperature in Sylhet station shows (Figure 2.6) gradual increasing trend, which depicts that annual average temperature is gradually rising in this region. Here the anaylsis has been done based in Sylhet station based on annual average temperature data of 1956-2013 from Bangladesh Meteorological Department (BMD).

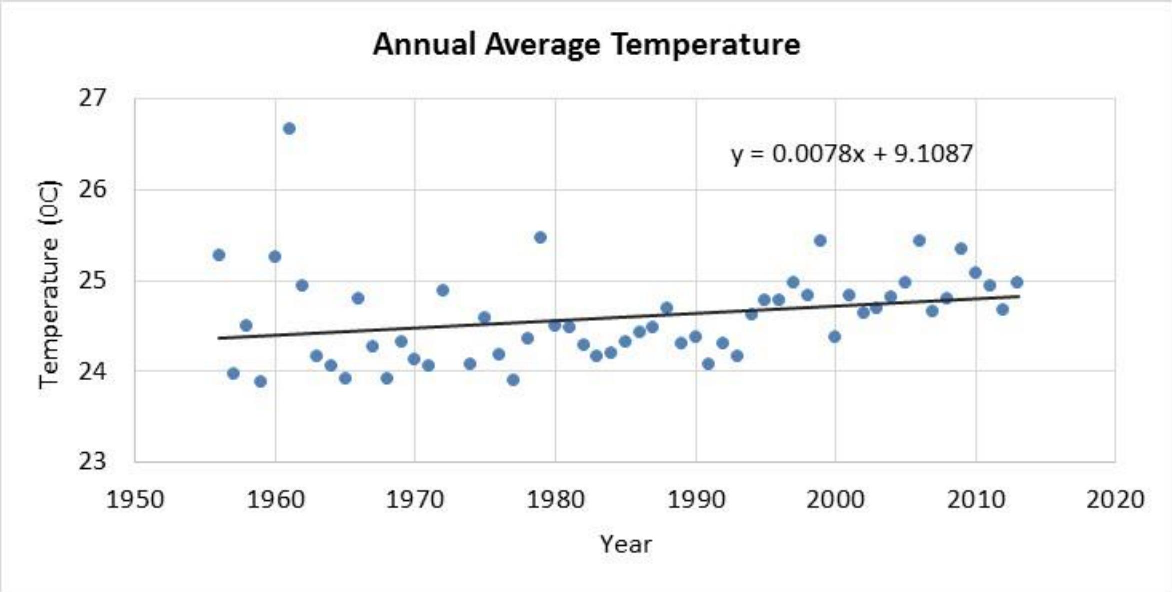


Figure 2.6: Annual average temperature for Sylhet station (1956-2013)

2.4 Water Resources System

2.4.1 River Network

The haor region lies in the Meghna basin which is 69,514 km^2 and 33% of this area fall within Bangladesh. The Meghna basin is drained ultimately into the Bay of Bengal through the Kalni-Kushiyara and Surma- Baulai system on average 159,087 million m^3/year. Of this flow, 56% is generated at the upstream of Bangladesh while 44% is generated within the country.

Many trans-boundary rivers enter in the north-eastern region of Bangladesh, of which most of the portion of catchments of these rivers are located outside the country. Among them The Barak River (Indian River) feeds the Surma and the Kushiyara and consequently, it also contribute in the other two major systems, namely the Surma-Baulai and the Kalni-Kushiyara.

Barak System

The Barak-Surma-Kushiyara river system is one of the three major river systems of Bangladesh. The length of the Barak River is 460 km inside India. The catchment area of the Barak is 26,165 km^2 which lies entirely within India. The Barak enters into Bangladesh from northeast India at Amalshid (Indo-Bangladesh border) where it is divided into two rivers: the northern branch is the Surma River and the southern branch is the Kushiyara River. Two-thirds of the average flow of the Barak passes into the Kushiyara, and the rest flows into the Surma at this station. The time series data (from 1980-2008) shows that the flow distribution of the Surma and the Kushiyara is around 40% and 60% respectively for all seasons except the dry season (MPHA, 2012). But in dry season Kushiyara carries major part (88% of total catchment flow) to this catchment.

Surma-Baulai System

The Transboundary Rivers Jadukata, Jalokhali, Nawagang, Umlam, Dhala, Piyan, Sari-Gowain and Surma enter into Bangladesh from India in this system. Surma carries one-thirds of the Barak's flows. In Bangladesh, the length of the Surma River is about 388 km, which meets the Kushiyara River at Bhairab upazila of Kishoreganj district. The Baulai is another important river of this system which flows entirely within Bangladesh. The total length of the

Baulai is about 134 km flowing from north to south. The Sari-Gowain River is one of the tributaries of the Surma River which enters Bangladesh through the northern part of Jaintiapur upazila in Sylhet district flowing about 85 km southwestward of Sylhet district. Baulai River receives flow from the Goyain River at Gowainghat upazila and transports a huge amount of sediments from the upstream.

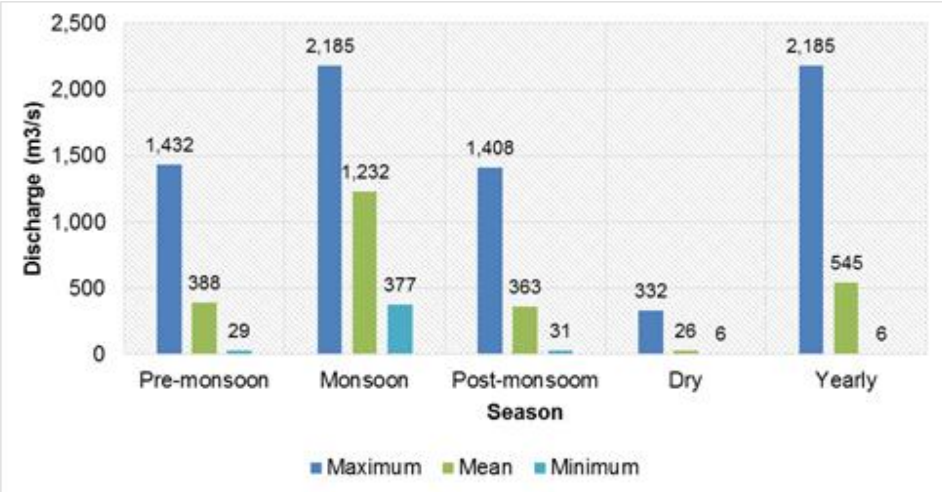


Figure 2.7: Seasonal variations of hydrological parameter (discharge) in the Surma River at Kanairghat

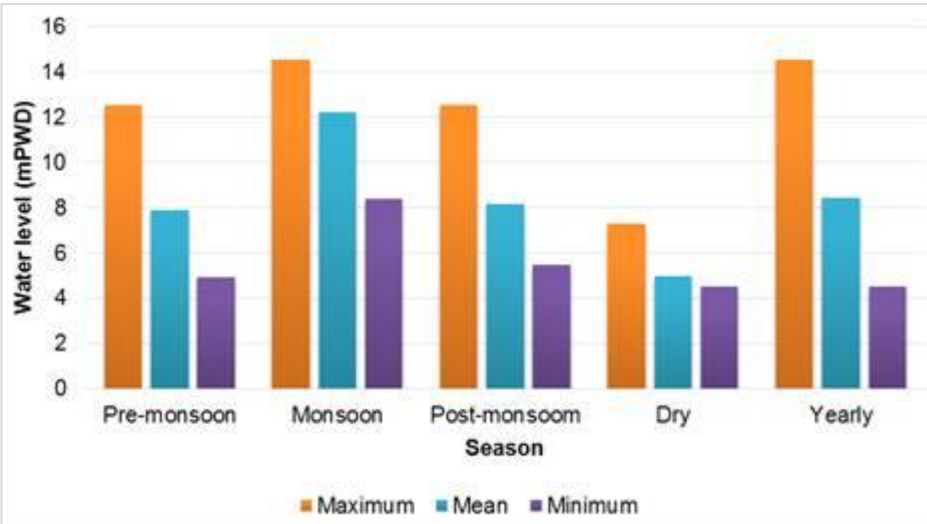


Figure 2.8: Seasonal variations of hydrological parameter (water level) in the Surma River at Kanairghat

Kalni-Kushiyara System

Kalni-Kushiyara system consists of the Sonai-Bordal, the Juri, the Manu, the Dhalai, the Laungla, the Sutang, the Khowai, the Sonai, the Haora and the Bijni rivers, which enter into Bangladesh and flow through this river system. The Kushiyara is the most important river of this system which is fed by the Barak's two third flows having catchment area of about 8,705 km^2. It travels around 170 km from Amalshid and inside Bangladesh, the Kushiyara carries the flows of the Sonai-Bordal, the Juri, the Manu and the Dhalai. The downstream portion of the Kushiyara is the Kalni, which carries the flow of Gangajuri and Ratnai rivers. In this river system the Gangaijuri River carries the combined flow of the Laungla and the Sutang.

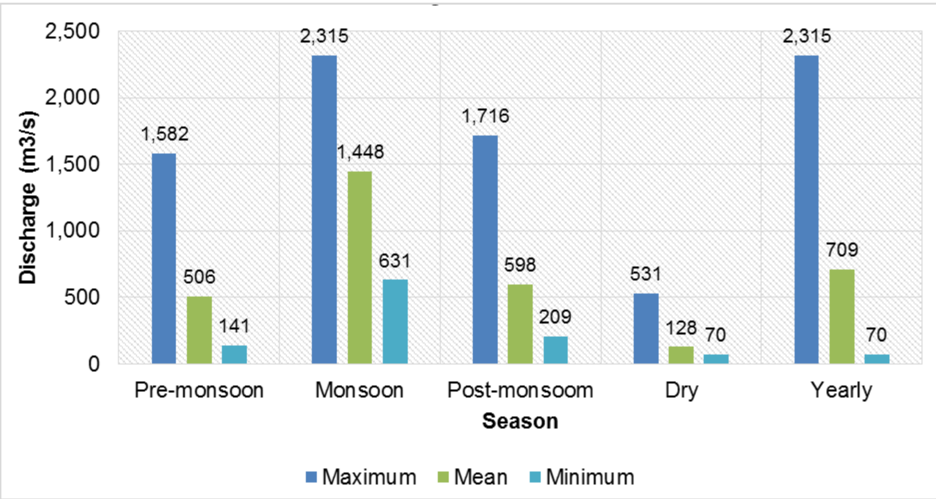


Figure 2.9: Seasonal variations of hydrological parameter (discharge) in the Kushiyara River at Sheola

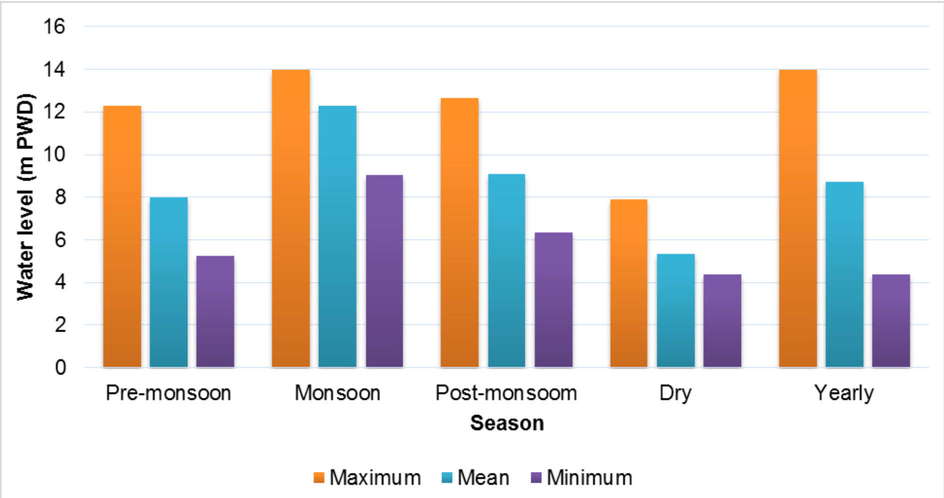


Figure 2.10: Seasonal variations of hydrological parameter (water level) in the Kushiyara River at Sheola

Kangsa-Dhanu System

This river system comprises of the Malijhi, the Chillakhali, the Bhogai and the Nitai, which are basically trans-boundary Rivers and feed this river system along the periphery of the haor area. Some other significant rivers of this river system are Kangsa, Someswari and Dhanu River. The Kangsa River carries the flow from India through Malijhihment, Chillakhali, Bhogai and Nitai. The catchment of this river is 5,925 km^2, which is mainly formed by the Meghalaya tributaries. The Kangsa River meets the Someswari at Purbadhala of Netrakona district. The Someswari River enters at Durgapur of Netrakona district touching the left boundary of the haor area. The combined flow of the Someswari and the Kangsa meets the Baulai at Mohanganj of Netrakona district. The Dhanu River originates from the Kangsa at Atpara of Netrakona district and finally joins with the Baulai. The total length of Dhanu is about 70 km.

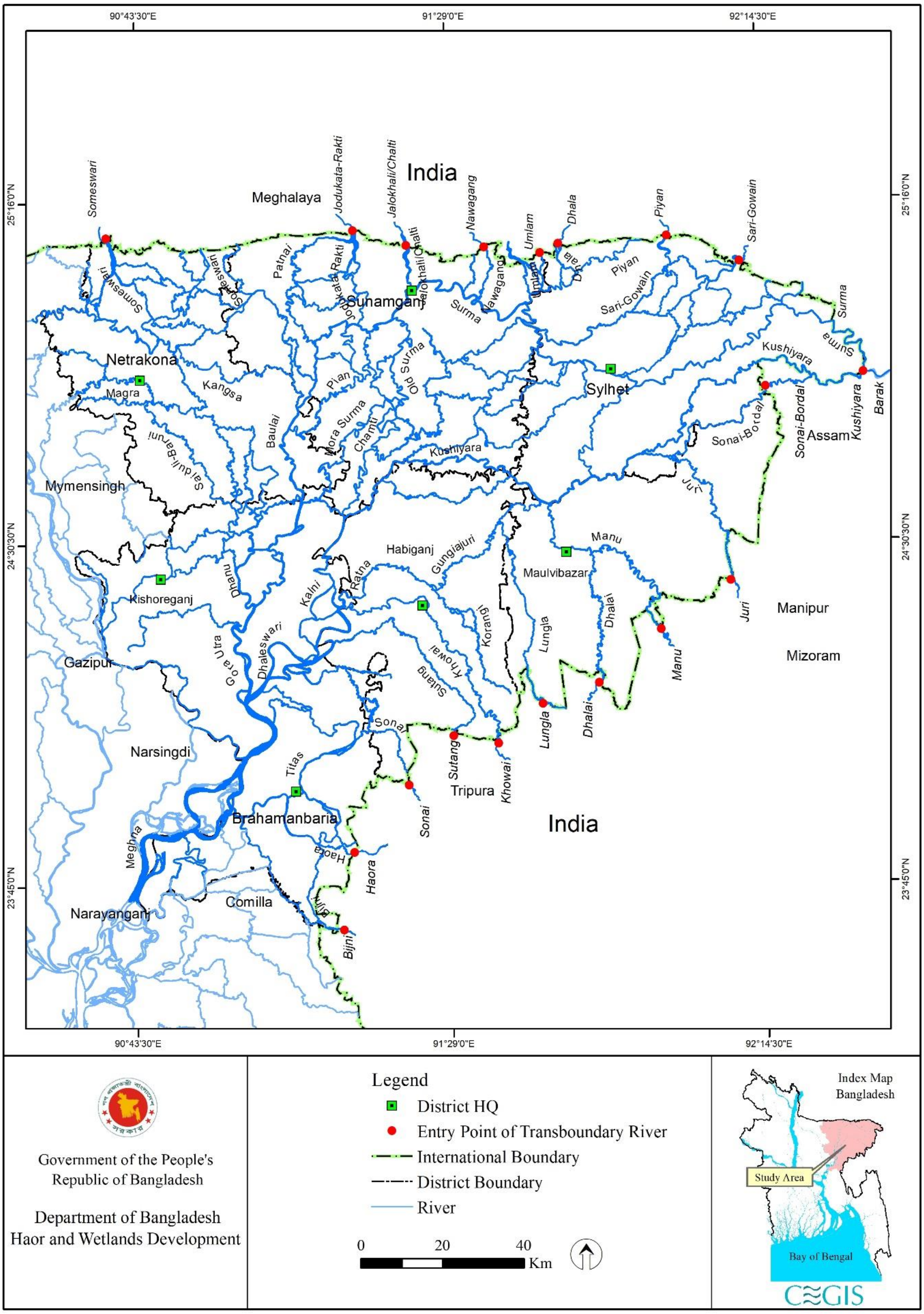


Figure 2.11: River network in the haor area

2.4.2 Haor

North-east region of Bangladesh comprises of large bowl shaped depressions, which basically reside in seven districts of Bangladesh i.e. Sunamganj, Habiganj, Netrakona, Kishoreganj, Sylhet, Maulvibazar and Brahmanbaria. These Haors cover about 1.99 million ha of area and accommodate about 19.37 million people. Haor Master Plan by the then Bangladesh Haor and Wetland Development Board (MPHA, 2012) classified haors of Bangladesh into three types based on geographic location and flooding characteristics i.e. 1) foot hill and near hill haor, 2) floodplain area haor and 3) deeply flooded haor. Haor area of Maulvibazar and Sylhet are situated at near hill or foot hills. Haor area of Netrokona, Kishoreganj and Brahmanbaria are designated as floodplain area haor, while Netrokona, Sunamganj and Habiganj area are deeply flooded haor. MPHA (2012) so far identified about 373 haors/wetlands in seven districts covering an area of 858,460 ha which is around 43% of the total area. Table 2.7 and Figure 2.12 show coverage and distribution of haors in north-east region of Bangladesh. Usually, these haors remain submerged more than six months in a year.

Table 2.7: Coverage of haor area

District	Total area (ha)	Haor area (ha)	Haor area (%)
Sunamganj	367,000	268,531	73
Habiganj	349,000	189,909	54
Netrakona	263,700	109,514	42
Kishoreganj	279,900	47,602	17
Sylhet	274,400	79,345	29
Maulvibazar	273,100	133,943	49
Brahmanbaria	192,700	29,616	15
Total	1,999,800	858,460	43

Source: MPHA, 2012

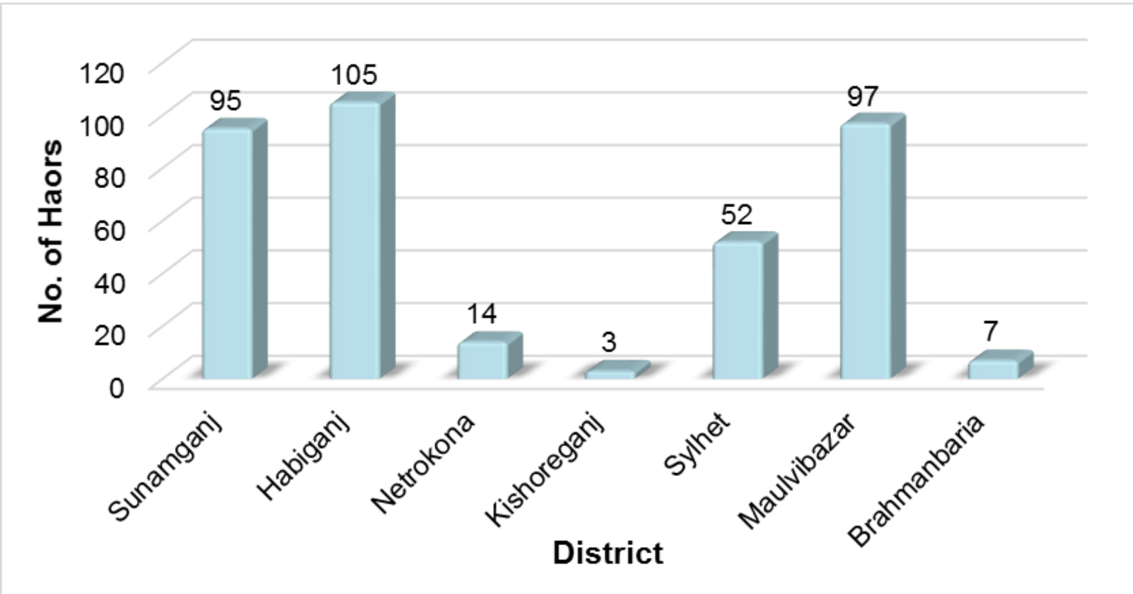


Figure 2.12: Distribution of haors in seven districts

2.5 Problem and Issues

2.5.1 Flood

The most common problem that takes place in haor area is flood. Usually there are two types of floods in that area: flash flood and monsoon flood. Between these two types of flood flash flood is more concerning than the other as the damage caused to the crops by this flood is severe. The other, monsoon flood does not cause that much damage.

Flash Flood

Flash flood is also known as the pre-monsoon flood, because it takes place all on a sudden before the monsoon in the months of March, April and May. This type of flood mainly occurs by surface runoff due to heavy or excessive rainfall within short duration. Relatively steep slope of basin and relatively short concentration time of floods on the basin triggers flash flood. This also occurs due to the huge volume of flow through trans-boundary Rivers within a very short period. Flash flood in haor area is a matter of huge concern as it causes a lot of damage to the harvesting of Boro, the major crop cultivated in the area. From the satellite images it was seen that 2,207 sq. km of area on an average was inundated by the pre-season flood from the year 2006 to 2010 (MPHA, 2012).

Monsoon Flood

The monsoon flood is a seasonal flood that increases and decreases slowly and inundates a huge area during June to September. The monsoon flood is significant for this area as it is needed for the conservation of ecosystem, but it is not considerably vital since it occurs no damage to crops due to the absence of crop in the fields during this season. The National Water Management Plan (NWMP) model data shows that 67% area of the haor area submerges in the monsoon flood. Sunamganj is the most flooded district due to monsoon flood among the seven districts of haor area.

2.5.2 Drainage Congestion

Drainage is a key problem in almost all over the haor area. The river bed levels are higher and the outfalls of the khals are heavily silted up which consequently creates drainage congestion. Although the avulsion and abandonment of the channels are natural process, frequency of which however, largely dependent on the human interventions –such as deforestation in the upstream catchment, mining activities, flood embankments and closure of channels. These processes generally facilitate with drainage congestion and consequently, hamper the navigation. It is suspected that cut-off and avulsion may increase in future and the problems of the pre-monsoon flood and navigation will increase. Therefore, the drainage problem is an issue of major concern as it happens in December which is the time of planting the Boro crops. The available satellite images show that on an average around 3,130 sq. km of land (16% of haor area) stays inundated in the month of October, November and December (MPHA, 2012).

2.5.3 River Bank Erosion

Riverbank erosion has become a common phenomenon in the Haor area of Bangladesh due to the shifting of river courses. Around 825 hectares of land was eroded along the Surma River in the last two decades and almost 1,360 hectares along the Kushiyara River. The rate of erosion is however, two to three times higher in the Sylhet basin than in the eastern Surma-Kushiyara floodplain. Like several other processes, the rate of river bank erosion would increase with the increase of sediment supply, and is likely to increase in future. Moreover climate change may aggravate the situation. So far, river bank protection works in very few locations are found along the Surma and Kushiyara rivers which in future may increase and would require in other locations.

2.5.4 Wave Erosion

Land erosion due to wave action is another major problem in this area. The settlements and the communication system of this area are on raised platforms. These man-made platforms keep them above the water level during the flood season which lasts for about five months of a year. Using bamboo and tarja fencing for platform protection, often proves ineffective. The patch of Hijal and Koroach tree in front of the villages acts as fence against wave action to protect the villages. The platforms of settlement are in the threat of erosion because of wave action. These settlements remain exposed to wave attack for around five months in a year. Recently wave attacks have been increased tremendously due to large scale deforestation.

2.5.5 Sedimentation

The trans-boundary Rivers in the Haor area carry a large amount of sedimentation from the upstream course. Sedimentation decreases the conveyance capacity of river bed and increases the possibility of flash flood. Consequently, flood water easily breaches or overtops the embankments and causes a serious damage to the crops and livelihood of the inhabitants. As a direct impact the flooding extent is increasing in the in the unprotected haor area. Mining activities, deforestation and poor sediment management in the Meghalaya and Tripura Hills will increase the extent of fan areas and frequency of sedimentation through the levee breaching. Increased sedimentation supply causes serious problems to the environment as well as to the agriculture. It is very difficult to decrease or round up sedimentation in the haors through extension of the alluvial fans. Proper sediment management in Indian part may work well to improve the situation.

Chapter 3: Approach and Methodology

3.1 Introduction

Environmental auditing is a tool to identify management gaps of recommended mitigation measures before implementation and after execution of the project. In practical, there is no recommended Environmental Management Plan (EMP) of any of the projects implemented by BWDB in haor region. Therefore, environmental auditing is being performed with respect to performance analysis of structures in terms of impact assessment, compliance of project with project objectives with recent policy directives. In following section approach and detailed methodology of environmental auditing is described.

3.2 Approach and Methodology

Environmental auditing portion of this study has been conducted according to following approach:

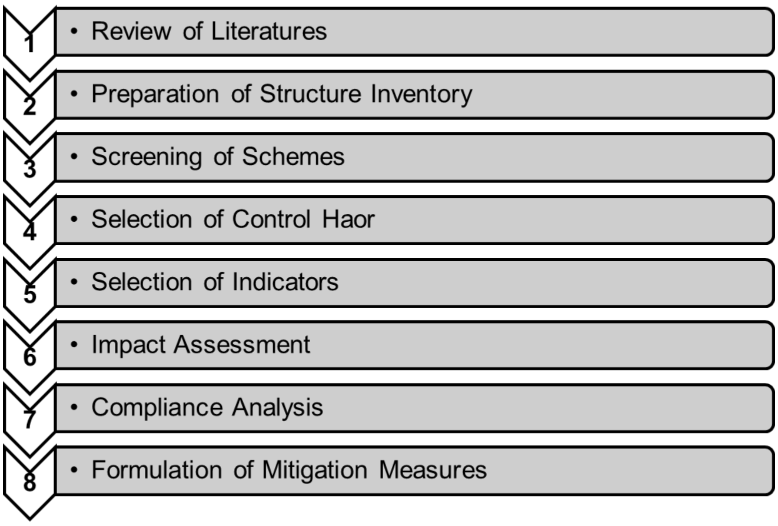


Figure 3.1: Approach of the environmental auditing

Detailed methodology of above mentioned approach is described below:

3.2.1 Review of Literatures

Different literatures relevant to environmental auditing i.e. national and international journals, conference papers, reports of previous relevant studies have been reviewed to understand the methodology of environmental auditing and gather knowledge base on environmental auditing. National policies, plans and acts have been reviewed have been reviewed to assess policy directives in respect to natural resources management as well as environment management in haor area. National strategies and guidelines have also been reviewed to assess the outlined strategies and guidelines for environmental management in haor area of Bangladesh.

3.2.2 Infrastructure Inventory Preparation

The Government of Bangladesh has taken several initiatives to manage water resources, flood, transportation system as well as poverty since early ‘60s in the haor areas. Implementing agencies like Bangladesh Water Development Board (BWDB), Local

Government Engineering Department (LGED), Roads and Highways (RHD), Zila Parishad, Upazila Parishad, Union Parishad, Pouroshova and other NGOs have constructed huge number of structures to cope up with extreme flooding events or flash floods, to facilitate well communication system, to protect crops and to achieve poverty reduction targets.

In this regard, a detailed inventory of all water management structures of three major implementing agencies i.e. BWDB, LGED and RHD have been prepared under this study. Structures of Zila Parishad, Upazila Parishad, Union Parishad, Pouroshova and other NGOs are established in settlement area only. Therefore, structures of local government agencies and NGOs have not been included in inventory preparation.

The final inventory of infrastructural development has been developed comprising two type of information i.e. basic information of structures and detailed information for major water regulation structures.

The inventory include basic information on all types of water management interventions (bridges, culverts, regulators, sluices, submersible embankments and other water management structures) like project name, project locations, type of structural interventions approached etc. Apart from this information, detail information of design parameters of structures, has also been incorporated, if available for major water regulation structural interventions.

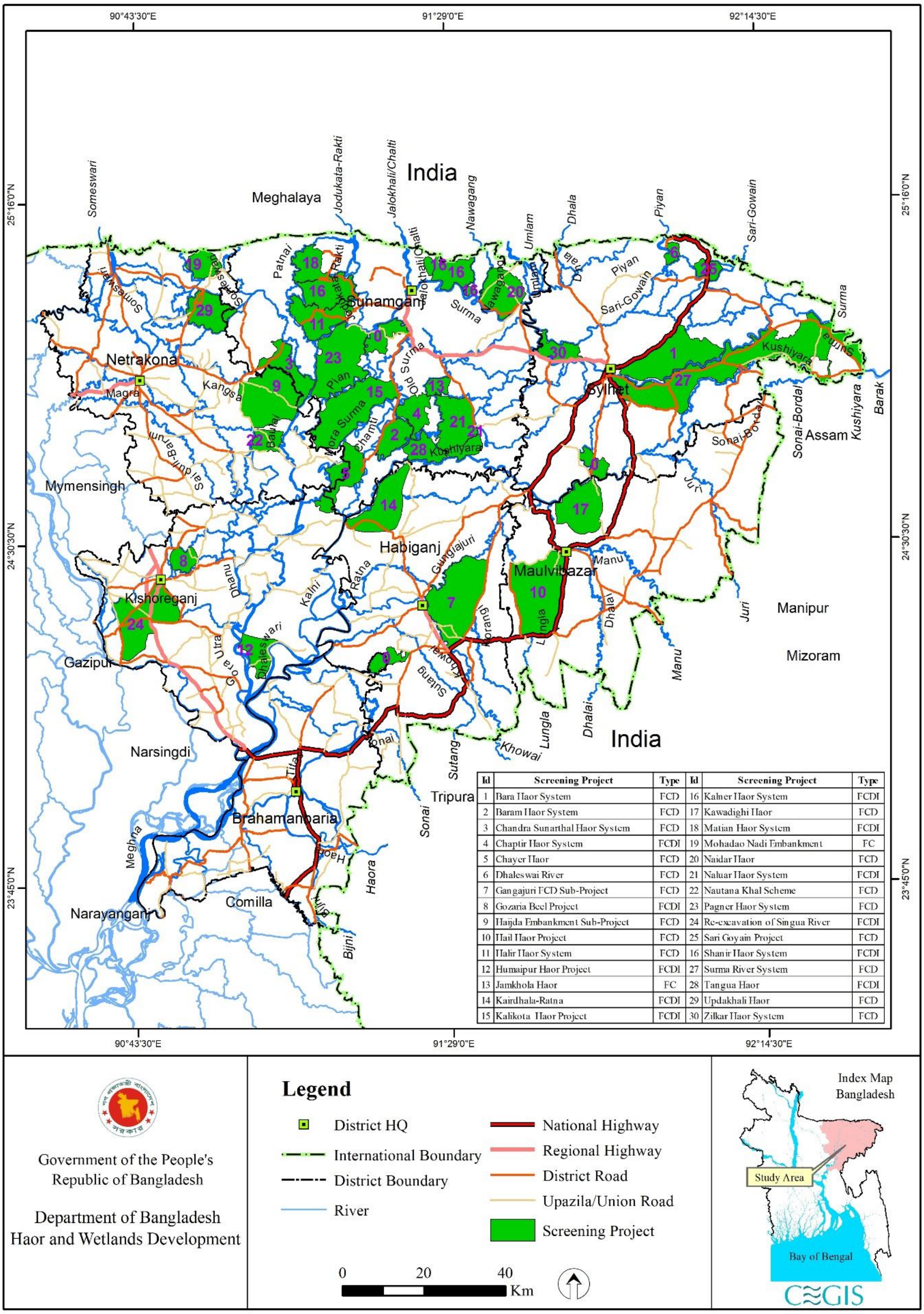
This inventory has been prepared through collection of data and information from secondary sources and extensive field visits.

3.2.3 Screening of Schemes

Performing environmental auditing in all of the 118 BWDB schemes is a time consuming tasks. Due to time constraints, screening of existing 118 BWDB schemes identified in Haor Master Plan with different kind of infrastructural interventions like embankment, submergible embankment, regulator, sluices etc. in the haor area have been performed for environmental auditing which are explicitly representative of 118 schemes.

Thirty (30) schemes or projects have been found after screening whose environmental auditing have been performed to find out cumulative positive or negative impacts in haor ecosystem after executing infrastructural interventions through these schemes.

Selection of thirty schemes has been done in a way that those thirty schemes are explicitly representative of 118 schemes over 7 districts (Sylhet, Sunamganj, Kishoreganj, Netrokona, Habiganj, Maulvibazar and Brahmanbaria). However, Brahmanbaria has not been considered in screening process, because this district's hydrology has major influence of Comilla. Screened schemes are also spatially distributed over 6 districts. Screened schemes are illustrated in Figure 3.2.



Id	Screening Project	Type	Id	Screening Project	Type
1	Bara Haor System	FCD	16	Kalner Haor System	FCDI
2	Baram Haor System	FCD	17	Kawadighi Haor	FCD
3	Chandra Sunarthal Haor System	FCD	18	Matian Haor System	FCDI
4	Chaptir Haor System	FCDI	19	Mohadao Nadi Embankment	FC
5	Chayer Haor	FCD	20	Naidar Haor	FCD
6	Dhaleswai River	FCD	21	Naluar Haor System	FCDI
7	Gangajuri FCD Sub-Project	FCD	22	Nautana Khal Scheme	FCD
8	Gozaria Beel Project	FCDI	23	Pagner Haor System	FCD
9	Haijda Embankment Sub-Project	FCD	24	Re-excavation of Singua River	FCDI
10	Hail Haor Project	FCD	25	Sari Goyain Project	FCD
11	Halir Haor System	FCD	16	Shanir Haor System	FCDI
12	Humaipur Haor Project	FCDI	27	Surma River System	FCD
13	Jamkhola Haor	FC	28	Tangua Haor	FCDI
14	Kairdhala-Ratna	FCDI	29	Updakhali Haor	FCD
15	Kalikota Haor Project	FCDI	30	Zilkar Haor System	FCD

Figure 3.2: Selected Schemes through Screening

3.2.4 Criterion for Screening

Screening has been performed on the basis of some criterion. Criterion have been analysed independently and finally, schemes have been selected considering combined results of this independent criteria. Criterion considered for screening of schemes are given and described below:

1. Schemes on Ecologically Important Haor
2. Types of haor
3. Type of schemes
4. Size of Schemes
5. Total percentage of intervened haors
6. Water system
7. Temporal and spatial distribution of schemes

Schemes on Ecologically Important Haor

In Haor Master Plan, 2012 it has been stated that, most significant wetlands are Hakaluki haor, Tanguar haor, Hail haor, Matian haor, PasuarBeel haor, Dekar haor, Bara haor, Gurmar haor, Sonamorol haor, Baram haor, Kalner haor, Kawadighi haor and Pagner haor. Bangladesh Delta Plan 2100 identified Important Bird Areas (IBA) in Tanguar Haor, AilaBeel, Hakaluki Haor and Hail Haor. All of these ecologically important haors have got special emphasis on screening of schemes in addition to types of haor, size of schemes, prevailing water system, temporal and spatial distribution of haors.

Types of Haor

There are three categories of haor according to Haor Master Plan, 2012. They are-

- Deeply Flooded Haor
- Floodplain haor and
- Foot hill haor

The haor area of Sylhet and Maulvibazar districts are situated near hills or at foothills. The haor areas of Netrakona, Kishoreganj and Brahmanbaria are floodplain haor while those of Sunamganj, Netrakona and Habiganj are deeply flooded haor. Out of the seven haor districts Sunamganj may be termed as the mother of the haor region. Table 3.1 shows that deeply flooded haor and flood plain haor area are highly intervened by BWDB schemes.

Table 3.1: Types of haor intervened by 118 BWDB schemes

Categories of Haor	Area (ha) coverage by all BWBD schemes	% of total intervened area
Foothill Haor	73153	15
Deeply Flooded Haor	237731	48
Floodplain Haor	188055	38
Total	**498939**	

Source: CEGIS analysis

Therefore, schemes residing on deeply flooded haor area have got high weight in screening of schemes than other two categories of haor.

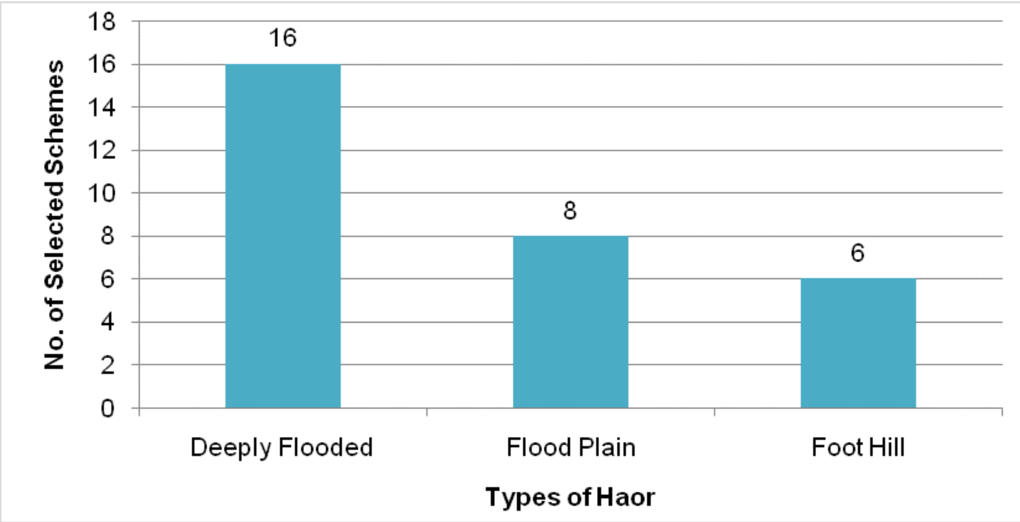


Figure 3.3: Haor type wise selected schemes

Type of schemes

All of the schemes of BWDB are either FCD or FCDI projects except two projects only. Therefore, emphasis has been given on selecting FCD or FCDI projects which are very usual in haor area.

Size of Schemes

Size of project area is one of the most important criteria for screening of schemes. Histogram by project area is drawn for 118 BWDB schemes and emphasis has been given to select big projects having all type of structural interventions rather very small type of projects. Efforts have been made to cover every area cluster as much as possible, where area clustered by 1000 ha. Following Figure 3.4 shows number of selected schemes from different area cluster of 118 BWDB schemes.

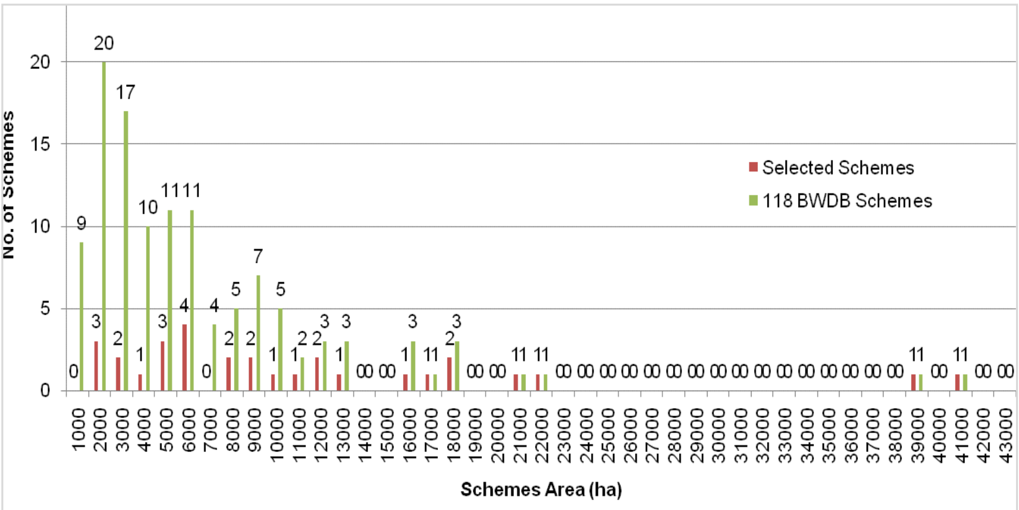


Figure 3.4: Histogram of selected schemes by area

Total percentage of intervened haors

In seven districts of north east region of Bangladesh haor area covers around 858460 ha, where existing 118 BWDB schemes covers 58% (498940 ha) of this total haor area. Schemes have been selected in such a way that total area of selected schemes under each category of haor can cover at least 50% of total area intervened by BWDB schemes. Statistics from following Table 3.2 shows that selected schemes can cover around 60% of the haor area intervened by 118 BWDB schemes.

Table 3.2: Percentage of each type of haors intervened by BWDB

Types of Haor	Selected Project Area (ha)	Percentage of each type of haors covered by projects
Foothill	62590	86
Deeply Flooded	138374	58
Floodplain	100548	53
Total	**301512**	60% of Haor area intervened by BWDB Schemes

Water system

Hydrological system prevailing in the haor region has also been considered for scheme selection, because it maintains the connectivity of haors with river system. Barak system, Meghalaya, Surma-Kushiyara system, Old-Brahmaputra, Upper Meghna and Tripura system have been considered for screening process. Schemes around this system has got special emphasis for selection. However, hydrology system of Brahmanbaria district has high influence of Comilla district, therefore, any schemes in Brahmanbaria district are discarded from the selection process.

Temporal and spatial distribution of schemes

Temporal and spatial distribution of schemes have also been considered for screening of schemes. For temporal distribution, three time slices have been considered i.e. 1961-1980, 1981-2000 and 2001-2017. For spatial distribution, uniform distribution over 6 districts (Habiganj, Maulvibazar, Sylhet, Sunamganj, Kishoreganj, and Netrokona) has been examined by graphical observations. Table 3.3 and Figure 3.5 show temporal and spatial distribution of selected schemes respectively.

Table 3.3: Temporal distribution of selected projects

Time Slices	No. of Selected Projects
1961-1980	3
1981-2000	20
2001-2017	4
No data	3
Total Projects	**30**

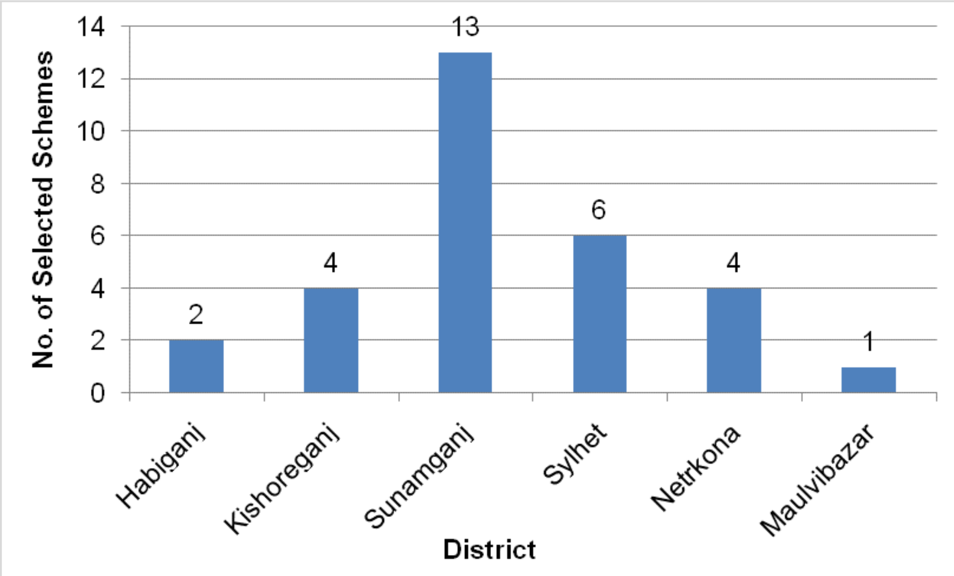


Figure 3.5: Spatial distribution of selected projects

List of schemes with basic details are given in Annex I

3.2.5 Selection of Control Haor

Various autonomous development through different agencies of GoB and NGOs have been taken place in haor region for agriculture boost up, poverty reduction, communication system improvement and improvement of social security, in addition to infrastructure development for water management. But, this study is solely focused on impact assessment of infrastructural development only. It necessitates to consider control haor where no interventions have been made, but autonomous development have been taken place. Impact of only infrastructure development has been assessed through subtracting impact of such autonomous development in control haor. Selection of control haor thus facilitated to assess impact of infrastructure development in selected 30 schemes.

In addition to the 30 screened schemes, more 3 haors have been selected as control haors using expert judgment. Three control haors have been selected from three types of haor mentioned in Haor Master Plan, 2012 i.e. Deeply Flooded Haor, Floodplain Haor and Foot Hill haor taking one haor from each type. Selected three control haors are shown in Table 3.4:

Table 3.4: Details of selected control haor

Sl. No.	Haor Type	Control Haor	Area (ha)
1	Deeply Flooded Haor	Dhakua Haor	4452
2	Flood Plain Haor	Maijail Haor	2900
3	Foot Hill Haor	Shelnir Haor	3030

3.2.6 Selection of Indicators

The northeast area of Bangladesh has a unique landscape, where natural patterns of flooding have created very productive fisheries in the wet season, and allowed rice to grow in the dry season. The productivity of this wetland (Haor) has contributed a lot for food production in this region, and it is believed that there is a potentiality for further increases of land for agriculture purposes. However, change of flood timing, duration and pattern is probably one of the main reasons for changing local ecosystem and the livelihood of the local people. In haor area, flash flood causes crop damage which is considered as a big threat to the people, especially who work as sharecroppers or landless laborers. Sometimes, the flash flood comes early, just before the rice harvesting and during that time the people of haor basin, do not even get the time to harvest their crops. In many cases, it has been found that this part of Bangladesh losses 80% of its crops. On the other hand, loss of suitable water flow and velocity due to different water control structures impacts on fish habitat condition. Increase of exposed agro-chemicals resulting from increased cropped area and use of fertilizer and pesticides also impact on fish growth. In addition, ecosystem of north east region becomes vulnerable to such kind of hazard as haor area is rich in biodiversity. Unexpected crop damage or reduced fisheries production or problems in navigation may also impact in socio-economic sector of this area. Assessment of impact on such verities of natural resources for different consequences is very difficult.Therefore, some indicators have been selected for water and navigation, land, agriculture and livestock resources, fisheries, ecology and socio-economic sector to make ease of impact assessment process. Selected indicators and their rationale for selection are described below:

Water Resources and Navigation

Structural interventions are made in haor area over the years in order to facilitate haor ecosystem sustainability and enhance navigation facilities. Haors receive water through different channel of rivers during monsoon and becomes dry during dry season. During monsoon, when haor area stays in full flood condition, navigation becomes the main communication system in that area. Siltation occurs and consequently, rivers and haors loss conveyance capacity. Sometimes drainage problem occurs due to delay of flood recession. With this considerations, following indicators have been identified for water and navigation:

- Flooding
- Drainage
- Sedimentation
- Navigation

Land, Agriculture and Livestock Resources

Indicators for land, agriculture and livestock resources have been identified through literature review, project documents review, secondary data analysis and Key Informant Interview (KII) for impact assessment as well as environmental auditing in haor ecosystem. These are:

- Land use
- Land degradation
- Cropping area
- Cropping pattern and intensity
- Crop production
- Crop damage
- Irrigated area
- Use of agro-chemical
- Livestock population, feed and diseases

For assessing these indicators land use, cropping pattern, crop area, yield rate, crop damage, irrigation, fertilizer and pesticides information have been collected partially from secondary sources BBS.

Fisheries Resources

Fisheries indicators have been selected through reviewing different literatures (study reports on haor areas of DoF, CEGIS, IUCN and CNRS and different articles on haor fisheries) as well as surveying different institutions and using fisheries expert judgment. Following indicators along are selected shown in Table 5.4.

- Fish Habitat
- Fish Migration
- Fish Diversity
- Fish Growth
- Fish Production
- Fishing Appliances
- Fisheries Livelihood
- Fisheries Management

Ecological Resources

Ecology is considered one of the important components for impact assessment as well as environmental auditing, because haor ecosystem is a unique and rich in biodiversity. It provides various tangible and intangible goods and services. Thus, auditing process for ecology has been designed with assessment of status of some key species and status of their habitats considering both pre and post project conditions. Some key ecological indicators have been identified based on literature review, review of project documents, secondary data analysis i.e. water level fluctuations and Key Informant Interview (KII) which are mainly dependent on hydrological changes. Selected ecological indicators are as below:

- Terrestrial Flora
- Terrestrial Fauna
- Aquatic Flora
- Aquatic Fauna
- Swamp Forest and Reeds
- Ecosystem Goods and Services

Socio-economic Resources

Social change is a continuous process and it comes from different development activities through the time. Livelihood is perceived here as strategies of people usually follow for their survival. Improved communication and transportation system due to interventions may change standard of living of people. Interventions may impact the income generating activities of the community people. Seasonal and permanent migration is common phenomena in the Haor region due to extreme hazardous event. In recent years, problems are raising due to poor institution and governance system. Considering all of these aspects following indicators have been selected for impact assessment as well as environmental auditing through review of reports, literatures, secondary data etc. They are-

- Livelihood
- Population
- Accessibility to Education and Health
- Land Price
- Agriculture based Income
- Wage Labor

- Migration
- Transportation and Communication
- Institution and Governance

3.2.7 Impact Assessment

Impact assessment has been performed for each of the 30 screened schemes and summarized for full haor region. Information and data has been collected for each of the identified indicators for five selected sectors and baseline has been created for pre and post project condition under each of the screened schemes. Later, impact has been assessed subtracting or comparing pre project condition status from post project condition status. Utmost effort has been made to quantify impact of indicators, otherwise impact has been assessed qualitatively. Both positive and negative impact has been found in this process. In case of summarizing the impacts only for infrastructure development, baseline condition of control haors has been used as mentioned before in section 3.2.4. For creating baseline pre and post project condition questionnaire has been prepared for each of the five selected sectors and rigorous field visits have been conducted in 30 screened schemes and 3 control haors. Professionals of five disciplines i.e. water and navigation, land, agriculture and livestock resources, fisheries resources, ecology and socio-economic resources were involved in each of the field visits. Several sessions of Focused Group Discussion (FGDs), Public Consultation Meeting (PCMs), Key Informant Interviews (KII) have been conducted in every field visit for taking opinions of community people and local stakeholders. Recall method has been used for creating baseline situation of pre and post project condition.

3.2.8 Compliance Analysis

Compliance analysis has been performed in this study as a component of environmental auditing. Compliance and gap analysis has been performed in two perspectives. They are:

- Compliance against project objectives
- Compliance against recent policy directives

To do compliance and gap analysis information on project objectives has been collected from secondary sources and national policies has been reviewed. Compliance against recent policy directives has been performed on the basis of some identified important environmental issues i.e. conservation of waterbodies, eco-friendly structures, food security, using advanced agricultural technologies, prohibiting dewatering of beel etc. which were found from comprehensive policy review.

3.2.9 Mitigation Measures Formulation

Mitigation measures for mitigating negative impacts or enhancing positive impacts has been formulated for full haor region. Overall mitigation measures have been formulated on the basis of mitigation or enhancement measures recommended in 30 screened schemes and 3 control haors. Expert judgment has been used to recommend such mitigation or enhancement measures in audited schemes. Preferences has been given on innovative ideas for mitigation measures formulation.

Chapter 4: Review of Literatures and Development Initiatives

4.1 Introduction

Mitigating the flood damage and improvement of the living environment in the Haor Region require the implementation of flash flood management, improvement of the rural infrastructure as well as promotion of the agriculture and fisheries sector. Therefore, huge infrastructural development is required to minimize adverse effect of the natural disasters alongside the improvement of the existing infrastructures which have been built almost over the last six decades. However, such development should be eco-friendly and comply with the existing policies, acts, rules and plans of the country which are relevant to the development of the Haor area. Therefore, the directives regarding haor area in connection to infrastructural development mentioned in different literatures and the existing developments in the Haor Region have been reviewed to facilitate the preparation of mitigation measures through conducting an Environmental Auditing of the infrastructural developments in the Haor Region under this study.

The Environment Auditing has been conducted for the selected FCDI projects or schemes which have been implemented by Bangladesh Water Development Board (BWDB) based on some screening criteria followed by an analysis of the impacts of these projects or schemes on the selected indicators (discussed in later chapters) of five relevant sectors namely: water and navigation, agriculture and land resources, fisheries, ecology and socio-economic sector. Therefore, a number of policies, acts, rules, strategies, plans, international conventions etc. relevant to these five sectors have been meticulously reviewed (list of literatures reviewed is given in Annex II). During the literature review, focus has been kept on the directives about the sector-wise indicators which are directly or indirectly associated with the infrastructure development. For ease of understanding and presentation; the findings of the directives have been summarized under some thematic issues which are presented in the following sections.

4.2 Review of Relevant Policies, Act and Rules

Review of Policy, Rules and Acts has been made focusing on the directives regarding the sector wise indicators which are directly or indirectly associated with the infrastructure development. For ease of understanding and presentation; the findings of the directives have been summarized under some thematic issues. Name of these sector-wise indicators considered for each issue is given in the following Table 4.1. The table also shows the name of the Policy, Act and Rule from which relevant directives have been found against the respective issues.

Table 4.1: Name of issues, applicable Indicator(s) and list of Policy, Rules and Acts as a source for relevant directives

Sl	Issue	Sector	Indicator	Source of Relevant Directives
1	Flood and Drainage Management	Water Resources and Navigation	• Flooding • Drainage	• Bangladesh Water Act, 2013 • Bangladesh Water Rule, 2017 (Draft) • National Land Use Policy, 2001 • Embankment and Drainage Act, 1952 • National Water Policy, 1999
2	Water resources management	Water Resources and Navigation	• Flooding • Drainage • Sedimentation • Navigation	• National Environmental Policy, 1992 • Bangladesh Water Act, 2013
3	Sustainable Land-Water Management	Land, Agriculture and Livestock Resources	• Land use • Land degradation • Cropping area • Cropping pattern and intensity • Crop production • Crop damage • Irrigated area • Livestock population, feed and diseases	• National Agriculture Policy, 2013 • National Forestry Policy, 1994 & 2016 (draft) • National Rural Development Policy, 2001 • Ecologically Critical Area Management Rules, 2016 • National Environmental Policy, 1992
4	Regular Maintenance and Rehabilitation of Interventions	Water Resources and Navigation	• Flooding • Drainage • Sedimentation • Navigation	• Embankment and Drainage Act, 1952 • National Land Use Policy, 2001
5	Sustainable Use of Surface and Ground Water for Agriculture	Water Resources and Navigation	• Flooding • Drainage • Navigation	• Bangladesh Water Rule, 2017 (Draft)
		Land, Agriculture and Livestock Resources	• Land use • Cropping area • Cropping pattern and intensity • Crop production • Irrigated area	• National Agriculture Policy, 1999
6	Fish Friendly Infrastructure Development	Fisheries Resources	• Fish habitat area • Fish Diversity • Fish migration • Fish production	• National Fisheries Policy, 1998 • The Protection and Conservation of Fish Act, 1950 • National Environmental Policy, 1992 • The Protection and Conservation of Fish Act, 1950 • National Land Use Policy, 2001

Sl	Issue	Sector	Indicator	Source of Relevant Directives
7	Conservation of Ecosystem and Bio-Diversity	Ecological Resources	• Terrestrial Flora • Terrestrial Fauna • Aquatic Flora • Aquatic Fauna • Swamp Forest and Reeds • Ecosystem Goods and Services	• National Water Policy, 1999 • National Environmental Policy, 1992 • Bangladesh Biodiversity Act, 2017 • Bangladesh Environment Conservation Act, 1995 • Bangladesh Environment Conservation Act, 1995 • Ecologically Critical Area Management Rules, 2016
8	Preservation and Conservation of Waterbody/Wetlands	Water Resources and Navigation	• Flooding • Drainage	• National Land Use Policy, 2001 • National Water Policy, 1999 • National Environmental Policy, 1992 • National Fisheries Policy, 1998
		Land, Agriculture and Livestock Resources	• Land use • Cropping area • Cropping pattern and intensity • Crop production • Irrigated area	
		Fisheries Resources	• Fish habitat area • Fish production	
9	Socio-economic Development	Socio-economic Conditions	• Wage labor • Institution and Governance	• National Rural Development Policy, 2001

The directives on the above-mentioned issues are presented below:

4.2.1 Flood and Drainage Management

Policy directives regarding flood and drainage management are found in several Policies, Acts and Rules. Bangladesh Water Act, 2013 provides directives for demarcation of flood control zone in wetlands to ensure smooth passage of flood water. Similarly, Bangladesh Water Rule, 2017 (Draft) has instructed to identify 'Flood Flow Zone' or 'Sub Flood Flow Zone' analyzing flood model and RS-GIS techniques, and restriction has been outlined to do any development. Moreover, Bangladesh Water Act, 2013 has asked for protection of flood control embankment, especially which protects property, life and crops by restricting construction any house, establishment or any other structure on or on the slope of such embankment. The National Water Policy, 1999 has advised to preserve natural water bodies like haors, baors and beels for sustaining the aquatic environment and facilitating drainage. The policy directives of the National Land Use Policy, 2001 say that regular maintenance of the embankments needs to be done in order to avoid drainage congestion. It also asks for establishment of consistent maintenance of the existing water bodies. The National Land Use Policy, 2001 calls for plantation of trees along embankments and provision of drainage facility for embanked areas. The Embankment and Drainage Act, 1952 has instructed to make better provision for the construction, maintenance, management, removal and control of embankments and water-courses for the better drainage of lands and for their protection from floods, erosion or other damage by water.

4.2.2 Water Resources Management

Instruction and directives regarding efficient and effective management of the water resources are found in several Policies, Acts and Rules. Environmentally sound water resource management is suggested in the National Environmental Policy, 1992 through utilization and development of water resources, construction of irrigation network and embankments, dredging of water courses and in-taking measures against water pollution. Conducting Environmental Impact Assessment has also been outlined as a requirement before undertaking projects related to water resource development and flood control measures. Delineation of water stress area and preferential use of water from sources for different purposes like for agriculture, fisheries, drinking water, industry etc. has been instructed in Bangladesh Water Act, 2013. The Act has also asked to ensure normal flow in water course prohibiting any kind of diversion through construction of structures without feasibility study

4.2.3 Sustainable Land-Water Management

Considering the high demand of land in this riverine country for human settlement, agriculture, industrialization etc.; directives for sustainable land-water management are found in Policy, Acts and Rules. The National Agriculture Policy, 2013 has advised for sustainable land-water management and expansion of integrated crop management activities. The policy has also encouraged protecting agriculture related biodiversity. The National Rural Development Policy, 2001 has discouraged the construction of building, new settlement etc. on cultivable agricultural land and has asked to take measures for planned construction of houses. Activities that cause or result in land erosion, salinity, alkalinity and loss of soil fertility are prohibited in National Environmental Policy, 1992.

4.2.4 Regular Maintenance and Rehabilitation of Interventions

Emphasis on regular maintenance and rehabilitation of interventions has been found in different policies. Embankment and Drainage Act, 1952 has provided such emphasis regarding in time repair or construction of embankment or sluices or gates etc. for the protection of cultivable land or life of property. The National Land Use Policy, 2001 has advised for regular maintenance of the embankments to avoid drainage congestion.

4.2.5 Sustainable Use of Surface and Ground Water for Agriculture

Policy directives for sustainable use of surface and ground water for agriculture has been found in different policies. Bangladesh Water Rule, 2017 (Draft) has advised the preparation of a guideline for the extraction and proper use of surface and ground water. The National Agriculture Policy, 1999 has stated that irrigation from surface water would get priority and suitable programmes would be taken up for the expansion and consolidation of appropriate technology. Moreover, importance would be given on the conjunctive use of ground and surface water in accordance with the National Water Policy, 1999 and Water Resources Development Plan of the government.

4.2.6 Fish Friendly Infrastructure Development

Policy directives regarding fish habitat, fish habitat condition, fish production etc. have been found in several Policies and Acts. The National Fisheries Policy, 1998 has stated that lakes, beefs, ditches-canals, beels and other open water bodies should not be completely dewatered which may threaten fish species. It has also stated that renovation of water bodies like haor, baor and beel should be done for fish culture and any reduction in size of these water bodies shall not be made. It has also asked to take proper care during the execution of all developmental activities such as flood control, irrigation and drainage (FCDI) projects, agriculture, industries, road and urban development projects to conserve fish habitats from damage. The National Environmental Policy, 1992 has asked for re-evaluation of activities that poses threats to wetlands and natural habitats for the fishes. Similarly, the Protection and Conservation of Fish Act, 1950 has advised for environment friendly infrastructure development in haor area to facilitate the conservation and preservation of fishes ensuring comfortable growing, breeding or migration. Moreover, it has specifically advised for protection and conservation of fishes by prohibiting and regulating the construction (temporary or permanent) of weirs, dams, bunds, embankments and other structures which may destroy fishes and/or cause depletion of fisheries. The National Land Use Policy, 2001 includes a prohibition against encroachment of existing wetlands. It has stated that regulation should be imposed over the wetlands with regular maintenance and rehabilitation so that they are not filled up but kept available for fish culture. It has also advised that re-excavation is to be done in filled-up wetlands.

4.2.7 Conservation of Ecosystem and Bio-Diversity

Conservation of ecosystem and biodiversity has been acknowledged through a number of policy directives. In this regard, the National Water Policy, 1999 has stated that only those water related projects would be executed which will not hinder the aquatic characteristics of haors, baors and beels. The National Environmental Policy, 1992 has asked for conservation and expansion of forest zones, conservation of wildlife and bio-diversity and conservation of wetland which are exclusive to fish culture and prevention of encroachment of wetlands. Bangladesh Biodiversity Act, 2017 has prohibited any development works which may interrupt safe living of bio-diversity or impose adverse impact. It also refers to the conservation of existing biodiversity and genetic resources in in-situ or ex-situ environment. Bangladesh Environment Conservation Act, 1995 has asked to declare Ecologically Critical Area if any ecosystem is in the state of critical situation and also stated that no interventions should be undertaken in this designated area. The Ecologically Critical Area Management Rules, 2016 has asked to designate “Ecologically Critical Area” after fixing some indicators like degradation of natural condition of river, khal, haor, baor, wetlands, biodiversity related to them, sanctuary etc.The National Forestry Policy, 1994 & 2016 (draft), in its directive regarding land-based public development initiatives has asked to incorporate appropriate initial environmental investigations and environmental impact assessments to avoid the fragmentation of wildlife and biodiversity habitats and minimize environmental damage.

4.2.8 Preservation and Conservation of Waterbody/Wetlands

The importance on preservation and conservation of wetlands and different types of water bodies has been given in many policy directives. The National Water Policy, 1999 has stated that natural water bodies like haors, baors and beels should be preserved for sustaining the aquatic environment and facilitating drainage. The National Land Use Policy, 2001 includes a prohibition against encroachment of existing wetlands. It has also advised that re-excavation is to be done in filled-up wetlands. According to this policy, Government will be responsible for reservation of large water bodies like haor, baors, beels, rivers etc. it also opines that water bodies should be used in a way that does not contradict the Fisheries Policy and still contributes in agricultural irrigation. It has also asked to establish consistent maintenance of the existing water bodies.

As mentioned earlier under the issue “**Fish Friendly Infrastructure Development**”; National Fisheries Policy, 1998 has stated that lakes, beefs, ditches-canals, beels and other open water bodies should not be completely dewatered which may threaten fish species. It has also asked for renovation of water bodies and taking proper care of the water bodies during the execution of all developmental activities The National Environmental Policy, 1992 has asked for re-evaluation of activities that poses threats to wetlands.

4.2.9 Socio-economic Development

Policy directives regarding socio-economic development associated with any development programmed have been found in different policies. The National Rural Development Policy, 2001 asked for formulation of area specific integrated development programme through assessment of local needs with active participation and involvement of the local people. It has also opined that giving priority to the use of land for rural poverty alleviation should be continued and ensured in the allocation, distribution and leasing out of Khash land and government water body.

4.3 Review of Strategy and Plans

Review of the strategies, plans and international conventions has been made focusing on the directives regarding the sector wise indicators which are directly or indirectly linked with the infrastructure development. Relevant recommendations have been summarized under some thematic issues for ease of presentation. Name of these sector-wise indicators considered for each issue is given in the following Table 4.2. The table also shows the name of the strategies and plans from which relevant directives have been found against the respective issues.

Table 4.2: Name of issues, applicable Indicator(s) and list of strategies, plans and international convention as source of relevant directives

Sl	Issue	Sector	Indicator	Source of relevant directives
1	Water Resource and Disaster Management	Water Resources and Navigation	• Flooding • Drainage • Sedimentation • Navigation	• The Haor Master Plan, 2012 • National Water Management Plan (NWMP), 2001 • 7th Five Year Plan • The North East Regional Water Management Project (FAP 6), 1993 • The Bangladesh Climate Change Strategy and Action Plan, 2009 • The EPWAPDA 1964 Master Plan • The Bangladesh Delta Plan (BDP) 2100 • The National Environment Management Action Plan, 1995 • The National Plan for Disaster Management (2016-2020)
2	Regular Maintenance and Rehabilitation of Interventions	Water Resources and Navigation	• Flooding • Drainage • Sedimentation • Navigation	• Bangladesh Climate Change Strategy and Action Plan, 2009 • The Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (Draft)
3		Water Resources and Navigation	• Flooding • Drainage • Sedimentation • Navigation	• The Haor Master Plan, 2012 • Bangladesh Delta Plan 2100 (draft)

Sl	Issue	Sector	Indicator	Source of relevant directives
	Agriculture Resources Management	Land, Agriculture and Livestock Resources	• Land use • Cropping area • Cropping pattern and intensity • Crop production • Irrigated area	• The EPWAPDA Master Plan, 1964 • The North East Regional Water Management Project (FAP 6)
4	Fish Friendly Infrastructure Development	Fisheries Resources	• Fish habitat area • Fish Diversity • Fish migration • Fish production	• The Biodiversity Strategy and Action Plan (2016-21) • The Sustainable Development Goals • 7th five year plan of the Government of Bangladesh • The National Environment Management Action Plan, 1995 • The National Sustainable Development Strategy (2010-2021)
5	Conservation of Ecosystem and Bio-diversity	Ecological Resources	• Terrestrial Flora • Terrestrial Fauna • Aquatic Flora • Aquatic Fauna • Swamp Forest and Reeds • Ecosystem Goods and Services	• Sustainable Development Goals • The Haor Master Plan, 2012 • The Biodiversity Strategy and Action Plan (2016-21) • Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (draft) • The National Conservation Strategy, 2016-31
6	Preservation and Conservation of Waterbody/Wetlands	Water Resources and Navigation	• Flooding • Drainage	• The Haor Master Plan, 2012 • The National Environment Management Action Plan, 1995 • The National Conservation Strategy, 2016-31 • the Sustainable Development Goals (SDG) • The Biodiversity Strategy and Action Plan (2016-21) • Ramsar Convention, 1972
		Fisheries Resources	• Fish habitat area • Fish production	
		Land, Agriculture and Livestock Resources	• Land use • Cropping area • Cropping pattern and intensity • Crop production • Irrigated area	
7	Socio-economic Development	Socio-economic Conditions	• Wage Labor • Institution and Governance	• The Haor Master Plan, 2012 • The 7th Five Year Plan (2016-2020) of the GoB

The directives on the above-mentioned issues are presented below:

4.3.1 Water Resource and Disaster Management

Management of water resources and water induced disasters i.e. flood and drainage management in the haor areas has been highlighted in various plans. The directives regarding water resources management and flood and drainage management in various plans, strategies and conventions are often overlapping in nature. Therefore, such directives on water resources management and flood and drainage management have been discussed below:

The Haor Master Plan, 2012 is a framework plan for developing the haor areas through optimal utilisation of natural and human resources for the next 20 years (up to FY 2031-32). In this plan, strategies have been formulated under the umbrella of six broad thematic areas. The strategies under the thematic area “Improved water and disaster management” suggests to safeguard the water resources and to preserve the natural characteristics of the whole basin with special attention to ecologically important areas.

The strategies and plans of the National Water Management Plan (NWMP), 2001 for water sectors also provide direct and indirect directives which are related to Haor. They are:

- Development and management of river system and embankments;
- Integrated development and management of haors and wetland;
- Flood proofing rather than flood control of the rural population living in haor basin;
- Reduction of encroachment and exploitation of ecologically sensitive haor basin; and
- Integrated river management plan covering erosion control, dredging and other elements of river maintenance such as pollution control, abstraction, navigation and environmental needs.

Planning Commission of Bangladesh launched the 7th Five Year Plan for the financial year 2015-16 to 2019-20 to achieve the targets envisaged in Bangladesh Perspective Plan 2010-21 with a vision 'Accelerating Growth, Empowering Citizens'. Apart from showing a way to conservation of wetlands including Jalmohals and rivers in dry season; several strategic directions and policy framework have been outlined in this five year plan, where watershed management and resilience against climate change got special emphasis in relation to haor area which are given below:

- Watershed management and wetland conservation should be initiated in the haor regions and hills districts and also would be intensified in the old areas for better conservation of nature during the plan period
- Integrated Haor Management Programme for Haor Region has suggested by BDP2100, which is also recommended by Seventh Five Year Plan (2016-2020)
- In respect to climate change, the country is not an actor but the worst sufferer. BWDB/LGED coastal FCD/FCDI projects and submersible embankment projects in Haor area are the first stage defence in case of climate change

The North East Regional Water Management Project (FAP 6), 1993 was prepared under the auspices of the Flood Action Plan to assist the GoB in planning and guiding the development of the haor region with particular emphasis on water management. A portfolio of 44 initiatives was developed from the eight regional strategy thrusts divided into four priority groups. Major objectives of this plan were to increase the amount of flood free land to accommodate the rising population and minimize flood damage. The guiding principles related to the study are:

- Protection of rural infrastructure and controlling floods to meet the needs of agriculture, fisheries, navigation, urban water flushing and annual recharge of surface and ground water resources
- Effective land and water management in protected and unprotected areas
- Measures to strengthen flood preparedness and disaster management
- Improvement of flood forecasting and early warning system
- Reduction of flood flow in major rivers by diversion into major distributaries and flood relief channels
- Channel improvement and structures to ensure efficient drainage and to promote appropriate water conservation and regulation
- Co-ordinated planning and construction of rural roads, highways and railway embankments with provision for unimpeded drainage
- Expanded popular support and beneficiary involvement in the planning, design and operation of flood control and drainage works
- Facilitate integrated development of deeply flooded areas

The Bangladesh Climate Change Strategy and Action Plan, 2009 established programmes of action on six main pillars for the five-year period (2009-2013). Programmes which are relevant to haor under these six pillars are stated below in Table 4.3:

Table 4.3: Programmes which are relevant to haor under six pillars of BCCSAP

Theme No.	Theme Name	Programmes
1	Comprehensive Disaster Management	• Improvement of flood forecasting and warning system
2	Infrastructure	• Repair and maintenance of existing flood embankments and ensuring continued flood protection by repairing and rehabilitating existing flood embankments and ancillary infrastructure. • Adaptation against floods to make flood prone areas more resilient by flood zoning and management. • Planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work.

The EPWAPDA 1964 Master Plan was designed to meet the agricultural demand of water through large-scale public sector development and water management in both dry season (irrigation) and wet season (flooding). The Master Plan identified 63 water development projects and grouped them per geographic locations. Major outcomes of the plan were the initiation of the process of national level water sector planning and the eventual implementation of large-scale Flood Control Drainage (FCD) and Flood Control, Drainage & Irrigation (FCDI) projects including the protection of most coastal zones against tidal flooding.

The insights of the Master Plan regarding flood management was to confine flood flow to the river channels and thus permit intensification of cropping

The Bangladesh Delta Plan (BDP) 2100, (Draft) is being developed as an adaptive, holistic and long term strategic plan acknowledging the opportunities and vulnerabilities created by the interface of water, climate change, natural disasters, environment, ecological balance, agriculture, land use and inland water management for national development. The sustainable use of water resources and prevention of water-related natural disasters provides the backbone to the Delta Plan. The plan has formulated strategies for protection of agriculture and vulnerable communities from flood. It has also suggested for building roads and railways keeping adequate space for flood passage; modification of existing FCD/I projects with Boat passes/navigation locks/ Fish Pass; and re-excavation of khal and modification/reconstruction of bridges and culverts keeping adequate free board for plying waterways.

The National Environment Management Action Plan, 1995 in the "Wetland Issues" section the NEMAP emphatically pointed out towards flooding and associate loss of life and property and suggested for flood proofing and flood protection work.

The National Plan for Disaster Management (2016-2020), designed to support the government of Bangladesh’s target to become a middle income country by 2021 and a developed country in 2041, sets out priorities and core targets for the next five years for safeguarding the country’s economic and development goals from disasters through disaster management (DM) for resilience. A phase-wise approach is adopted by the plan. This plan outlined 4 investment priorities under which different targets for different timeframe has been set up. Study relevant targets under are given are: Nationwide capacity building for resilience; physical works and structural measures for resilience; and strengthening flood management.

4.3.2 Regular maintenance of Infrastructure

The programmes of action formulated under the thematic area “Infrastructure” of the Bangladesh Climate Change Strategy and Action Plan, 2009 provided suggestions regarding regular maintenance and rehabilitation of interventions which are given below:

- Repair and maintenance of existing flood embankments and ensuring continued flood protection by repairing and rehabilitating existing flood embankments and ancillary infrastructure.
- Adaptation against floods to make flood prone areas more resilient by flood zoning and management.
- Planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work.

The Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (Draft) has advised for Strengthening coastal and inland embankments and improve drainage capacity and also for Support for operation and maintenance of water management

4.3.3 Agriculture Resources Management

The directives found in different plans and strategies for agricultural resources management associated with infrastructure development are discussed below:

The Haor Master Plan, 2012 has suggested agricultural development for food security to provide food security, economic development and poverty reduction of the haor people. The Bangladesh Delta Plan 2100 (draft) has suggested to protect agriculture and vulnerable communities from flood. Development of climate resilient cropping system appropriate for different agro-climatic regions and sub-regions has been recommended by the Bangladesh Climate Change Strategy and Action Plan, 2009. The EPWAPDA Master Plan, 1964 was designed to meet the agricultural demand of water through large-scale public sector development and water management in both dry season (irrigation) and wet season (flooding). Recommendation of the Master Plan was for development of the water sector to confine flood flow to the river channels and thus permit intensification of cropping. The North East Regional Water Management Project (FAP 6), prepared under the auspices of the Flood Action Plan to assist the GoB in planning and guiding the development of the haor region with particular emphasis on water management, asked for protection of rural infrastructure and controlling floods to meet the needs of agriculture, fisheries, navigation, urban water flushing etc.

4.3.4 Fish Friendly Infrastructure Development

Several strategies and recommendations regarding development of fish friendly infrastructure have been outlined in various plans, strategies and conventions. These strategic recommendations are presented below:

The Biodiversity Strategy and Action Plan (2016-21) has suggested that, by 2021, stock assessment of fish, invertebrate stocks and aquatic plants should be undertaken keeping in mind the safe ecological limit. It has also advised for raising awareness of the stakeholders so that aquatic biodiversity can be managed and harvested sustainably. The Sustainable Development Goals in its Goal 15 has signified on protection, restoration and promotion of terrestrial and inland freshwater ecosystems and halting biodiversity loss. It is also mentioned in Target 15.1.2, that by 2020, important sites for terrestrial and freshwater biodiversity that are covered by protected areas shall also be prompted, by ecosystem type.

The following directives regarding the fisheries resource management are found in the 7th five year plan of the Government of Bangladesh:

- Prevent deterioration of water logging, blockade of water-flows and shrinkage of water-bodies by infrastructures like embankment, roads, urban housing projects and industrialization. Such projects must follow the environmental rules and regulations (including EIA, SIA, etc.) and incorporate adequate mitigation measures in consultation with the Ministry of Fisheries and Livestock
- Projects and programmes should be implemented to construct and maintain fish-passes, fish-friendly regulators, re-excavate canals and rivers restoring and conserving productivity as much as possible
- Establish and maintain fish and wetland sanctuaries which would comprise complete ban on fishing in certain eco-sensitive areas like Sundarbans, parts of Kaptai Lake, and several sections of the river Halda, selected beels and haor areas
- Daudkandi model of seasonal floodplain aquaculture should be further promoted to expand all over the country but with added emphasis to combine maintaining sanctuaries in the important beel and haor areas

The National Environment Management Action Plan, 1995 identified the key environmental issues, and the actions required to halt or reduce the rate of environmental degradation, improve the natural and manmade environment, conserve habitats and bio-diversity, promote sustainable development and improve quality indicators of human life. The strategies and associated action plan as mentioned under the water resources sector directly or indirectly relate to the fisheries management. They are: re-designing the projects for creating infrastructure for facilitating fish migration to and from floodplains and conducting research development activities on the fish migration and natural recruitment in the FAP area.

The National Sustainable Development Strategy (2010-2021), acknowledging the development aspiration, has provided some sustainable development strategies. The strategies specifically mentioned for haor area for ensuring wise use of wetlands are as following:

- Set aside at least 10% of wetland areas as fish sanctuaries. In important fish resource areas such as haor, the protected area it should be at least 20%
- Establish and maintain sanctuaries which will comprise complete ban on fishing in certain eco-sensitive areas like the Sundarbans, parts of Kaptai Lake, and several sections of the Halda river, selected beels in haor areas and certain sections of the Bay of Bengal etc.
- Identify key habitats that ensure ecosystem integrity and connectivity (migratory flyways of birds, fish passes, etc) and support actions to maintain and promote such connectivity between the earmarked critical and sensitive areas

4.3.5 Conservation of Ecosystem and Bio-Diversity

Conservation of ecosystem and bio-diversity has been given priority in various global and national plans. Goal 15 of the Sustainable Development Goals signifies on protection, restoration and promotion of terrestrial and inland freshwater ecosystems and halt biodiversity loss. It is also mentioned in Target 15.1.2 that by 2020, important sites for terrestrial and freshwater biodiversity that are covered by protected areas shall also be prompted, by ecosystem type. The Haor Master Plan, 2012 suggested for biodiversity enhancement and wetland management to maintain ecological balance, protect the environment and improve livelihoods of the poor people of the area.

The Biodiversity Strategy and Action Plan (2016-21) which is a guiding framework for biodiversity conservation, ensuring sustainable use of its components along with fair and equitable sharing of benefits arising out of utilization of genetic resources. Twenty national targets have been proposed to be taken into action during the fiscal year 2015-2016 to 2020-2021. Following targets among 20 national targets are found relevant to this study

i. By 2021, Studies on the impacts of incentives or subsidies on biodiversity, as well as development of policy roadmaps for phasing out of incentives or subsidies harmful to biodiversity will be completed towards mainstreaming the relevant ministry for implementation of the policy roadmap

ii. By 2021, studies on the rate of habitat loss will be furnished towards promoting implementation of land use policy and enforcement of relevant legislations on conservation of natural habitats

iii. By 2021, development of Integrated Management Plan will be completed for areas under agriculture, aquaculture and forestry towards ensuring conservation and sustainable use of biodiversity

iv. By 2021, Bangladesh's 3% area under terrestrial ecosystem (forests), 3% area under inland wetlands and coastal ecosystems and 5% of total marine area will come under PAs or ECAs with development and implementation of management plan for these areas

v. By 2021, develop and implement restoration plan for degraded wetlands and rivers taking into account the needs of vulnerable people and local communities

vi. By 2021, initiate implementation of restoration plan for degraded ecosystems, especially, forest lands and wetlands for addressing climate change mitigation, adaptation and combating desertification

Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (draft) provides a strategic framework for the national and international investments for the environment, forestry and climate change sectors in Bangladesh. This strategy has indicated some guidelines for the preservation of the ecosystems of the water bodies, including haor, which is the home to a number of species of fishes and a great source of nutrition for the people of the country. Relevant programmes and sub-programmes taken in the Country Investment Plan (CIP) for Environment, Forestry, Climate Change sector include development and enhancement of conservation of protected areas through joint government-community co-management; and improvement of biodiversity monitoring (including strengthen monitoring capacities of institutions)

The National Conservation Strategy, 2016-31 was formulated to foster development in the country through the conservation, development and enhancement of natural resources in the country within the framework of sustainable development, particularly as envisioned under the Sustainable Development Goals (SDG). This strategy expected to create a conducive policy environment and strategy for conservation, development and enhancement of natural resources in the country. The strategy is divided into 17 chapters on the basis of sectoral issues. The sectors span all the important areas that require inter-sectoral and intra-sectoral considerations: human resources, land resources, water resources, forest resources, biodiversity, fisheries resources, crop agriculture, industry, rural development, energy and minerals, urbanization, health and sanitation, transport and communication, disaster and disaster management, environmental education and awareness, gender Issues and environment and international obligations. Analysing current status and interventions of these different sectors strategies as well as action plans have been suggested on the basis of Sustainable Development Goals. Some strategies relevant to this study are as following:

- Prepare management plan for all ecosystem of the country including the Wildlife Sanctuary, National Parks, Ecologically Critical Areas etc
- Improvement of the understanding the species diversity of different inlands water bodies like Beels, lakes, rivers and streams of Bangladesh
- Management plans incurred from human causes and natural disaster

It is narrated in Target 6.6 of Goal 6 of the Sustainable Development Goal that by 2020, the water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes will be protected and restored. Ensuring the availability of fresh water across the world is another target of this goal.

4.3.6 Preservation and conservation of waterbody/wetlands

Preservation and conservation of wetland and waterbodies has been outlined as a major concern in many plans and conventions. Plans and strategies regarding preservation and conservation of wetland and waterbodies which are associated with the development of infrastructure are summarized below:

The Haor Master Plan, 2012 has called for biodiversity enhancement and wetland management to maintain ecological balance, protect the environment and improve livelihoods of the poor people of the area. The National Environment Management Action Plan, 1995 has identified key environmental issues, and the actions required to halt or reduce the rate of environmental degradation, improve the natural and manmade environment, conserve habitats and bio-diversity, promote sustainable development and improve quality indicators of human life. The "Wetland Issues" section the NEMAP emphatically pointed out that "the reduction of wetlands is one of the marked features of environment degradation in Bangladesh". Strategies and associated action plan directly or indirectly related to study are as below in Table 4.4:

Table 4.4: Strategies and associated action plan related to study

Sector	Key Issues	Action Plan
Wetland	Poisoning wetlands for some aqua culture project intervention in the open water environment (Haor area)	Implementation of wetland conservation laws and creation of sanctuaries.
	Loss of wetland biodiversity	Bio-diversity conservation
	Absence of integrated management of the wetlands	Development of a comprehensive wetland management policy

The National Conservation Strategy, 2016-31 was formulated to foster development in the country through the conservation, development and enhancement of natural resources in the country within the framework of sustainable development, particularly as envisioned under the Sustainable Development Goals (SDG). This strategy expected to create a conducive policy environment and strategy for conservation, development and enhancement of natural resources in the country. This strategy calls for inventory preparation for wetland protection and recovery along with fish, migratory species of birds and wildlife. Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (draft) has suggested to support implementation and scaling up of the Master plan for Haor and flood prone areas for Sustainable management of wetlands and rivers.

The Biodiversity Strategy and Action Plan (2016-21) has set the following targets considering the importance of conservation and preservation of wetlands and waterbodies:

i. By 2021, Bangladesh’s 3% area under terrestrial ecosystem (forests), 3% area under inland wetlands and coastal ecosystems and 5% of total marine area will come under PAs or ECAs with development and implementation of management plan for these areas

ii. By 2021, develop and implement restoration plan for degraded wetlands and rivers taking into account the needs of vulnerable people and local communities

iii. By 2021, initiate implementation of restoration plan for degraded ecosystems, especially, forest lands and wetlands for addressing climate change mitigation, adaptation and combating desertification

The Convention on Wetlands of International Importance, called the Ramsar Convention was adopted by the international community in 1972. It is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem and the Convention's member countries cover all geographic regions of the planet. Bangladesh became a member of the Convention in 1992. At the center of the Ramsar philosophy is the “wise use” concept. The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". The pioneering ‘Wise Use Guidelines’ emphasized the importance for the contracting parties to:

- Adopt national wetland policies, involving a review of their existing legislation and institutional arrangements to deal with wetland matters.
- Develop programmes of wetland inventory, monitoring, research, training, education and public awareness.
- Take action at wetland sites, involving the development of integrated management plans covering every aspect of the wetlands and their relationships with their catchments.
- The Wise Use Guidelines also emphasised the benefits and values of wetlands for sediment and erosion control, flood control, maintenance of water quality and abatement of pollution; maintenance of surface and underground water supply; support for fisheries, grazing and agriculture; outdoor recreation and education for human society; and climatic stability.

Considering the ecological value of the haor, Tanguar haor and Hail-Hakaluki haors have been declared as Ramsar sites under the Ramsar Convention for protection of wetlands.

4.3.7 Socio-economic Development

Socio-economic development is an integral part of any structural intervention. The recommendation regarding socio-economic development found in different strategies and plans which fit with the scope of this study are presented here.

The Haor Master Plan, 2012 for developing the haor areas through optimal utilization of natural and human resources for the next 20 years (up to FY 2031-32) has suggested for improved physical infrastructure to contribute in regional economic growth in general and pro-poor growth in particular, enhance tourism, employment generation and poverty reduction. It has also advised for enterprise and technology development to contribute in regional economic growth in general and pro-poor growth in particular. The 7th Five Year Plan (2016-2020) of the GoB calls for development and refinement of technologies which may bridge yield gaps and promote diversification, sustainable natural resources management.

4.4 Review of Existing Development in Haor Area

The haor area is still under-developed due to its physical and hydrological settings, although it is one of the major economic production zones of the country. The history of intervention in the Haor Region dates back to the British and Pakistan period when some submersible embankments were constructed and maintained through local initiatives. However, the Government of Bangladesh has taken several initiatives to manage water resources, flood, transportation system as well as poverty since early ‘60s in the haor areas. During 1975-76 to till date about 118 schemes have been implemented by BWDB in the haor area. Moreover, other agencies like LGED, RHD etc. undertook many development works for flood and disaster management, development of road network, other infrastructural development while the DBHWD prepared a 20-year Master Plan for overall development of this region. The development initiatives taken by different agencies are discussed in the following sub-section which will give a picture of existing development in this region.

4.4.1 Initiatives by BWDB

BWDB has implemented about 118 schemes in the haor area since 1975-76 to till date with a view to mainly protect Boro crop with some other functions like, drainage, irrigation; full flood protection etc. In addition there are some projects only for flood protection, some are for irrigation, and some are for drainage only whereas some are of mix-function. These interventions in haor were made by BWDB through EIP, SRP, FAP, Haor Rehabilitation Schemes etc. and are maintained every year by BWDB to the required extent to facilitate food production with the allocated budget by GoB. The number of water management structures under different BWDB schemes is given in Table 4.5. However, sometimes maintenance work is hampered due to fund constraints.

Table 4.5: Water Management Structures of BWDB Schemes

Structure Name	Total Number
Regulator	128
Sluice	65
Inlet	157
Outlet	21
Closure	28
Flood Protection Wall	3
Cross Dam	3
Public Cut	22
Earth Work	3
Grand Total	430

Source: NWRD, WARPO

The following sub-sections review the previous projects in Bangladesh for the haor areas.

Early Implementation Project (EIP)

The Early Implementation Projects, which started in 1972, were implemented through 88 schemes in different regions of Bangladesh, covering an area of 463,250 ha. The implemented schemes consisted of the development of haor (dish shaped depressions within a perimeter consisting of river levees) and polders, i.e., the excavation of canals, construction of sluices, closures, and embankments. In 1976, BWDB reconstructed the submersible embankment in the Shanir Haor (the construction of which was initiated in 1915 through local initiatives) and replaced the regulator on the embankment with a 6 vent regulator equipped with fall boards. BWDB also started other interventions in haor areas under EIP in 1975.

Systems Rehabilitation Projects (SRP, 1982)

The Systems Rehabilitation Project of BWDB was identified in 1982 with the main aim to protect and increase agricultural production and incomes and to raise the standards of living through rehabilitation and improved O&M of BWDB's existing sub-projects. After detailed reviewing of the physical conditions, topography, climate & hydrology, land tenure, labor utilization, agriculture and fisheries and environmental situations; the study conducted under SRP proposed the rehabilitation work through the sub-projects nominated for Karchar Haor, Kalner Haor, Halir Haor, Shanir Haor, Matian Haor, Mohalia Haor, Chandra Sonar Thal Haor, Dhankunia Haor and Joydhuna Haor in Sunamganj District. The submersible embankments in the Haor areas were designed for a 1 in 10 year for pre- monsoon flood. Design flood level was determined in the rivers near the respective Haors by interpolating the water levels of nearby gauge stations. The regulators were designed satisfying both post monsoon drainage criteria and pre-monsoon flushing criteria.

Kalni-Kushiyara River Management Project

The Kalni Kushiyara River Management Project Feasibility Study is one of the most important initiatives recommended in FAP 6. The objective of the study was to improve the stability of the rivers, reduce pre-monsoon flood damage, reduce erosion damage and improve all weather navigation along the river as these rivers is experiencing large ongoing sedimentation and instability over the last few decades leading to widespread over-bank spills, erosion of the river bank, channel shift and increased pre-monsoon flooding. These events have resulted in deteriorating river capacity to drain the surrounding area efficiently. The feasibility study of Kalni-Kushiyara River Management Project (KKRMP) proposed some engineering interventions for river stabilization, flood control and drainage. The interventions included construction of loop cuts, channel re-excavation, channel re-alignment by dredging point-bars, construction of bank protection works, construction of embankments and construction of regulators on two off-take channels. KKRMP is now under implementation by BWDB as per the schedule of approved DPP.

Haor Rehabilitation Scheme (2004)

BWDB selected 37 haor schemes for rehabilitation considering local demand after the unexpected damage of Boro Crop caused inside these schemes by flash flood of 2004. This rehabilitation scheme was formulated to design embankments of haor projects to resist 1 in 10 year pre-monsoon flood and to fill and drain out haors. The project considerations were: Drainage congestion; River sedimentation; Confinement effect of the haor projects; Navigation; and Conflict between agriculture and fisheries. The main components of this project are: Redesign of embankments for 37 haor schemes; Dredging of Kalni-Kushiyara river system which has three parts (i.e. Kalni River (Markuli to Issapur), Baida River (Issapur to outfall) and Dhaleswari River (Austogram to outfall)); Dredging of Baulai River (Lalpur to Mitamain); Dredging of Old Surma (Kamagoon to outfall); Dredging of Chamti River (Dulbazar to outfall); and Dredging of Rakti. On the basis of the study, BWDB has prepared a DPP for the rehabilitation of 52 haors and has been approved accordingly for initiating the work from the financial year 2011-12.

Water Management Improvement Project (WMIP, 2007)

The Water Management Improvement Project (WMIP) consisted of three components: (i) System Improvement and Management Transfer (SIMT); (ii) O&M Performance Improvement; and (iii) Institutional Improvement. System Improvement and Management Transfer (SIMT) supported rehabilitation and improvement (R&I) of about 33 existing medium (average area 2,500 ha) and 3 large (average area 8,400 ha) FCD and FCDI schemes of BWDB. The objective of Operations and Maintenance Performance Improvement was to ensure the sustainability of those schemes that are currently functioning well and have already undergone major rehabilitation and improvement like for schemes under component 1 (or have gone through a similar process under projects funded by GoB or other donors). The study has been completed in 2016. It is likely that some haor projects may be included in the rehabilitation and improvement list of the WMIP.

4.4.2 Initiatives by LGED and RHD

LGED has constructed 184 sub-projects in the haor areas that relate to partial flood management, drainage and water management. Among those projects, 111 subprojects are identified as FMD/ drainage type subprojects and the rest are for water management, irrigation/CAD subproject in the periphery of Haor area. LGED has also constructed 2 rubber dams for flood management purposes by replacing an existing an old regulator, and in other case by providing a Rubber Dam at an existing opening in the embankment in connection with Karehar Haor project. There are other two rubber dams for water retention by LGED. BADC has implemented Michhakhali Rubber Dam for FMD in Angurali Haor in Biswambarpur Upazila of Sunamganj District. The concept of Haor sub-projects executed by BWDB, LGED and others for water management is to provide flood protection to the main crop Boro against early flash flood of the surrounding rivers by the provision of submersible embankments and to provide early drainage to Haor land by means of drainage sluices and regulators in the post monsoon. The sluices and regulators also serve for flushing water into the sub-project to reduce the head difference between the inside and outside of the polder at the time of overtopping and so reduce the damage to the embankments.

Furthermore, vast network of roads have been developed by LGED and RHD department to expedite socio-economic development to the almost inaccessible areas of the northeast. Government is also pursuing infrastructure development and livelihood support activities through IFAD assisted HILIP and CALIP in Haor areas through implementation of upazila, union and village roads, submersible roads, bridges, culverts, boat landing platforms, markets, erosion protection to villages, etc. These measures may in some cases bring about adverse impacts on already fragile environment and ecology of the area.

The rural roads in the Haor areas are constructed by the Local Government Engineering Department (LGED) and consist of upazila, union and village roads (Table 4.6). Eleven upazilas out of the total 69 upazilas in the haor districts are not connected with the RHD network. The upazilas are: Austagram, Itna and Mithamain upazilas in Kishoreganj district, Kalmakanda and Khaliajuri upazila in Netrakona, Dowarabazaar, Jamalganj, Sulla and Tahirpur upazila in Sunamganj district. There are 1055 bridges and 2074 culverts in the RHD road network of the haor region (RHD 2010). Sunamganj district has the lowest number of roads in terms of density while Sylhet has the highest road coverage.

Table 4.6: Rural road network in the haor area by LGED in km

District	Upazila		Union		Village A		Village B	
	Unpaved	Paved	Unpaved	Paved	Unpaved	Paved	Unpaved	Paved
Sunamganj	64	102	630	97	1883	25	1044	6
Habiganj	217	126	406	112	1270	66	806	2
Netrakona	271	224	591	100	1764	31	710	1
Kishoreganj	208	217	526	119	1388	60	1377	21
Sylhet	135	120	608	161	2329	199	1300	33
Maulvibazar	64	172	356	161	1596	195	639	18
Brahmanbaria	130	174	285	153	830	110	659	58
Grand Total	1091	1134	3403	902	11061	685	6536	138

Source: MPHA, 2012

The 1,761 km long Bangladesh national highways are included in the Asian Highway network. Two major routes of the Asian Highway, AH-1 and AH-2 cross Bangladesh. Route AH-1 enters Bangladesh at Tamabil in the east and passes through the Sylhet-Dhaka-Padma Bridge-Narail-Jessore–Benapole. Route. AH-2 also enters Bangladesh through Tamabil and follows the same route as that of AH-1 up to Dhaka and then takes a turn towards Tangail in the North-

West direction. AH-2 then passes through the Jamuna Bridge-Bogra-Rangpur-Dinajpur-Banglabandh route. The other Asian Highway route AH-41 connects the two sea ports of Bangladesh with AH-1 and AH-2.Railway network of 430 km length connects all the districts and 54 upazilas of the haor region with 88 number of railway stations. Only 14 km railway line lies within the Sunamganj district. Bulk of the passenger traffic and cargo enters the haor region through Kasba station in Brahmanbaria District and ends at the Shahbazpur station of the border district of Maulvibazar.

4.4.3 Initiatives by DBHWD

Acknowledging the need for the sustainable development considering future challenges in the context of climate change and variability and the slow pace of development in the Haor Region inspite of having development potentials and moderate pace of economic development of the country; a 20-year Master Plan was formulated by the Department of Haor and Wetlands Development (DBHWD) aiming at the integrated development of the Haor area. The objectives of the Master Plan was to develop the resources of the Haor region as rapidly as possible so as to promote the welfare of its inhabitants, provide adequate living standards, social services and equal opportunity, and aim at the widest and most equitable distribution of income and property. The Master Plan is a framework plan which will be implemented on the short, medium and long term basis. The development strategies in the Master Plan have been formulated under the umbrella of six broad thematic areas: 1) Improved water and disaster management, 2) Agricultural development for food security, 3) Biodiversity enhancement and Wetland management, 4) Social safety net and improved standard of living, 5) Improved physical infrastructure, and6) Enterprise and technology development. The planned investment portfolios have been prepared for 17 (seventeen) sectors namely:1) Water Resources, 2) Agriculture, 3) Fisheries, 4) Pearl Culture, 5) Livestock, 6) Forest, 7) Education, 8) Health, 9) Transportation, 10) Housing and Settlement, 11) Water Supply and Sanitation, 12) Industry, 13) Energy and Power, 14) Mineral Resources, 15) Biodiversity and Wetland, 16) Tourism and 17) Social Services. Multi-organisational involvement and community participation would be the key to successful implementation of the Plan for optimum utilisation of resources and reduction of poverty. The implementation of the Master Plan of Haor Area would be financed through the government's own resources and with external support. Public Private Partnership (PPP) has also been foreseen for implementation of the initiatives which are private and commercial in nature. 38 implementing organizations are identified under 16 ministries to execute the master plan. Involvement of development organisations and people's participation will create conditions in which the development of sustainable livelihoods and integration of the area into the national development processes can take place.

Chapter 5: Inventory of Infrastructures

5.1 Introduction

Implementing agencies of Government of Bangladesh (GoB) Bangladesh Water Development Board (BWDB), Local Government Engineering Department (LGED), Roads and Highways (RHD), Zila Parishad, Upazila Parishad, Union Parishad, Pouroshova and other NGOs have constructed huge number of structures to cope up with extreme flooding events or flash floods, to facilitate well communication system, to protect crops and to achieve poverty reduction targets. Among all those implementing agencies BWDB, LGED and RHD are mainly involved in construction of water management structures with a view to improve flooding situation as well as facilitating boosting up of agricultural production in that region. Structures of Zila Parishad, Upazila Parishad, Union Parishad, Pouroshova and other NGOs are established in settlement area only. Therefore, structures of local government agencies and NGOs have not been included in inventory preparation.

BWDB has constructed around 2000 km of submersible embankments, 128 regulators, 65 sluices, 157 inlets, 21 outlets, 28 closures and 3 cross dams. LGED has constructed 24,948 km rural roads, 8 rubber dams, 123 regulators, 17 sluices, 23 inlets and outlets, 55 water retaining structures. RHD constructed 430 km National Highways, 578 km Regional Highways, 937 km district road. There are 1005 number of bridges and 2074 number of culverts in the RHD road network of the haor region.

5.2 Inventory of BWDB

The Bangladesh Water Development Board (BWDB) has implemented 118 Flood Control (FC), Flood Control and Drainage (FCD), Flood Control, Drainage and Irrigation (FCDI) and Drainage Control or Irrigation projects/schemes in the haor area since early ‘60s, under which a total of 430 different water management structures exist *(Haor Master Plan, 2012).*

Therefore, basic and detail information of water management structures of those schemes has been collected and stacked from secondary sources like survey reports, BWDB head office and site offices. Inventory of seventy nine (79) schemes among 118 schemes has been developed in this study based on available data. Basic information of a scheme includes project type and name, its beneficial area, length of embankment and starting and ending year while detailed information includes types and dimensions of structures, number of vents and their sizes, sill level, deck level, soffit level and their geographic location as well. Table 5.1 and 5.2 illustrates basic and structural information of Angurali haor as an example. Figure 5.1 shows spatial distribution of different water management structures in haor area.

Total structure inventory of BWDB has been placed in Annex 4.

Table 5.1: Summary Inventory of Angurali Haor System

Scheme Name	Angurali Haor System	**Division**	Sunamganj O&M Division		
Project Type	FCD	**Project Area**	2440 Hectare	**Beneficial Area**	1464 Hectare
Project Started	1981	**Project Ended**	1986	**Embankment Length**	26 Kilometer

Table 5.2: Detail Data Inventory of Angurali Haor System

Sl No.	Structure Type	Lat	Long	No. of Vents	Barrel Length (m)	Height (m)	Width (m)	Dia (m)	Sill/Bed	Soffit	Deck
1	Sluice Gate	25.0731	91.2896	2	2.430	5.700	1.500		0.83	6.53	6.84
2	Box Culvert	25.0667	91.2923		9.050	1.150	1.230		3.17	4.32	4.45
3	Pipe	25.0666	91.2668		18.900			0.750	2.11	2.85	
4	Box Culvert	25.1028	91.2559		7.200	0.660	0.600		4.74	5.40	5.52
5	Box Culvert	25.1060	91.2555		7.300	0.470	0.600		5.73	6.20	6.30
6	Box Culvert	25.1079	91.2536		5.500	1.010	1.350		5.87	6.88	7.14
7	Box Culvert	25.1081	91.2558		3.700	3.020	2.100		5.40	8.42	8.67
8	Box Culvert	25.1084	91.2578		7.100	1.840	1.850		5.14	6.98	7.34
9	Box Culvert	25.1093	91.2594		6.550	1.820	1.850		6.35	8.17	8.33
10	Bridge	25.1357	91.2970			2.620	8.650		5.75	8.37	8.84
11	Box Culvert	25.1336	91.2985		6.430	1.220	0.950		7.19	8.41	8.53
12	Box Culvert	25.1318	91.2989		4.250	2.500	2.480		6.15	8.66	8.89
13	Bridge	25.1291	91.2992	4	0.000	4.140	3.580		5.19	9.33	9.80
14	Box Culvert	25.1276	91.2991		3.770	2.340	2.250		5.34	7.68	7.77
15	Pipe	25.1261	91.2990		7.700			0.500	6.24	6.74	
16	Box Culvert	25.1254	91.2990	2	4.900	2.500	3.500		6.09	8.59	8.99
17	Box Culvert	25.1093	91.2962		4.150	2.850	2.500		4.94	7.79	8.02
18	Box Culvert	25.1021	91.2932		4.280	2.630	5.800		4.71	7.34	7.68
19	Box Culvert	25.0998	91.2947		6.500	1.870	1.820		5.25	7.12	7.29
20	Box Culvert	25.0949	91.2951		12.800	0.900	0.600		3.69	4.59	4.71

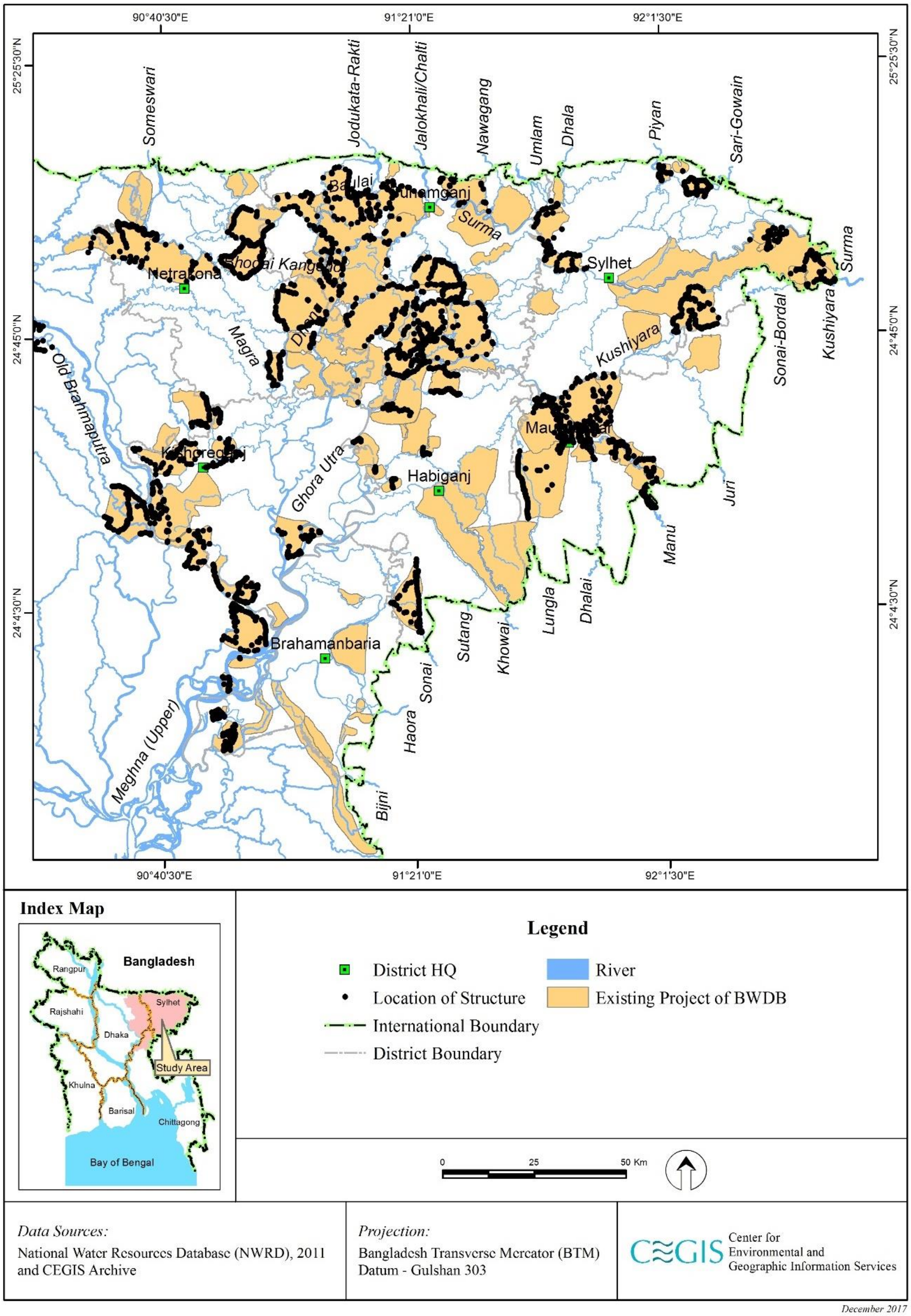


Figure 5.1: Spatial distribution of different water management structures in haor area

5.3 Inventory of LGED

Local Government Engineering Department (LGED) has constructed 184 subprojects in the haor area that relate to partial flood management, drainage and water management *(Haor Master Plan, 2012)*. Among those projects, 111 subprojects are identified as FMD/ drainage type subprojects and the rest are for water management, irrigation/CAD subproject in the periphery of Haor area. Furthermore, LGED have developed vast network of roads in this region.

In order to make an inventory of structures of LGED, available structural information of seven (7) districts i.e. Sylhet, Sunamganj, Habiganj, Netrokona, Kishoreganj, Maulvibazar and Brahmanbaria has been collected from LGED main office which includes upazilla wise structural information under different schemes or sub-projects covering whole haor area. Inventory of LGED includes information on name of scheme, name and types of structure, dimensions of structures, number of vents and size, beneficial area, name of respected Upazilla and District. Table 5.3 illustrates information of water management structures of LGED under Habiganj district. Figure 5.2 shows spatial distribution of all types of roads constructed by LGED in haor area.

Table 5.3: Structure inventory of LGED under Habiganj district

Name of Schemes	Project Name	Type of Structure	No. of Vent	Height (m)	Width (m)	Length (m)	Dia (m)	Beneficial Area (Ha)	Upazilla
Sundrateki-KamaiChhara	SundratekiKamaichara WRS	Water Retaining Structure	8					391	Bahubal
Sundrateki-KamaiChhara	RCC Pipe Culvert 2 Nos	Pipe Culvert						391	Bahubal
DholiaChhara Subproject	Water Retaining Structure	Water Retaining Structure	3	1.5	2.5			180	Bahubal
Newar Khal Subproject	Newar Khal WRS-2 at Ch.0+800Km	Water Retaining Structure	1	1.5	1.8			390	Bahubal
Newar Khal Subproject	Newar Khal WRS-1 at Ch.1+125Km	Water Retaining Structure	2	1.5	1.8			390	Bahubal
Katiar Bon Subproject	Saluka Dhayer Khal WR Sat Ch.1+812 Km	Water Retaining Structure	2	1.5	2			587	Baniachang
Katiar Bon Subproject	Pilu Khali Khal Khal WRS at Ch.1+031Km	Water Retaining Structure	2	1.5	2			587	Baniachang
Protappur-AndhauraBeel	Box Sluice at Ch.0+700km (Embk)	Box Sluice	2	1.5	1.8			136	Baniachang
JibdharChara Subproject	Jibdhar Chhara WRS-1 at Ch.0+672km(Km)	Water Retaining Structure	2	1.5	1.8			190	Chunarughat
JibdharChara Subproject	Jibdhar Chhara WRS-2 at Ch.1+644km (Khal)	Water Retaining Structure	2	1.5	1.8			190	Chunarughat
Kurungi Subproject	Rubber Dam	Rubber Dam			25	25		500	Chunarughat
Kurungi Subproject	Syphone on Brick Lined Channel-1	Syphone				28.5		500	Chunarughat

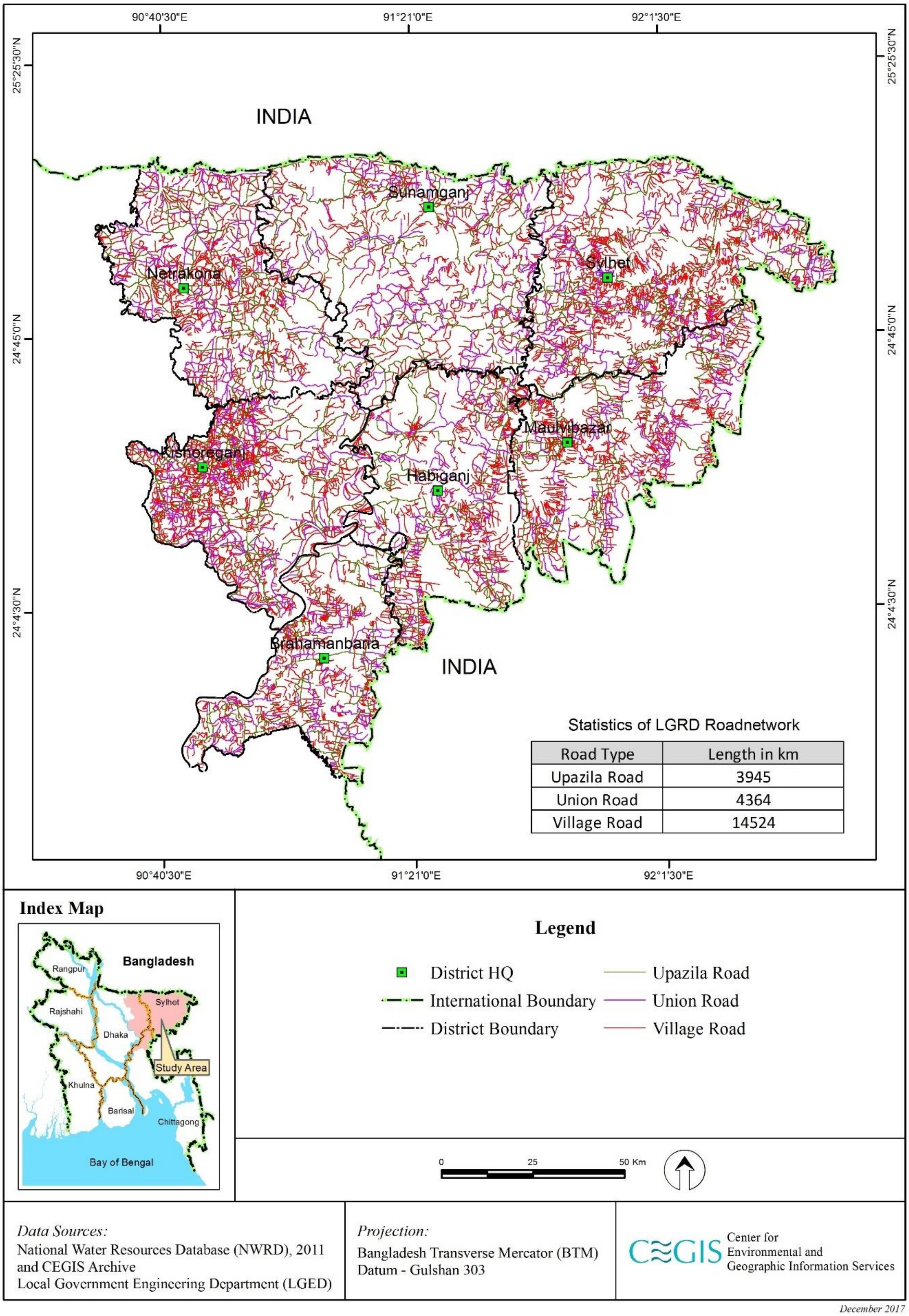


Figure 5.2: Spatial distribution of road network of LGED in haor area

5.4 Inventory of RHD

Roads and Highways Department (RHD) has constructed vast network of national and regional roads for improvement of communication facilities in haor area. Some bridges and culverts have also been constructed by RHD to facilitate drainage among this vast network of roads. In this study, available information of roads, bridges and culverts of Seven (7) districts of haor region has been collected from secondary sources. Inventory of RHD includes name and types of road, bridges, or culverts along with RHD code and length of road and bridges. Table 5.4 and Table 5.5 illustrate information of roads and bridges or culverts under Brahmanbaria district respectively. Figure 5.3 shows spatial distribution of all types of roads constructed by RHD in haor area.

Table 5.4: Information of roads of RHD under Brahmanbaria district

Road No	Road Name	Road Length (km)	Road Type
N102	Comilla (Mainamati)-Brahmanbaria (Sarail) Road	42	National
N103	Brahmanbaria Town Portion (Kuatali-Ghaturia)	5	National
N2	Dhaka (Katchpur)-Bhairab-Jagadishpur-Shaistaganj-Sylhet-Tamabil-Jaflong Road	34	National
N213	Asugonj River port Connecting Road	0	National
R120	Akhaura Town By-Pass Road	2	Regional
R203	Bhulta-Araihazar-Bancharampur-Nabinagar-Shibpur-Radhika Road	56	Regional
R220	Sarail-Nasirnagar-Lakhai-Habiganj Road	25	Regional
Z1042	Eliotganj-Muradnagar-Ramchandrapur-Bancharampur Road	12	Zilla
Z1043	Bancharampur-Homna Road	14	Zilla
Z1201	Kashba-Kuti Road	10	Zilla
Z1202	Dharkhar-Akhaura-Senarbadi Road	15	Zilla
Z1206	Companiganj-Nabinagar Road	12	Zilla
Z1210	Brahmanbaria-Lalpur Road	14	Zilla
Z1216	Sultanpur-Chinair-Akhura Road	11	Zilla
Z2031	Nabinagar-Ashuganj Road	19	Zilla

Table 5.5: Information of bridges or culverts of RHD under Brahmanbaria district

Structure Name	Road No.	Bridge Type	Length (m)
SONAROMPUR	N2	Box Culvert	6.1
SONARAMPUR CULVERT	N2	Box Culvert	3.1
SUNARAMPUR CULVERT	N2	Box Culvert	3.15
SUNARAMPUR BRIGE	N2	RCC Girder Bridge	79.75
Sonarampur Bridge	N2	RCC Girder Bridge	79.75
SUNSRAMPUR CULVERT	N2	Box Culvert	3.15
SOHAGPUR 1	N2	Box Culvert	6.1
SOHAGPUR 2	N2	Box Culvert	12.5
KAMORA	N2	Box Culvert	12.3
KHARIALA 2	N2	Box Culvert	3.1

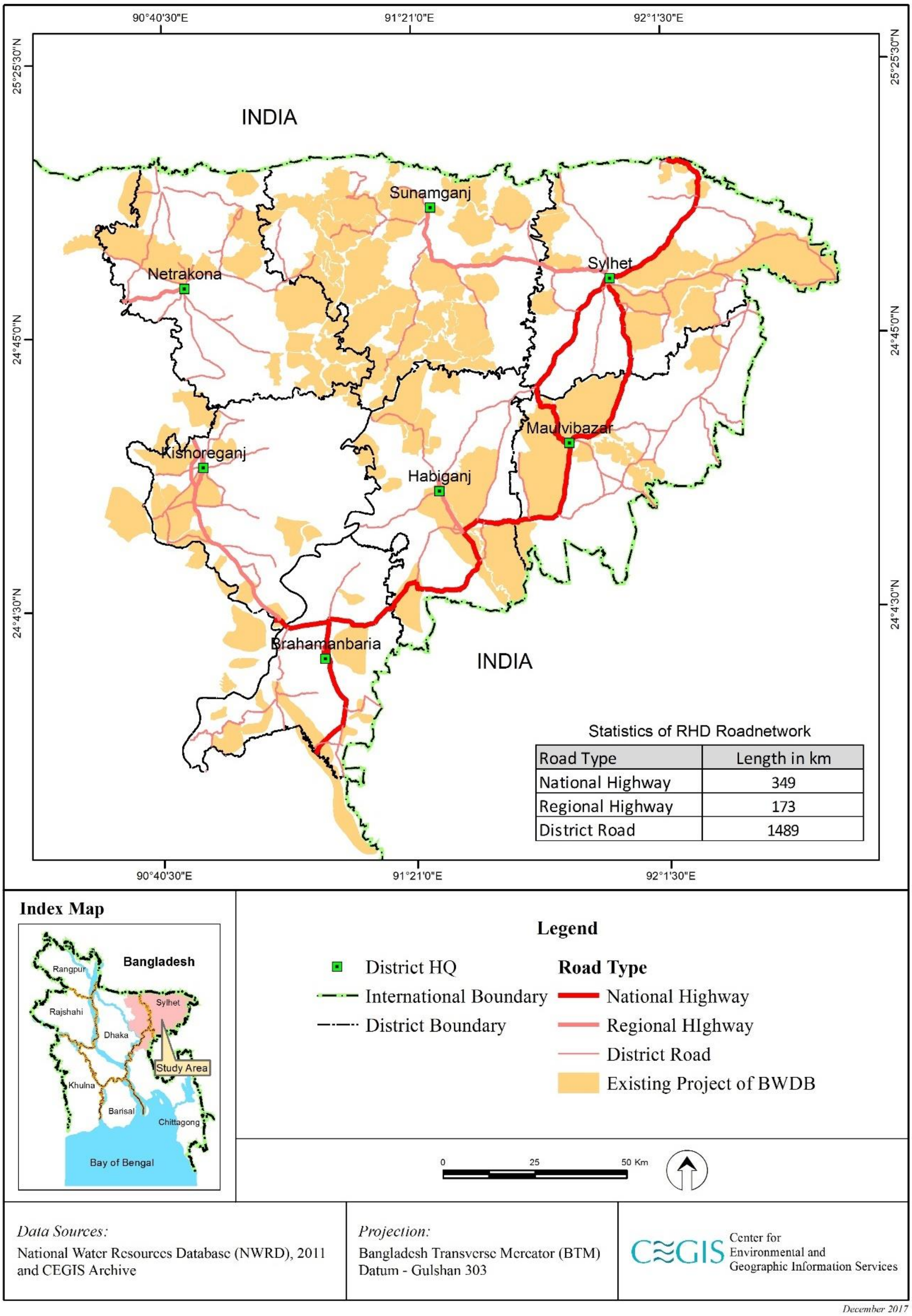


Figure 5.3: Spatial distribution of road network of RHD in haor area

Chapter 6: Impact Assessment

6.1 Introduction

Bangladesh Water Development Board implemented 118 FC/FCD/FCDI/DR/IRR projects in the haor area of Bangladesh with a view to flood and drainage management in haor area since early ‘60s. Main objectives of each of the flood management schemes were to protect Boro crop from early flash floods and to facilitate crop production constructing different kind of water management structures i.e. submersible embankment, regulator, sluices, box culverts, fish pass, irrigation inlets and drainage outlets etc. These structural interventions exerted both positive and negative impacts on different components of environment. In this section, impact has been assessed on water resources and navigation, land and agriculture resources, fisheries resources, ecological resources and socio-economic resources.

6.2 Water Resources and Navigation

Haor region passes huge volume of flow every year through its three main catchments Barak (50%), Meghalaya (36%) and Tripura (14%). Major portions of this flow are generated from huge rainfall in Meghalaya and Barak in addition to the local contribution (annual average of 4000 mm) of Sylhet region of Bangladesh. This huge volume of flow gets stuck in large bowl shaped depressions i.e. in haor before draining out through Meghna River. Frequency analysis of water level (Table 6.1) on different rivers of north-eastern region reveals that, haor area receives severe floods once in every five year due to its low depression (80% below 10m) topography. But, it suffers a lot to the life and properties when, sudden fall from Indian hills causes severe flash floods in pre-monsoon season specially, when happens in between end of March to early April. Evidence has been found from analysis of pre-monsoon rainfall that, pre-monsoon rainfall has increased from 18%-24% (from the period 1691-1990) to 25%-27% in recent years (1991-onwards) due to climate change.

Table 6.1: Frequency analysis of flood level of month of April on different rivers of haor area

Station Id	Station Name	Return Period			
		5	10	20	50
266	Sylhet	11.9	13.5	15.1	17.1
267	Kanairghat	9.3	10.9	12.4	14.4
173	Sheola	11.8	13.4	14.9	16.7
36.1	Mohonganj	5.5	6.1	6.7	7.5
251	Sarighat	11.3	12.5	13.5	14.8
174	Fenchuganj	8.6	9.8	11.0	12.4
201	Monu Rly. Bridge	16.7	17.4	18.0	18.7
192	Motiganj	8.3	8.6	8.9	9.2
158.1	Shaistaganj	11.4	12.0	12.4	13.0
269	Sunamganj	6.8	7.8	8.7	9.8
233A	Jaflong (Spill)	10.8	11.5	12.1	12.8
72B	Sukdebpur	5.2	5.9	6.5	7.3

Bangladesh Water Development Board (BWDB) started flood and drainage management projects since early ‘60s constructing submersible embankments and other water management structures. Satellite image analysis shows, in an average flood year around 2% and 10% of total FC/FCD/FCDI project area inundates in April and May respectively. But, in extreme year, around 15% and 50% of FC/FCD/FCDI project area inundates in April and May respectively (see Figure 6.1 and Figure 6.2). Risk of entrance of early flash floods reduced significantly due to implementation of these projects by delaying entrance of water from mid-April to 15 May through constructing submergible embankments and compartmental dykes with 10 year return period design crest level.

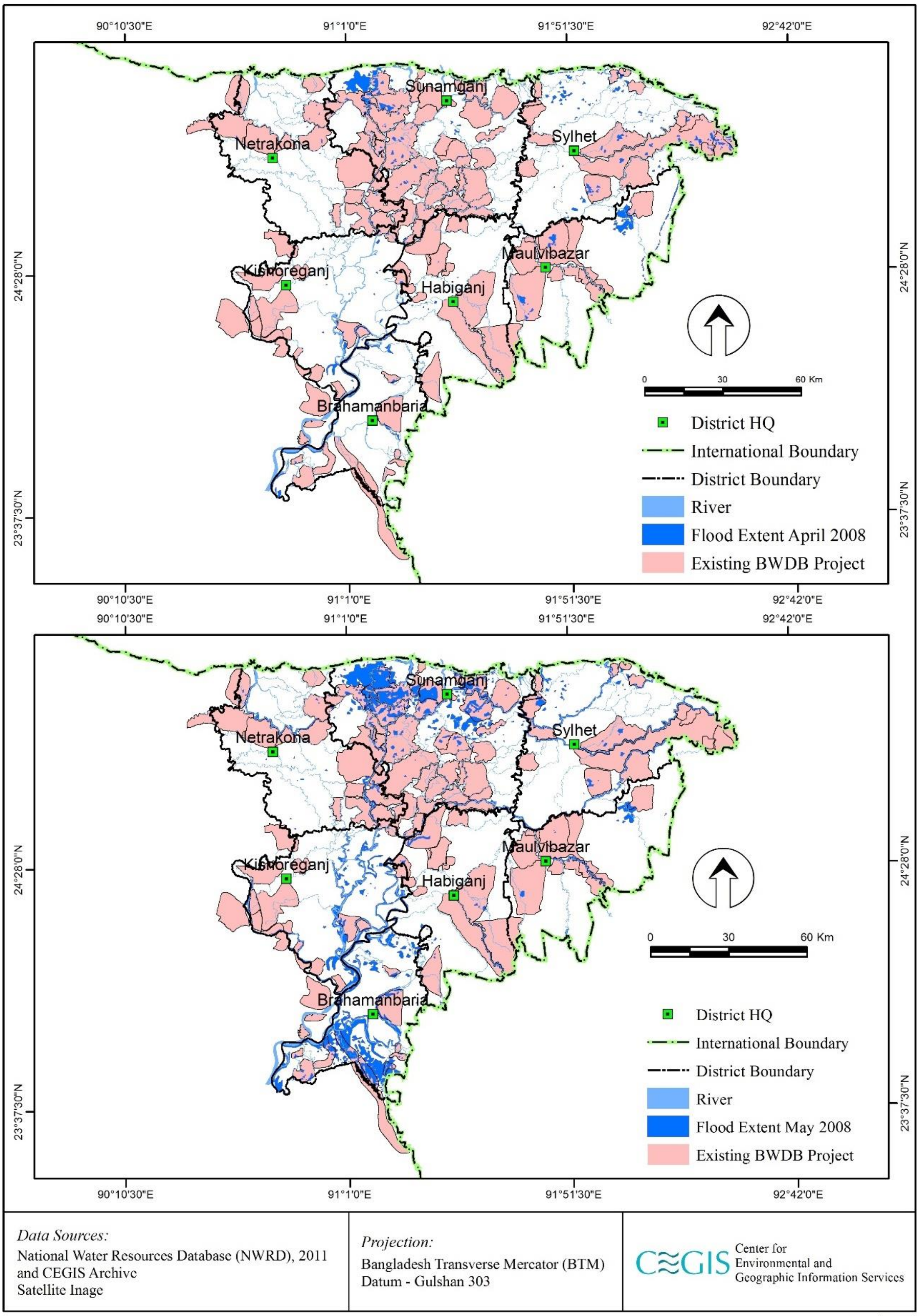


Figure 6.1: Flood extent of average year flood (2008) in FC/FCD/FCDI project area

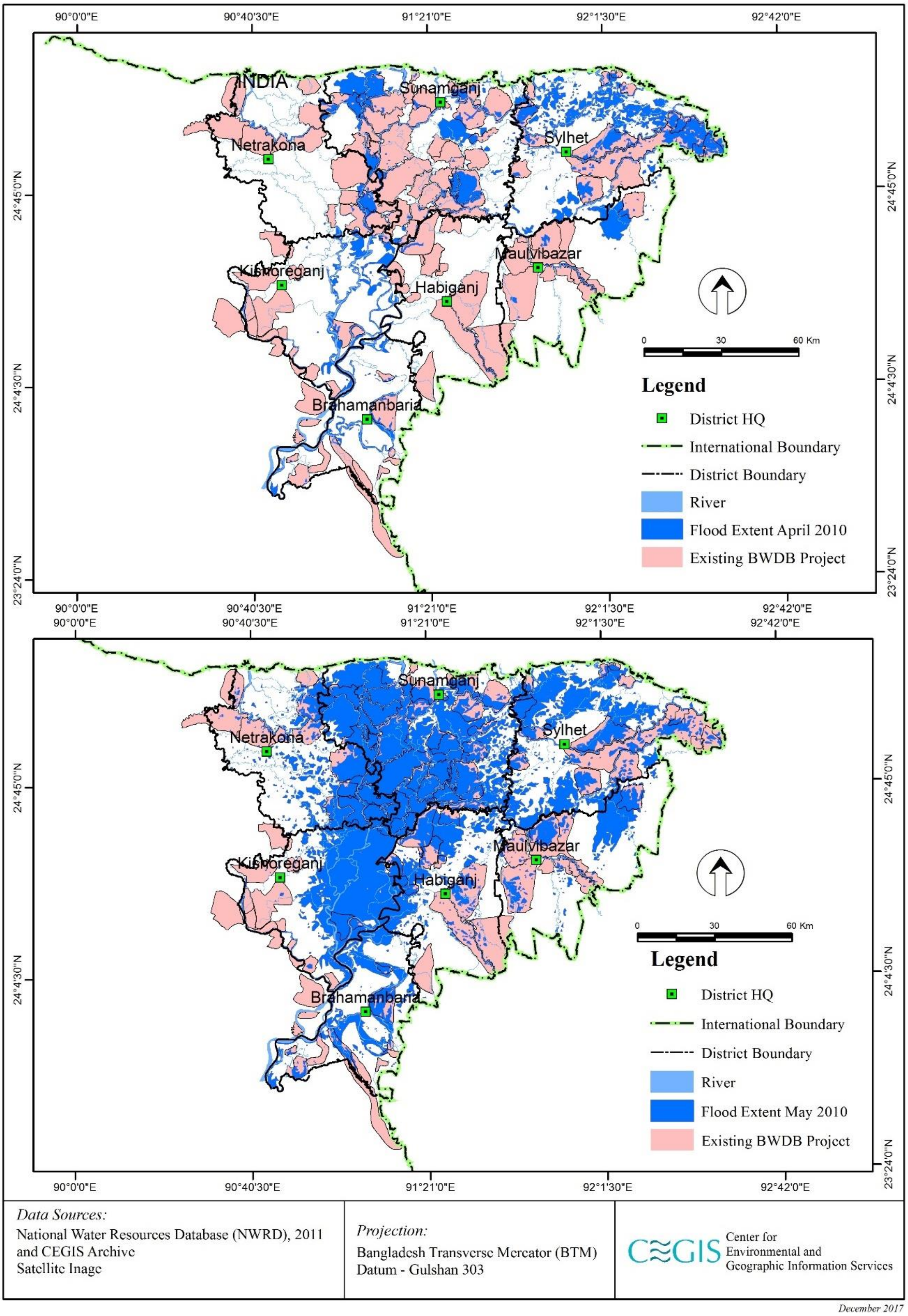


Figure 6.2: Flood extent of extreme year flood (2010) in FC/FCD/FCDI project area

Haor area faced mentionable occurrence of floods in 1974, 1988, 1998, 2004, 2007, 2010 and 2017. Among them, early flash flood of 2004, 2010 and 2017 were devastating to life and properties. Because, those flash floods hit the region in early April with approximately 20 year return period water level which overtopped submersible embankments of 10 years return period design crest level, even it was persist. In addition, remaining public cuts or breached points due to delayed and lack of regular operation and maintenance works might facilitated the progression of floods. Table 6.2 shows return period of different flood events in different rivers of haor area analysing water level data of the month of April from 1961-2017. Figure 6.3 and Figure 6.4 show peak flood level of month of April in Sylhet and Sunamganj against peak flood level of different return periods for different extreme flood events.

Table 6.2: Return period of flood events analysing water level data of the month of April at different stations in haor area

Station Id	Station Name	Peak Flood Level of April in Different Flood Events						
		1974	1988	1998	2004	2007	2010	2017
266	Sylhet	11.8	7.2	9.1	15.0	10.5	13.7	14.4
267	Kanairghat	9.1	5.3	6.6	11.3	8.1	10.8	11.3
173	Sheola	10.7	8.0	10.2	14.4	10.7	13.9	13.9
36.1	Mohonganj	5.0	4.5	4.5	6.0	5.7	5.7	6.5
251	Sarighat	13.3	8.0	8.3	13.3	7.9	12.5	12.9
174	Fenchuganj	7.9	6.2	7.7	10.5	8.9	10.3	10.4
201	Monu Rly. Bridge	15.7	14.3	15.4	18.3	16.9	15.5	16.2
192	Motiganj	8.1	8.0	8.1		8.7	8.8	8.4
158.1	Shaistaganj	10.8	9.3	11.6	12.8	12.3	10.7	12.0
269	Sunamganj	7.2	4.2	4.7	8.1	5.8	8.0	8.1
233A	Jaflong (Spill)			9.5	12.5	9.1	11.4	12.1
72B	Sukdebpur		3.6	4.2			5.98	

Source: CEGIS analysis

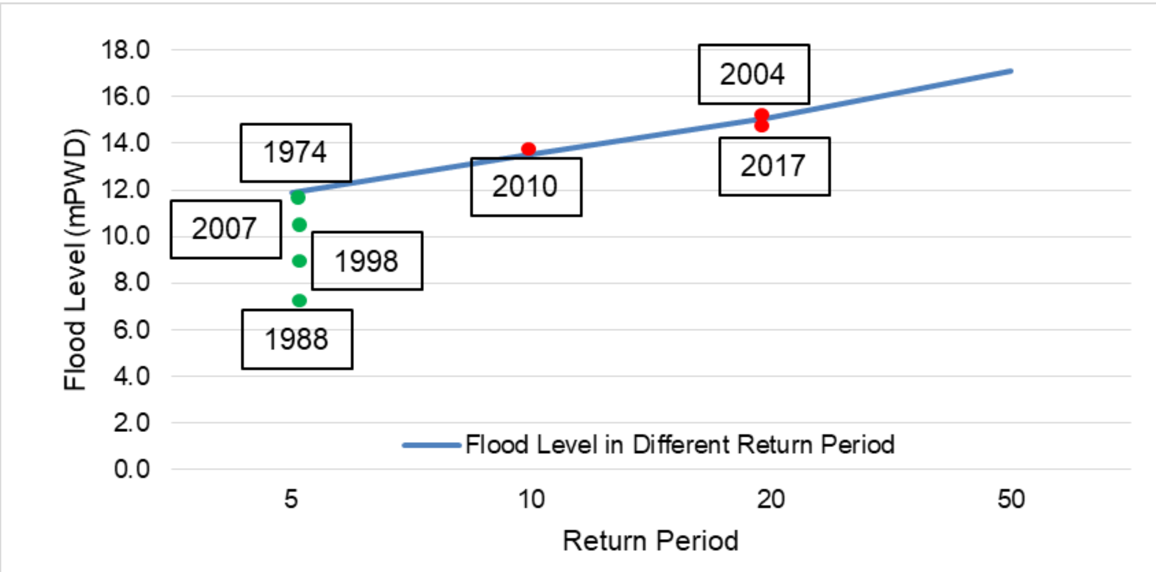


Figure 6.3: Peak flood level of Sylhet station in April against different return periods

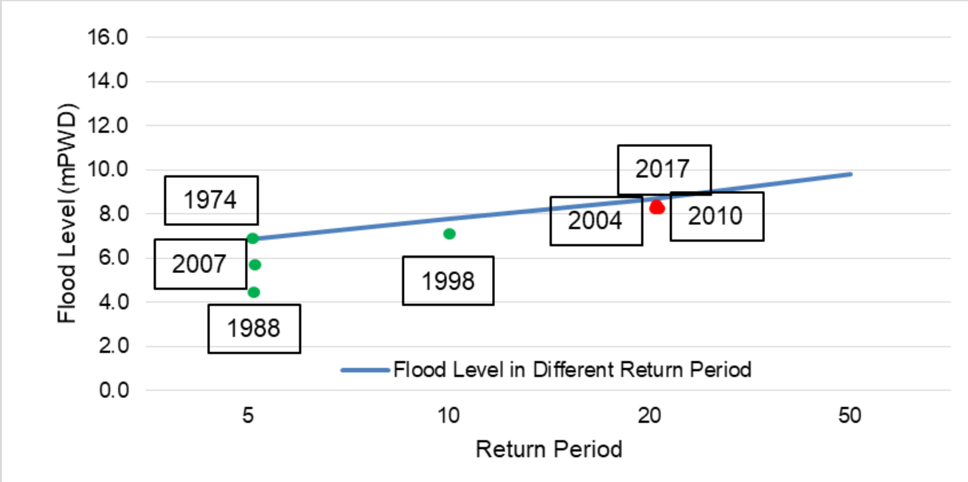
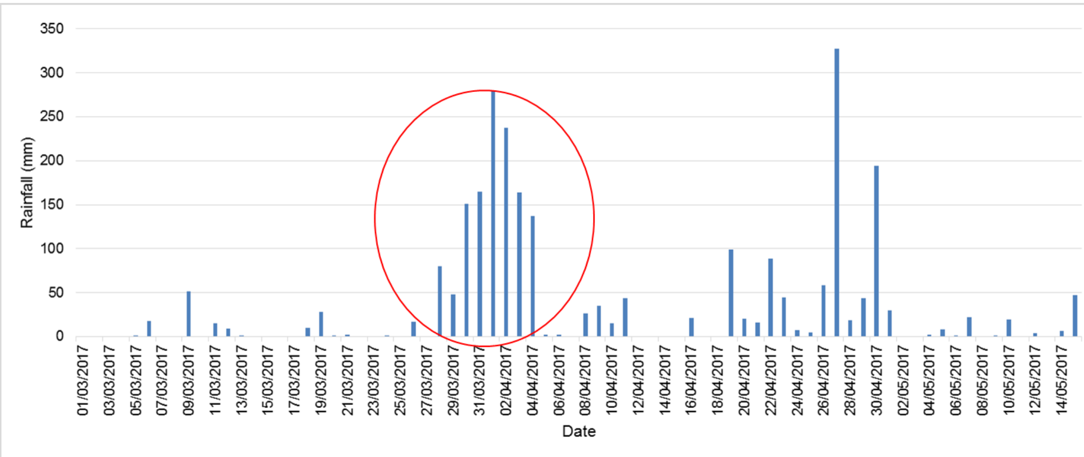


Figure 6.4: Peak flood level of Sunamganj station in April against different return periods

Flash Floods of 2017: A Case Study

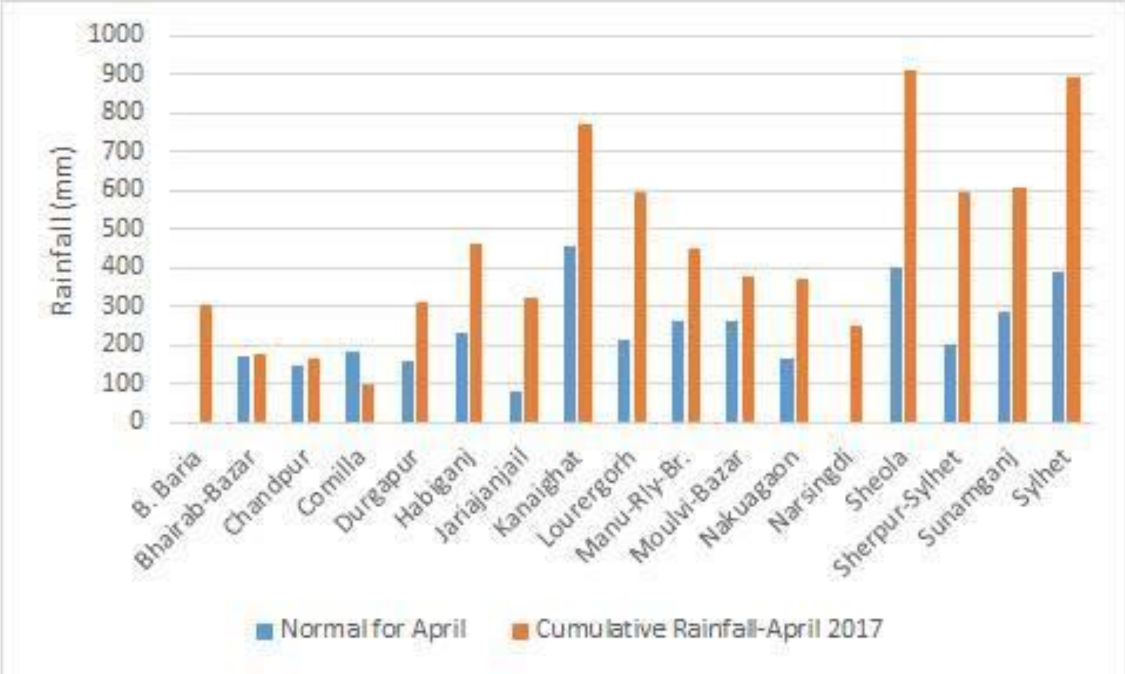
In 2017, flash flood occurred a little earlier than anticipated in the month of April due to excessive rainfall intensity which is of greater than 20 year return periods. This unprecedented event triggered the flood event which was further intensified by the relatively steep slope of the sub-regional basin and prolonged retention time of flood water. Huge volume of flow through trans-boundary Rivers receded within a very short period in deeply flooded haor region. Figure 6.5 shows Cherapunji in Meghalaya received around 1262 mm of rainfall in between 28 March 2017 to 4 April 2017. Barak and Tripura basins also received huge amount of rainfall around 800 mm and 700 mm respectively in same time which generated huge amount of flood flow. In addition, rainfall within the haor region as well as several unrepaired public cuts and submergible embankments accelerated the propagation of flood within very short time. Submersible embankment with 10 year return period design crest level even would fail to protect flood, if its design level were persist.

Figure 6.6 shows internal rainfall in April 2017 and Figure 6.7 shows peak of water level at Sheola station on the Kushiyara River during same period. Sylhet and Sunamganj received highest amount of rainfall around 900 mm and 600 mm respectively according to the Figure 6.6.



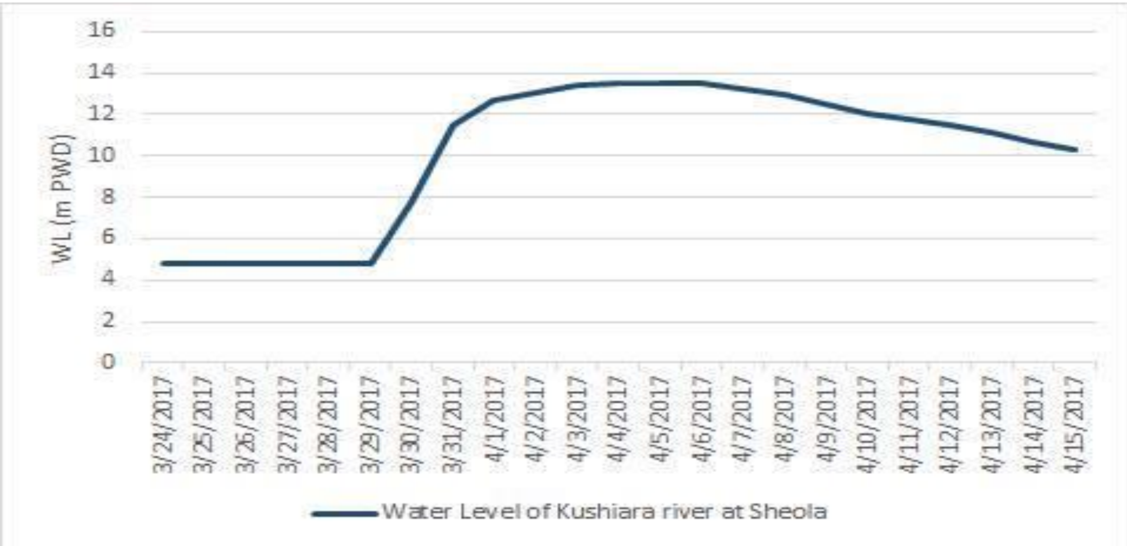
source: IMD

Figure 6.5: Rainfall of Cherapunji during March 2017 to Mid-May 2017



Source: BWDB

Figure 6.6: Internal cumulative rainfall during month of April 2017



Source: BWDB

Figure 6.7: Water level at Sheola station on the Kushiyara River

(Source: BWDB)

Analysis of LandSAT image of 12 April, 2017 and 14 April, 2017 illustrates total area of haor region was inundated due to this early flash floods, where Sunamganj (58%) was mostly affected district. Figure 6.8 shows flood extent map of haor area in mid-April and Table 6.3 shows statistics of flood extent in seven districts of north eastern region.

Table 6.3: Flash flood affected area in haor region (2017)

District	Inundated Area (Sq. Km.)	Percentage of District
Brahamanbaria	125	7
Habiganj	268	10
Kishoreganj	601	23
Maulvibazar	437	16
Netrakona	532	19
Sunamganj	2148	58
Sylhet	1634	48

Source: CEGIS analysis

Lesson learns from this case of 2017 and frequency analysis described above depict that flood once in 5 year return period is normal in haor area and flood up to 10 year return period must be allowed in consideration with sustainable ecosystem of the haor area. Local people must have to be prepared for early flash floods greater than 10 year return period and authorized administration should have to formulate and implement pre and post disaster risk reduction program to tackle such havoc.

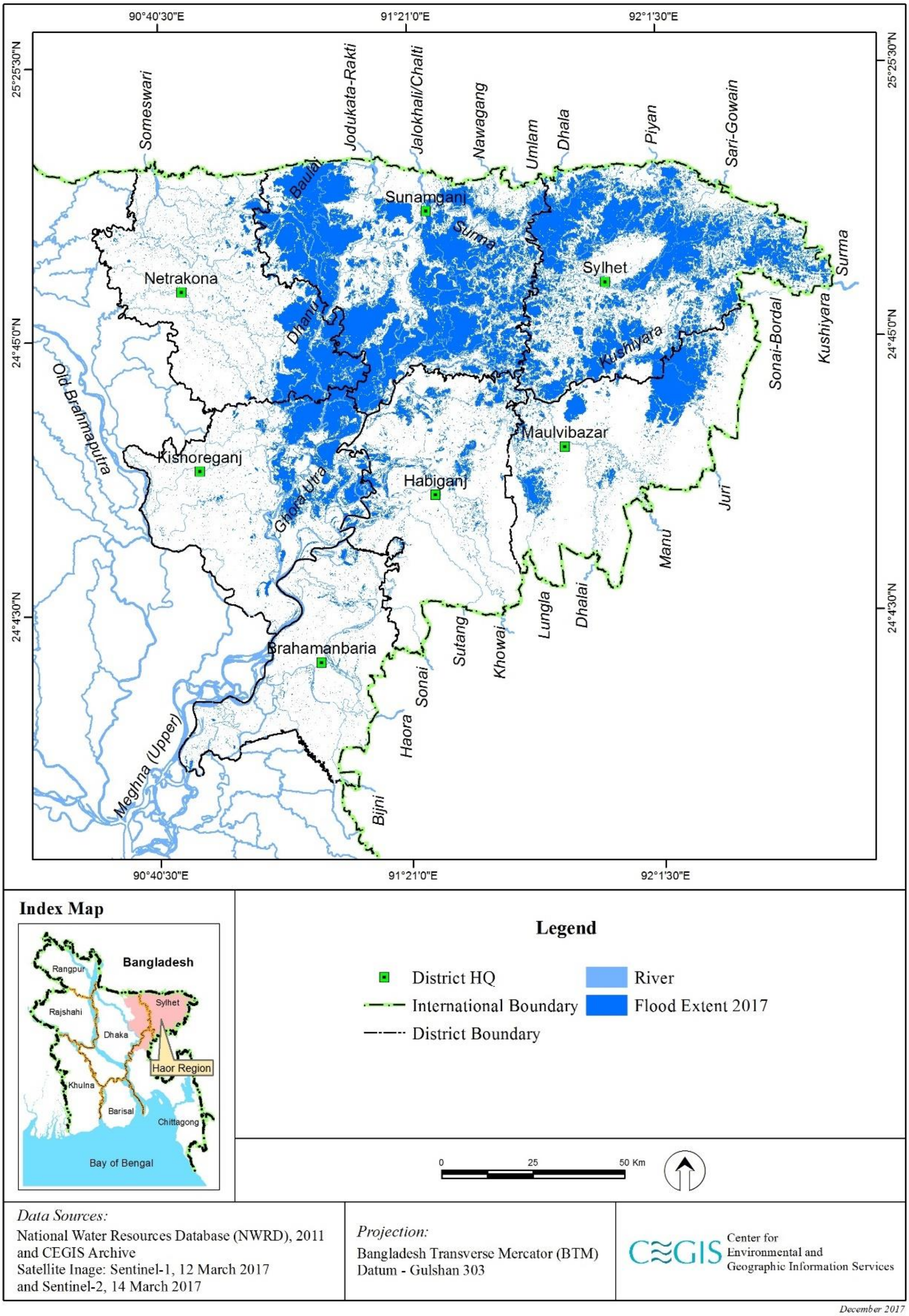


Figure 6.8: Extent of early flash floods of 12 April 2017 in haor region

Impact Summary on the basis of 30 Schemes

Form field visits of 30 screened schemes, it is revealed that, all of the schemes in all of the haor have delayed the risk of entrance of early flash floods up to mid-May. Schemes functioned well in their implementation period, even after 5 years of implementation period, but later specifically after 2000 started to be dysfunctional due to delayed O&M or lack of regular operation and maintenance work. Regular O&M has been hampered due to stringent financial rules and regulations, delay and cumbersome procedure of fund release, delay in contract awarding process, and delay in implementation by contractors. Consequently, earthen submersible embankments breach in many places and public cuts have not been repaired in time. Sedimentation problem has increased than before except Halir Haor, Jamkhola Haor, Humaipur Haor and Naluar Haor. Bed level of rivers, internal khals and in some cases inside the haor has been raised reducing flow conveyance capacity due to lack of regular maintenance dredging. Some regulators or sluices or gates have also get clogged by sedimentation problem and become dysfunctional to drain out flood smoothly. As a result, drainage problem is also deteriorated in recent years except Gazaria beel project, where regulator works fine. Flood recession is getting delayed due to drainage problem increasing sufferings of life and properties. Other than these, navigation is being hampered inside the haor in pre-monsoon season due to submergible embankments and compartmental dykes. Even in some cases, navigational connectivity has been lost entirely due to interventions. However, boats can play in rivers throughout the years. In some places, no impact has been found for navigation where traditionally limited scope is available for navigation like surroundings haor area of Singua River.

Table 6.4: Summary impact matrix in water resources and navigation based on 30 screened schemes

SL. No.	Scheme Name	Status of Indicator			
		Flooding	**Drainage**	**Sedimentation**	**Navigation**
1	Bara Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
2	Baram Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
3	Chandra Sunarthal Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
4	Chaptir Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
5	Chayer Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
6	Dhaleswai River	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
7	Gangajuri FCD Sub-Project	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
8	GozariaBeel Project	Delayed the Early Entrance of Flash Floods	Improved	Increased	No Significant Change
9	Hail Haor Project	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Lost Navigational Connectivity
10	Haizda Embankment Sub-Project	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
11	Halir Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	No Significant Change	No Significant Change

SL. No.	Scheme Name	Status of Indicator			
		Flooding	Drainage	Sedimentation	Navigation
12	Humaipur Haor Project	Delayed the Early Entrance of Flash Floods	No Significant Change	No Significant Change	Hampered in Pre-monsoon
13	Jamkhola Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	No Significant Change	Hampered in Pre-monsoon
14	Kairdhala-Ratna	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Lost Navigational Connectivity
15	Kalikota Haor Project	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
16	Kalner Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
17	Kawadighi Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Lost Navigational Connectivity
18	Matian Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
19	MohadaoNadi Embankment	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
20	Naidar Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
21	Naluar Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	No Significant Change	No Significant Change
22	Nautana Khal Scheme	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
23	Pagner Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
24	Re-excavation of Singua River	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	No Impact
25	Sari Goyain Project	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
26	Shanir Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
27	Surma River System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
28	Tangua Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
29	Updakhali Haor	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon
30	Zilkar Haor System	Delayed the Early Entrance of Flash Floods	Delayed and Deteriorated	Increased	Hampered in Pre-monsoon

6.3 Land, Agriculture and Livestock Resources

Land Resources

Haor area has fallen under nine agro-ecological regions. These are A) Sylhet Basin, B) Northern and Eastern Hill, C) Old Meghna Estuarine Floodplain, D) Old Meghna Estuarine Floodplain, E) Northern and Western Piedmont Plains, F) Eastern Surma Kushiyara Floodplain, G) Young Brahmanputra and Jamuna Floodplain H) Old Brahmanputra Floodplain and I) Akhaura Terrace . Maximum area (19.7%) is covered under the agro-ecological region of Eastern Surma-Kushiyara Floodplain which is identical (19.34%) with the agro-ecological region of the Sylhet Basin. About 74% of top soil texture is clay to clay loam, 21% loam and rest of the areas are silty loam, sandy loam and sand. The land type characteristics are not uniform within the Haor region. About 44.2% of cultivable land is medium high to high land where maximum flooding depth is below 90 cm during the monsoon period. Cultivable land which normally is flooded between 90 -180 cm depth of inundation continuously for few months in flood season is about 21.4% (medium low land). About 34.2% of cultivable areas are low to very low land where minimum flooding depth is above 180 cm during the monsoon period. But in study area (30 Haor) about 55% of cultivable area is low to very low land followed by 21%, 16% and 8% medium lowland, medium highland and high land respectively. Surface floodwater recession at the end of the monsoon season depends on soils and topography. Recession of surface water starts in first week of October to middle of November in about 25% of cultivable areas, 19% of cultivable areas become free of floodwater from middle of November to middle of December and 38% of cultivable areas are from middle of December to end of December. Rest of the recession of flood water starts after December. Detailed surface water recession characteristics is presented in Figure 6.9.

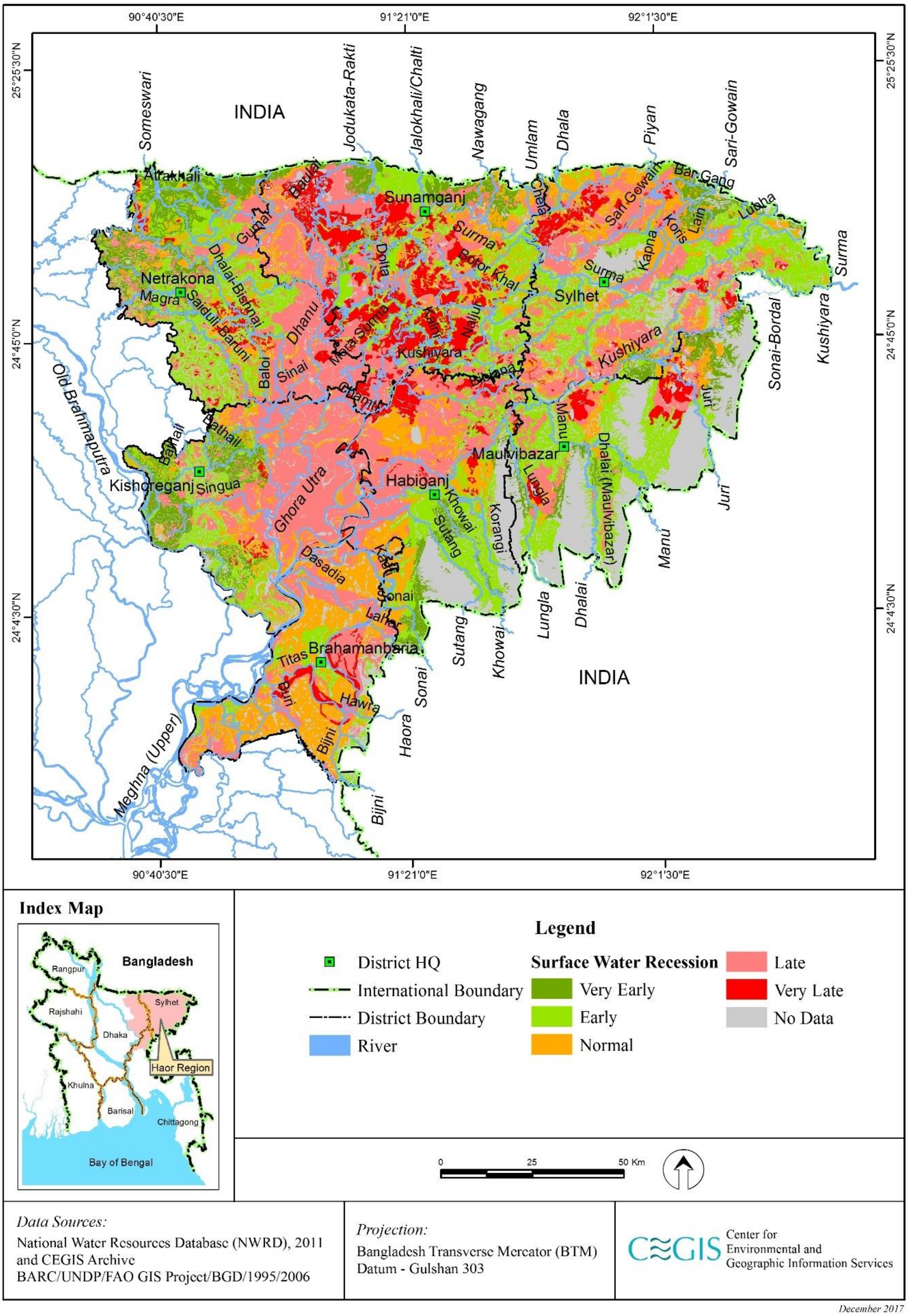


Figure 6.9: Surface water recession of the study area

Land use

Major land use/land cover of seven Haor districts during 1989 and 2015 are illustrated in Table 6.5. The largest area is covered by crop land which was estimated 1,229,844 hectare in 1989 and with a gradual decrease it reached to 1,215,776 hectare in 2015. The loss of agriculture land was estimated 14,068 hectare. In this course of time (1989-2015), the area of water bodies has decreased 8,565 hectare. On the other hand, 21,152 hectare settlement and 2,111 hectare forest area has increased in that period. Detailed land use in seven Haor districts are presented in Table 6.5.

Table 6.5: Land Use change in Seven Haor Districts

Land Use	Pre-Project (1989)	Post-Project (2015)	Impact
Agriculture	1,229,844	1,215,776	-14,068
Waterbodies	92,445	83,880	-8,565
Forest	166,350	168,461	+2,111
Settlement	280,255	301,408	+21,152
Others	4,327	3,696	- 631
Total	**1,773,221**	**1,773,221**	**0**

Source: CEGIS estimation from 30 m Resolution Landsat Satellite Images, March: 1989 and 2015

In study (30 schemes) area, the crop land was estimated 2, 37,524 hectare in 1989 and with a gradual decrease it reached to 2, 36,090 hectare in 2015. The loss of agriculture land was estimated 1,434 hectare. In this period, the water bodies has decreased 2,363 hectare. On the other hand, settlement and forest area have increased 2764 and 834 hectare respectively in that time. Detailed land use in study area (30 schemes) are presented in Table 6.6.

Table 6.6: Land use change in study area (30 schemes)

Scheme Name	Agriculture	Waterbodies	Forest	Settlement	Others	Total
Bara Haor System	-679	558	-134	231	24	0
Baram Haor System	57	-10	-57	10	0	0
Chandra Sunarthal Haor System	-3	-16	-11	29	0	0
Chaptir Haor System	43	-55	8	3	0	0
Chayer Haor	-11	-27	-2	40	0	0
Dhaleswai River	48	-78	0	2	28	0
Gangajuri FCD Sub-Project	-444	42	5	311	87	0
Gozaria Beel Project	-4	-32	0	35	0	0
Haijda Embankment Sub-Project	-397	32	193	168	4	0
Hail Haor Project	-897	675	-1	240	-17	0
Halir Haor System	406	-511	87	18	0	0
Humaipur Haor Project	-23	16	0	7	1	0
Jamkhola Haor	-1	-9	0	21	-10	0
Kairdhala-Ratna	-14	-62	0	76	0	0
Kalikota Haor Project	-21	-142	31	131	0	0
Kalner Haor System	-73	22	-2	53	0	0
Kawadighi Haor	-780	628	38	114	0	0
Matian Haor System	1321	-1294	-28	2	0	0
Mohadao Nadi Embankment	-77	-75	0	160	-7	0
Naidar Haor	54	-134	-1	82	0	0

Scheme Name	Agriculture	Waterbodies	Forest	Settlement	Others	Total
Naluar Haor System	-364	-8	251	121	0	0
Nautana Khal Scheme	-51	-7	0	58	0	0
Pagner Haor System	425	-472	-21	69	0	0
Re-excavation of Singua River	-289	74	0	154	61	0
Sari Goyain Project	-12	-11	-25	43	5	0
Shanir Haor System	1261	-1279	5	14	0	0
Surma River System	-588	70	79	423	16	0
Tangua Haor	-364	-90	441	12	0	0
Updakhali Haor	56	-155	-24	114	8	0
Zilkar Haor System	-13	-11	0	24	0	0
Total	**-1434**	**-2363**	**834**	**2764**	**200**	**0**

Source: CEGIS estimation from 30 m Resolution Landsat Satellite Images, March: 1989 and 2015

Land Degradation (Sand Carpeting)

Land degradation is a major problem in the haor areas. In this project, sand carpeting is observed in respect of quantify land degradation situation. Land degradation (1,361 ha) was observed in Chandra Sonarthal haor, Kalner haor, Dhaleswai river, Haizda Embankment, Moahdao nadi, Naluar haor, Nautana khal, Updakhali haor area are facing sand carpeting problem in pre project and post project situation. Due to sand carpeting problem, farmers did not cultivate crop in the haor areas. Out of 1,361 ha areas 58 ha areas of Dhaleswai River, Moahdao nadi and Updakhali haor are now brought under cultivation and fish culture. This is due to siltation of surrounding river, khals and beels in the haor areas.

Agriculture Resources

The north-east haor area of Bangladesh has a unique landscape, where natural patterns of flooding have created very productive fisheries in the wet season, and allowed rice to grow in the dry season. The productivity of this wetland (Haor) has contributed a lot for food production in this region, and it is believed that there is a potentiality for further increases of land for agriculture purposes. However, change of flood timing and pattern is probably one of the main reasons for changing local ecosystem and the livelihood of the local people. In haor area, flash flood causes crop damage which is considered as a big threat to the people, especially who work as sharecroppers or landless laborers. Sometimes, the flash flood comes early, just before the rice harvesting and during that time the people of haor basin, do not even get the time to harvest their crops.

Crop Area

Rice is the important crop in the study area. It is grown in a multitude of environments, either solely or in rotation with dry land crops. Thus the major cropping patterns in the Haor region are rice based and almost all segments of the cultivated land are cropped with at least one rice crop annually. Recent (BBS 2016) data indicates that 1.69 million hectares in Haor region cropped under different rice crops of which 9.6%, 38.6% and 51.8% are covered with Aus, Aman and Boro crops respectively. It is estimated that high yielding varieties are grown in 88% of the area under rice cultivation. The practices of HYVs of Boro, Aus and Aman are about 98%, 93% and 73% respectively. The HYV incudes the hybrid Boro crops. The trend of Boro crop area including HYV and local varieties is presented in Figure 6.10.

It is mentioned that after independence of Bangladesh, the Boro crop area was 0.43 million ha. Currently (2015-16), the Boro crop area has increased to about 0.87 million ha in Haor region. In this course of time, Boro area has been increased by 100 percent. The trend of Boro crop area is presented in Figure 6.10.

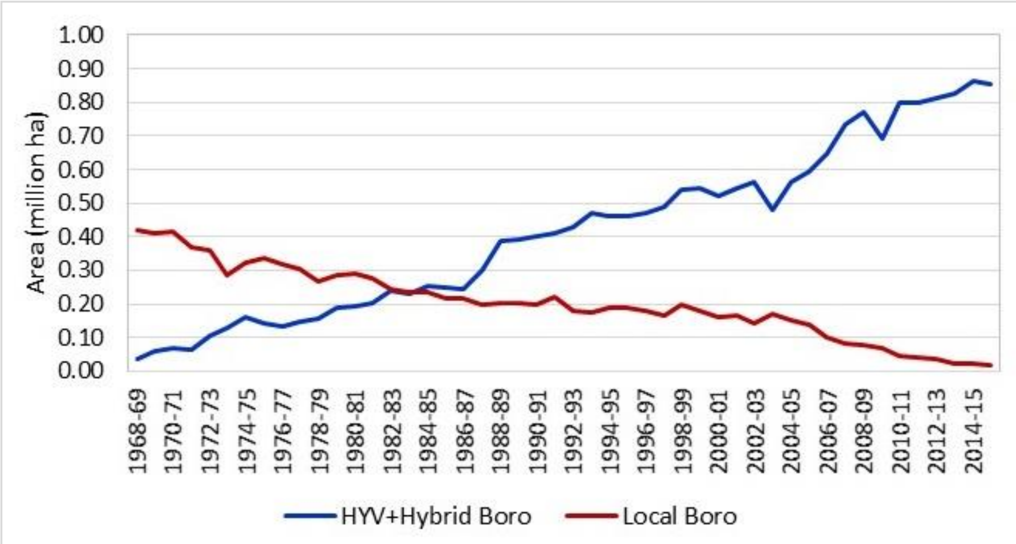


Figure 6.10: Trend of Boro Area of Haor Region

In the study (30 Haors) area, total cropped area has increased only 48,500 ha. The net cultivated area of most Haors has been decreased due to increase of settlement for increased population. However, in most of the Haors (26 haors out of 30), total cropped area has been increased for decreasing of flood vulnerability due to implementation of the project interventions and enhancement of agriculture extension services. The total cropped area of remaining four Haors (Kawadighi Haor, Naluar Haor, Nautana khal and Tangua Haor) has been decreased because of water logging problem in Kawadighi Haor, sand deposition on crop land in Nautana Khal and Naluar Haor, and converted crop land to forest land in Tangua Haor.

Cropping Intensity

The cropping intensity in Haor region is about 147% (Haor Master Plan, 2012) which is much below the national average (194%, BBS 2016). The cropping intensity in the study area (30 Haors) was about 139% which is increased about 24% from pre-project situation (124%). The cropping intensity has been increased in 19 Haors out 30 of Haors. The major reason behind this is crop diversification in this area. Department of Agricultural Extension (DAE) has taken many extensive works to diversify crop. Short duration crops like mustard, vegetable and other crops increase the number of crops in croplands. No cropping intensity change has found in 11 haors. In these areas, no crop cultivation is possible except Rabi season, because most of these areas are low land to very low land and water recession completes during early Rabi season and flood water starts to come in this area during early Kharif-I. But, cropping intensity is decreased in Naluar Haor for sand carpeting on cropland. Impact of cropping intensity by individual Haor is presented in Table 6.7.

Crop Production

In the Haor region, about 5.21 million metric tons of rice are produced annually (BBS, 2016), of which about 63% is Boro, 29% is Aman and 8% is Aus crops. It is estimated that high yielding varieties are produced about 94% of the total rice production. The trend of Boro rice production in terms of clean rice is presented in Figure 6.11.

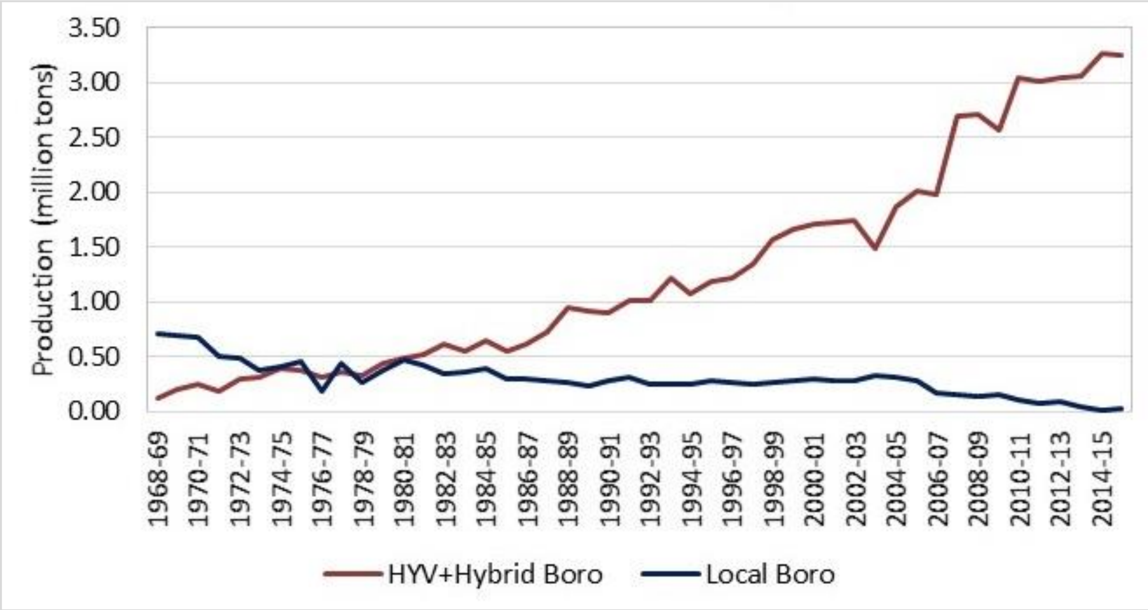


Figure 6.11: Trend of Boro Production by varieties

It is mentioned that after independence of Bangladesh, the Boro crop production in term of clean rice was 0.70 million tons. Currently (2015-16), the Boro crop production in terms of clean rice is about 3.29 million tons. In this course of time, Boro production is increased by 370% due to implementation of different structural and non-structural interventions like water control structure, re-excavation of khals, development and extension of HYV and Hybrid varieties in the Haor region. The trend of Boro production is presented in Figure 6.12.

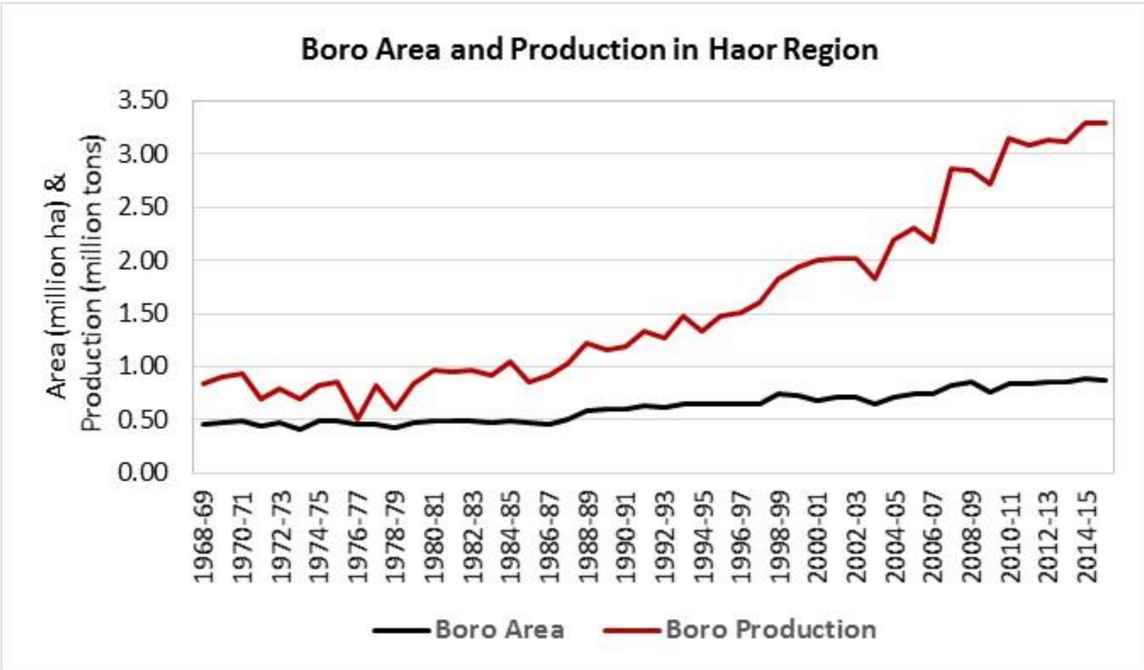


Figure 6.12: Trend of Boro Area and Production of Haor Region

In the study area (30 Haors), annual total rice production is about 1.1 million tons of which Boro is about 80% under post project situation. In pre-project situation 0.48 million tons Boro rice was produced in terms of clean rice. On the other hand, about 0.87 million tons of Boro rice is produced in post project situation. Additional annual 0.39 million tons Boro rice is being produced in post project situation. The rice production is increased due to the protection of flash flood which encourages the farmers for practicing high yielding variety instead of local variety. Detailed estimation of impact on crop production is presented in Table 6.7.

Crop Damage

Crops are damaged by floods, drainage congestion, hailstorm, cyclones, pests, and so on. Flooding is the major cause of crop damage and rice is the major crop damaged by floods in the study area. In year 1980 to 2017, Boro crop was damaged due to flash flood in year 1983, 1984, 1986, 1991, 1993, 1994, 2002, 2004, 2010 and 2017. But devastating flash flood was occurred in year 1993, 2004, 2010 and 2017 where Boro crop was damage more than 70%.

In study area, annual 0.15 million ton Boro crop is damaged due to flash flood and drainage congestion. The crop damage area is increasing day by day due to reducing height of submersible embankment, malfunctioning of the sluice gates, regulators, pipe sluices and reduced water carrying as well as retention capacity of surrounding rivers, khals and beels. Detailed estimation of impact on crop damage is presented in Table 6.7.

Irrigated Area

Total irrigated area is about 0.67 million hectare in six Haor (Sunamganj, Sylhet, Moulvibazar, Habiganj, Kishoreganj and Netrokona) districts (BBS 2016). Among the irrigated area, about 93% of the total irrigated area is provided irrigation for Boro crop and only 7% of the other dry land rabi crops like, wheat, potato and vegetables etc. However, year 1980 the irrigated area was found about 0.35 million hectare. In this course of time (1980-2016) irrigated area has increased about 0.31 million ha in six Haor district. The trend of irrigated area by crops is presented in Figure 6.11.

Before initiation of the project, only surface water was used for irrigating Local Boro crops. The local people normally transplanted this crop immediately after the floodwater recedes and the land is under shallow inundation. Local farmer reported that they stored water with help of bundh/dyke management and irrigated their crop with the help of flooded water in the low lying part of the Haor. They also used traditional modes like *Seuti, Don and Kune* for irrigating their crop from surrounding rivers, Beels and Khals during dry season. Prior to the implementation of the project, irrigation water was more available than the requirement of crops.

After implementation of the project, the irrigation water demand has been increased due to cultivation of high water demanding HYV Boro instead of Local Boro crop. On the other hand, the availability of surface water is being reduced due to siltation of surrounding rivers, khals and beels of the Haor area. Therefore, the scarcity of irrigation water has been observed from early February to end of March in most of the year.

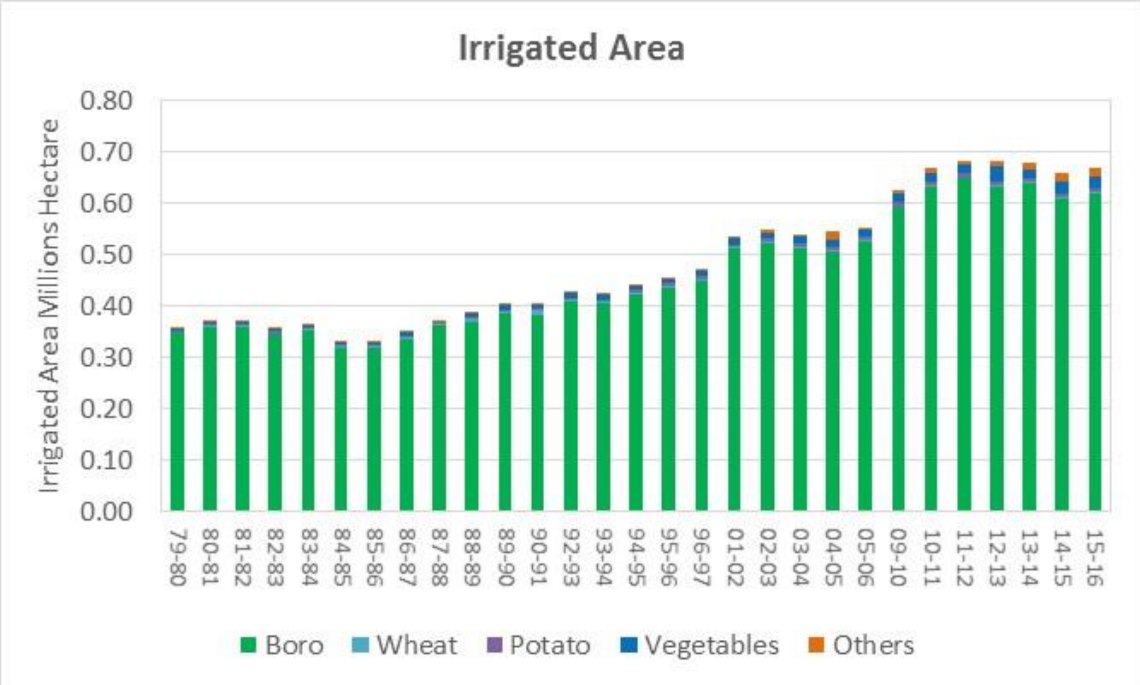


Figure 6.13: Trend of irrigated area in Six Haor Districts

Agro Chemical Use

Chemical fertilizers are important input for crop production, particularly in HYV rice production. In seven hoar district about 3, 27,635 tons chemical fertilizer is used of which urea, TSP and MP are about 81%, 10% and 9% respectively (Haor Master Plan, 2012). Besides, about 32,857 tons of Di-ammonium phosphate (DAP), Gypsum, Zinc sulphate and others are used to crop cultivation in Haor area. On the other hand, about 3,277 metric tons / kilo litre of pesticides are used, of which insecticides are about 1,810 tons in granular form, about 322 kilo litre in liquid form and about 42 tons in powder form to the 1.93 million ha crop area of the study area. In addition, about 743 tons of fungicide, 357 tons of herbicide and 3 tons of rodenticide are applied for crop protection (Haor Master Plan, 2012).

In pre-project situation mainly local variety crops were grown in the study area. The nutrient intake capacity of local variety is lower than the HYV or Hybrid varieties. On the other hand, diseases prevention capacity of local variety is higher than the HYV or Hybrid varieties. The cultivated area of local varieties has gradually been decreased and replaced by HYV/Hybrid variety after completion of project due to its higher yield rate. Therefore, additional annual 75,390 tons of chemical fertilizers and 1060 tons or kilo litre pesticides are used for cultivating crops and protecting crops from pest and diseases. Annual additional amount of fertilizer and pesticide which are used in study (30 Haors) area is presented in Table 6.7.

Table 6.7: Summary impact matrix in agriculture resources based on 30 screened schemes

Scheme Name	Cropping Intensity (%)	Boro Production (tons)	Crop Damage (ton)	Irrigation	Fertilizer (ton)	Pesticide (ton/Kilo-litre)
Bara Haor System	23	15071	7333	Deficit	2504	52
Baram Haor System	0	8400	7622	Deficit	1202	2
Chandra Sunarthal Haor System	11	6510	3665	Deficit	1757	45
Chaptir Haor System	0	5881	518	Deficit	942	20
Chayer Haor	0	14405	4722	Deficit	1730	33
Dhaleswai River	2	1195	280	Deficit	235	3
Gangajuri FCD Sub-Project	69	50078	6102	Deficit	7545	103
Gozaria Beel Project	35	3019	1168	Deficit	1262	13
Haijda Embankment Sub-Project	10	21644	10777	Deficit	4986	76
Hail Haor Project	42	47952	13383	Deficit	4812	60
Halir Haor System	0	12303	5100	Deficit	1971	2
Humaipur Haor Project	0	9386	1656	Deficit	1557	18
Jamkhola Haor	0	2509	2726	Deficit	568	1
Kairdhala-Ratna	35	20905	3040	Deficit	3326	12
Kalikota Haor Project	8	27861	9963	Deficit	630	79
Kalner Haor System	6	7353	2417	Deficit	3232	65
Kawadighi Haor	4	16931	3652	Deficit	2987	9
Matian Haor System	0	10664	1766	Deficit	995	11
Mohadao Nadi Embankment	13	916	795	Deficit	1202	7
Naidar Haor	10	5989	5167	Deficit	4807	54
Naluar Haor System	-5	4331	9689	Deficit	1944	69
Nautana Khal Scheme	0	1767	2402	Deficit	629	13
Pagner Haor System	4	20967	25099	Deficit	4835	88
Re-excavation of Singua River	42	15750	3706	Deficit	7520	65
Sari Goyain Project	30	1660	609	Deficit	503	6
Shanir Haor System	0	19172	4736	Deficit	1840	23
Surma River System	37	20796	8087	Deficit	6221	89
Tangua Haor	0	6271	215	Deficit	780	14
Updakhali Haor	6	9318	1090	Deficit	1958	23
Zilkar Haor System	17	5099	977	Deficit	665	11
Total	**-**	**394103**	**141459**		**75145**	**1064**

Source: CEGIS Estimation

Livestock

Livestock and poultry, being an essential element of integrated farming system, play an important role in the economy of the haor area. Livestock provides significant draft power for cultivation, threshing and crushing of oil seeds; cow dung as a source of manure and fuel; a ready source of funds; and meat, milk and eggs for human consumption. A large number of livestock are reared in haor areas but constrained by flash flood causing inundation of large areas during most of the time in the year. This area is famous for duck rearing due to availability of natural feed for ducks in natural large water bodies. All of livestock species suffer much due to shortage of feed, outbreak of waterborne diseases and inadequate shelter facilities. The livestock rearer in the haor areas do not get fair price due to poor communication as well as lack of marketing facilities.

According to agriculture census 1996, the livestock and poultry population in the project area were 0.35 million cattle, 0.10 million goats, 1.16 million chicken and 0.51 million ducks. However, 0.45 million cattle, 0.11 million goats, 1.29 million chicken and 0.48 million ducks were found according to agriculture census 2008. From 1996 to 2008, about 95,460 cattle, 7450 goat and 1,31,060 chicken have increased due to reducing flood vulnerability, improvement of marketing facilities and strengthening of livestock extension services in the study Haor area. However, the duck population has been decreased due to outbreak of different waterborne diseases. Details about impact on livestock are presented in Table 6.8.

Table 6.8: Status of livestock/poultry in study Haor area

Scheme Name	Cattle HH	Cattle No	Goat HH	Goat No	Chicken HH	Chicken No	Duck HH	Duck No
Bara Haor System	1670	5130	580	2030	2320	2850	-700	-770
Baram Haor System	570	1500	-60	-120	310	2300	-320	-2190
Chandra Sunarthal Haor System	1110	3430	60	150	1140	5400	690	3090
Chaptir Haor System	590	1630	-60	-110	480	3320	-250	-1880
Chayer Haor	830	2070	-100	-250	-110	810	-630	-3820
Dhaleswai River	150	570	70	200	190	900	20	240
Gangajuri FCD Sub-Project	2530	3450	30	950	3560	15340	450	5180
Gozaria Beel Project	1150	1970	80	160	1190	6100	370	1150
Haijda Embankment Sub-Proj ect	2630	6850	240	820	2150	11840	110	-2910
Hail Haor Project	1260	3390	150	1550	460	2310	-620	3170
Halir Haor System	1160	3090	-30	-30	1040	6100	-300	-2480
Humaipur Haor Project	990	1800	550	-620	170	-3690	-440	-2240
Jamkhola Haor	90	210	-130	-290	-140	-1650	-260	-1650
Kairdhala-Ratna	1660	4040	-30	-20	240	3560	-450	-2470
Kalikota Haor Project	2000	5280	-220	-450	1120	8130	-1130	-7660
Kalner Haor System	1380	3160	460	1100	1200	4890	-310	-2160
Kawadighi Haor	600	2150	-110	-20	1060	690	330	3610
Matian Haor System	790	2580	20	360	280	2480	-330	-770
Mohadao Nadi Embankment	870	1850	240	50	470	5070	110	620
Naidar Haor	1080	2890	100	260	770	1550	-670	-2320

Scheme Name	Cattle HH	Cattle No	Goat HH	Goat No	Chicken HH	Chicken No	Duck HH	Duck No
Naluar Haor System	930	2590	-10	210	-280	-720	-1910	-7890
Nautana Khal Scheme	450	1340	-40	-50	220	2080	-110	-1290
Pagner Haor System	2130	5710	-130	-250	2080	12250	-560	-5140
Re-excavation of Singua River	4200	7530	-1460	-3660	3720	14850	-320	1000
Sari Goyain Project	250	840	160	540	360	580	40	140
Shanir Haor System	1250	3680	60	470	550	3800	-460	-1400
Surma River System	4380	9680	890	3010	6470	4240	240	5550
Tangua Haor	510	1400	-50	-80	370	2620	-270	-1800
Updakhali Haor	1610	3510	420	110	930	9220	260	1370
Zilkar Haor System	610	2140	440	1430	550	3840	-230	190
Total	**39430**	**95460**	**2120**	**7450**	**32870**	**131060**	**-7650**	**-25530**

Source: CEGIS estimation based on agriculture census (1996 and 2008)

After implementation of the project, crop is protected from early flash flood. As a result, the feed availability of livestock is increased due to increase of crop production. However, some of the year, the crops were damaged by early flash flood. In that year, the small holders were dependent on water hyacinth and other aquatic plant for their cattle. The poultry feeds are same as in pre project situation. On the other hand, more or less similar diseases are found in post project situation. The mortality rate of the livestock/poultry became negligible during the project period, due to extension works at farmers' level such as immunization and insemination program by Department of Livestock (DLS). Marketing facilities during dry season also improved due to improvement of the communication system by constructing the submersible embankments. Therefore, market prices are increased due to high demand of products and by products.

Before implementation of the project, the major feed available to ruminants was mostly crop residues (rice straw) supplemented with weeds from cultivated fields. They are to depend on naturally grown grasses in Kandas and alongside roads and embankments. Most of the year before implementation of the project, the crops were to damage by early flash flood. As a result, shortage of feed from crop residues, reduction of grazing facilities seriously affect livestock rearing. That time, the small holders were to depend on water hyacinth and other aquatic plant for their cattle. The major poultry feeds were rice bran, broken rice, kitchen wastes like rice, rice-gruel, vegetables, fish wastes etc. In addition, the duck usually scavenge in the nearby waterbodies like haor, beel, khal, river or any other low lying areas; mainly eat various types of aquatic insects, small fish, shell or snails. Major livestock and poultry diseases were Gola Fula (Haemorragic Septicemia), Foot and Mouth Diseases (FMD), Pox and Cholera, Duck Cholera, Fowl Pox and Fowl Cholera etc. The most vulnerable period was between July to November for spreading diseases to livestock and poultry populations. Mortality rate of the livestock/poultry was higher due to poor shelter condition and they lived in unhygienic condition. Marketing facilities was not in good condition and price was also low due to less demand of their products and by products. Producer consumed their products at family level and additional products were sold at local village market.

6.4 Fisheries Resources

Fisheries Context

The Haor area is a vast wetland having functions of ecosystem goods and services. Among the ecosystem goods and provisioning services of the Haor wetlands, fish claims the most. The wetlands also possess vital supporting services for fisheries, i.e., breeding, nursing, feeding and overwintering grounds of the resident as well as most of the freshwater migratory fish species. The haor area comprises a wide variety of fin fish including 143 indigenous and 12 exotic species along with a several species of freshwater prawns. Estimated fish habitat area in the seven Haor-districts is nearly 966,900 ha. An analysis between 1983 to 2014 reveal that, fish habitat area has been decreased only 2% but fish production has been increased around 9 times due to enabling environment by BWDB and autonomous development by fisheries extension agencies.

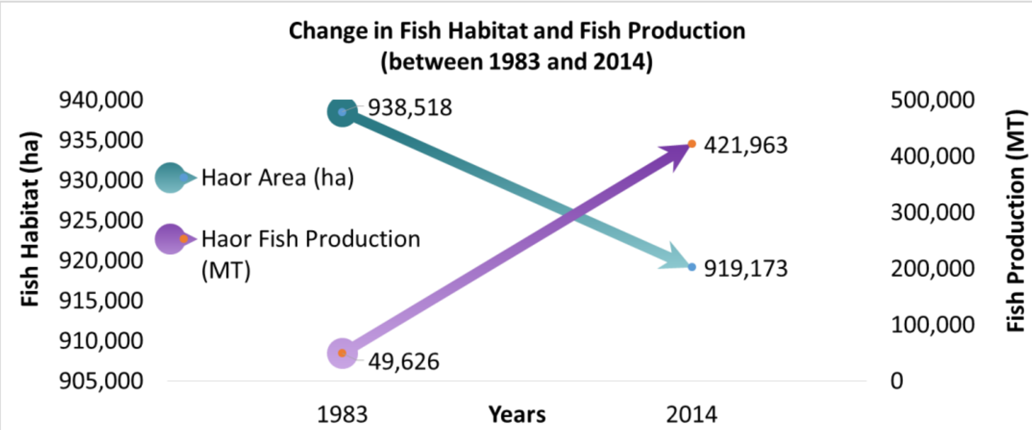


Figure 6.14: Major carp spawning grounds and occurrences of carp spawn

The area of fish habitats altogether produce about 4.22 lac tons of fish in 2015 where 67.5% comes from capture fishery and the rest is contributed by culture fishery. Among the Haor-districts, Sunamganj contributes about 21% in the total fish production followed by Kishoreganj (16.9%), Sylhet (15.5%), Netrokona (14.3%), Habiganj (12%), Brahmanbaria (11.6%) and Moulvi Bazar (8.8%). Of the capture fish production, floodplain contributes the bulk portion which is about 81.6% followed by Beel 16.8% and river 1.6%. The wetlands are the residence for breeding and feeding grounds of most of the freshwater migratory fish species. Culture fish ponds in the area produce about 1.37 lac tons which is 32.5% of the total production.

Fish Breeding, Spawning and Grazing Ground

Haor region fish species are mostly resident, breed more or less in any water bodies in the region except major carps, pangas and ilish which are migratory. The species can be separated into two types of fish spawning patterns based on their preferred breeding habitat:

River breeders: rui (Labeo rohita), catla (Catla catla), kalibaus (L. calbasu), mrigel (Cirrhinus mrigala), chital (Chitala chitala), ayre (Aorichthyes aor), rani (Botia Dario), pabda (Ompok pabda), pangas (Pangasius pangasius), bacha (Eutropichthyes vacha), garua (Clupisoma garua), shilon, baspata, kajoli, etc. and

Floodplain and Beel breeders: boal (Wallago attu), ghonia (Labeo gonia), singi (Heteropneustes fossilis), sarpunti (Puntius sarana), magur (Clarius batrachus), koi (Anabas testudineus), bheda (A. anabas), punti (Puntius spp.), icha (Leander styliferus), Chanda

(Chanda spp.), mola (Amblypharyngodon molitrix), golsha (Mystus bleekeri), tengra (M. mystus), khalisa (Colisa fasciatus), etc.

Floodplain and beel breeding pattern: Breeding starts at the onset of monsoon flooding, when water in adjacent rivers and channels flows into beels. Piscivorous species (boal, shol and gozar) breed earlier than the non-piscivorous species. Most of the catfish, live fish and other small fishes move to the inundated shallow water area and start breeding at the end of March and early April. Flash flood and torrential rainfall with thunder stimulate breeding of boal, ghonia, pabda, koi, batasi, punti and lasu. Species such as ghonia, boal, foli, pabda, shol, gozar, lati, koi and lasu prefer a newly inundated weedy area with shallow water and slow current. Boal, pabda and ghonia also breed in the khals connected to beels.

River breeding pattern: Reproductive patterns are more diverse among river breeders. Ayre, rita, ghagot and guizza dig pits for breeding in the shallow area in April and May and also known to breed around katha (Fish Aggregating Device- FAD). Chital and foli breed during May to June in shallow areas over hard substances such as stones, bamboo or submerged tree branches. Small fish including batashi, bashpata, chela, kachki, baila and baim breed shallow areas of rivers in April and rani prefers to breed in calm and quite places.

The Upper Meghna River major carp stock spawns in the head waters of tributaries in the Letha Range and possibly in Assam hill in India during April to June and depends upon rainfall and this stock is associated with Haor basin. Four (04) species of major carps are known to breed in rivers and it is suspected that Tanguar haor, Pasuar haor, Hakaluki haor, Erali beel, Laudi and Bawa beel in the Haor area, have carp breeding areas (Ali, 1997). Local fishermen record that carp spawn occurs in (i) Kawnai River near Daulatpur and Milanpur (Dharmapasha); (ii) Boroiya River near Shanbarir bazar (Dharmapasha); (iii) Baulai River near Mukshedpur (Dharmapasha); (iv) Alamduarer baank in Tanguar haor; (v) Surma River near Sunamganj town; (vi) Dhanu River near Ranichapur and Dhalimati (Kaliajuri area); (vii) Kalni River near Markuli (Derai) and (viii) Khoiltajuri River near Dighirpar (Companiganj area). Local people also suspect that rui, mrigel, kalibaus and ghonia breed in Luba River and kalibaus (also ghonia and catfish) may breed in Dekker haor. The following Figure 6.15 portrays the major carp spawning grounds and spawn occurrences of the Haor area.

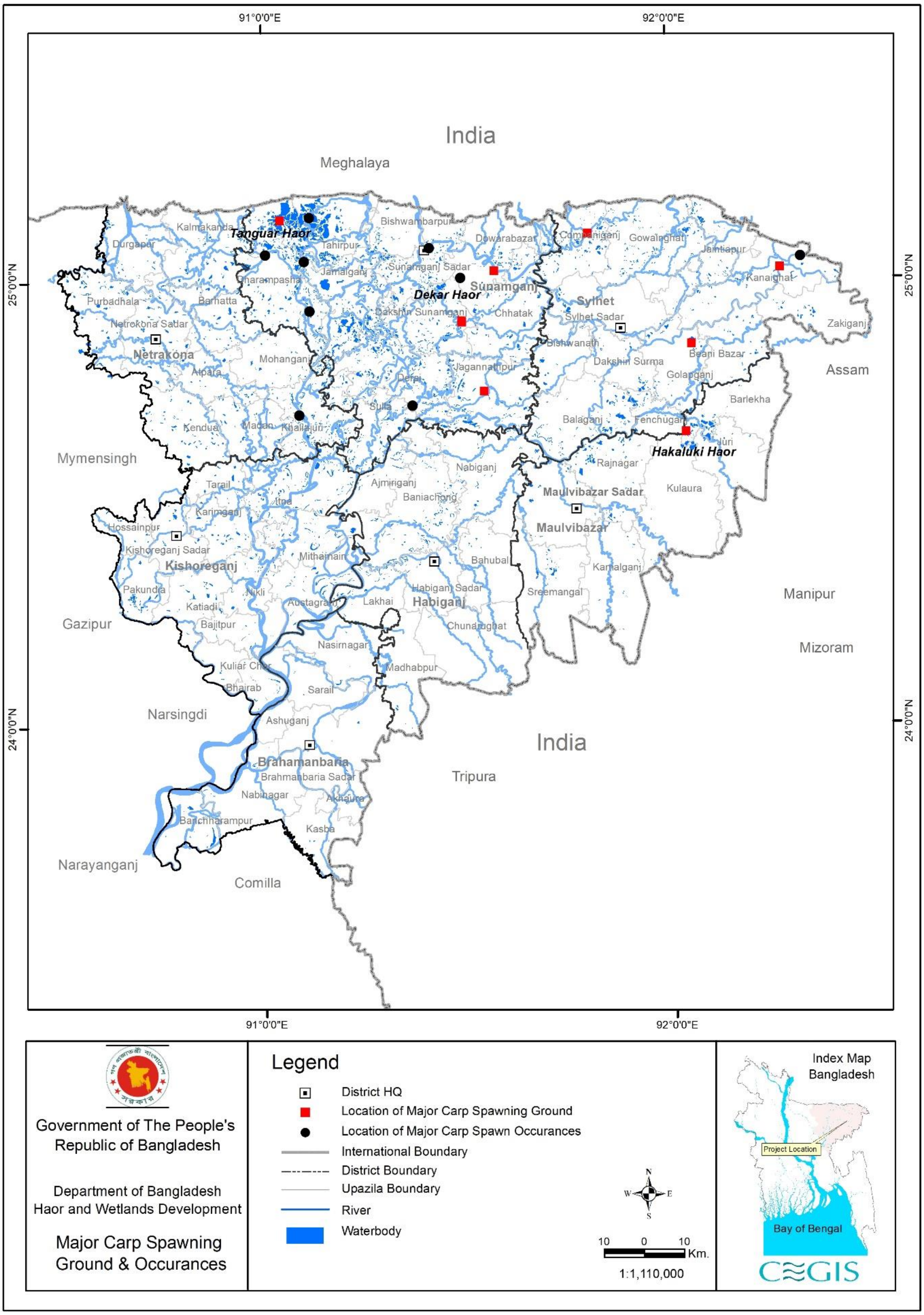


Figure 6.15: Major carp spawning grounds and occurrences of carp spawn

Fisheries Trend in Haor Areas

Analysis of time series fishery data for 32 years (1983-2014) reveals the declining trend of capture fishery habitat area and it has decreased to about 863,603 ha in 2014 which was 919,823 ha in 1983. This means capture habitat area has been declined by an area of 56,220 ha in three decades. Gradual downturn of capture fishery habitat has also been causing decline of capture fish production. The Figure 6.16 portrays the historical trend of fish habitat for all the districts in Haor areas. Similar analysis for culture fishery for the period of 1983-2014 reveals the increasing trend of culture fish habitats. Culture fishery area has increased to 55,570 ha in 2014 which was 8,575 ha only in 2003. This means culture habitat area has been increased by an area of 46,995 ha in a decade. In accordance with such upturn of capture fishery habitat, its contribution to the inland fishery has been increasing at higher rate as people are moving towards creating more aquaculture area by converting capture habitat area, agriculture field and other types of lands.

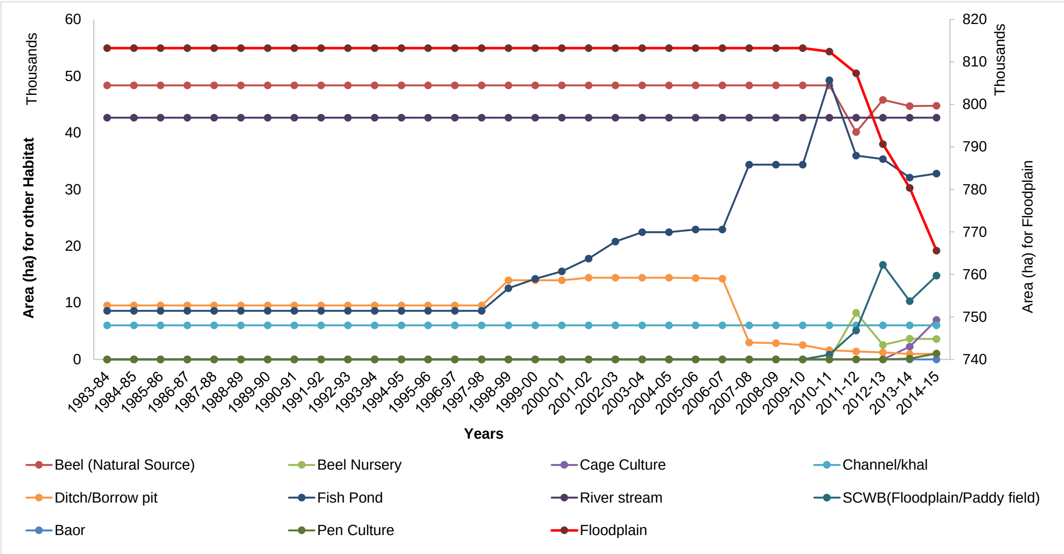


Figure 6.16: Historical habitat change in all District

The trend of major habitat-wise catch in inland fisheries from 1983-2014 is shown in Figure 6.16. It appears from the production data analysis that overall fish production has increased by 11.8% in 2014 from the production of 1983. The production in floodplain and Beels has drastically increased since 2009-10 to 2014-15 (Figure 6.17). The production trend of other habitats of the capture fishery was found more or less steady. The reasons of increasing production from the open water sources are include the followings: floodplain stocking with carp fingerlings, Beel nursery programme, and the strengthening of conservation measures. On the other hand, production from pond fishery has gradually been increasing since 1996-97.

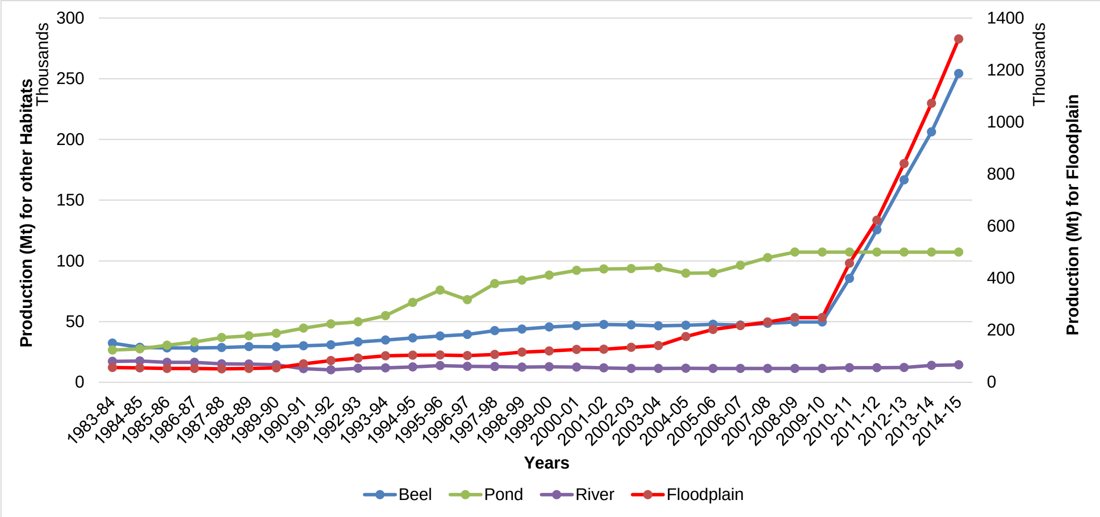


Figure 6.17: Historical change of fish production in all District

Gain of fish habitat area has been found in case of Bara Haor, Baram Haor, Chandra Sunarthal, Chaptir Haor, Chayer Haor, Hail Haor, Humaipur Haor, Jamkhola Haor, Nautana Haor, Pagner Haor, Singua River Project and Surma River System by about 19, 17, 1, 12, 214, 2060, 8, 1, 40, 14, 370, 1174 and 113 hectare respectively. However, fish habitat has been lost in case of Dhaleswari River Scheme, Gungiajuri FCD Project, Gozaria Beel Project, Haizda Embankment Project, Halir Haor, Kalikota Haor, Kalner Haor, Kawadighi Haor, Matian Haor, Mahadeo River, Naider Haor, Nalua Haor, Sari Goyain Project, Updakhali Haor and Zilker Haor. Among them highest habitat loss is found in Sari Goyain Project and lowest habitat loss in Kawadighi Haor. Moreover, an important perennial beel, Kairdala Beel, has totally been lost in Kairdala Ratna Haor. In addition to these no change is also found in case of Kairdala Ratna Haor. It has been found in case of all the projects, fish habitat quality and water quality degrading by incremental use of agrochemicals, pesticides and fertilizer in boro field and also polluted by wastage from different sources.

Table 6.9: State of indicators in individual 30 haors

Sl. No.	Haor Name	Status of Indicator							
		Fish habitat area	Fish habitat Condition	Fish Diversity	Fish migration	Fish production	Fishing Appliances	Fishers Livelihood	Fisheries Management
1	Bara Haor	1	-1	-1	-2	5	-1	-1	-1
2	Baram Haor	1	-2	-2	0	5	-1	-1	-1
3	Chaptir Haor	1	-1	-1	-1	3	-1	-	-
4	Jamkhola Haor	1	-2	-2	0	5	-1	-1	-1
5	Chandra Sunarthal	0	-1	-1	-1	5	-1	-1	-1
6	Chayer Haor	1	-1	-1	-2	5	-1	-1	-1
7	Dhaleswari River	-1	-1	-1	-1	3	-1	-2	-2
8	Gungiajuri FCD Project	-1	-1	-1	-1	3	-1	1	-1
9	Gozaria Beel	-1	-1	-1	-1	3	-1	1	-1
10	Hail Haor	1	-1	-1	-2	3	-2	2	-2
11	Haizda Embankment Project	-2	-1	-1	-1	5	-1	-1	-1
12	Halir Haor	-1	-1	-1	-2	5	-1	-1	-1
13	Humaipur Haor	1	-1	-1	-1	1	-1	1	-1

Sl. No.	Haor Name	Status of Indicator							
		Fish habitat area	Fish habitat Condition	Fish Diversity	Fish migration	Fish production	Fishing Appliances	Fishers Livelihood	Fisheries Management
14	Kairdala Ratna Haor	0	-1	-1	-3	2	-1	-1	-1
15	Kalikota Haor	-2	-1	-1	-2	5	-1	-1	-1
16	Kalner Haor	-1	-1	-1	3	-1	-2	-1	-1
17	Kawadighi Haor	-1	-1	0	-1	3	-1	-1	1
18	Matian Haor	-1	-1	-2	-1	-1	3	-1	-1
19	Mahadeo River	-1	-2	-1	-2	1	-2	-1	-1
20	Naider Haor	-1	-1	-1	-1	3	-1	-2	-2
21	Nalua Haor	-2	-1	-1	0	5	-1	-1	-1
22	Nautana Haor	1	-1	0	-1	5	-1	-1	-1
23	Pagner Haor	1	-1	-1	-2	5	-1	-1	-1
24	Singua River	1	-1	-1	-1	4	-1	2	-1
25	Sari Goyain Project	-1	-1	-1	-1	2	-1	-2	-2
26	Shanir Haor (After Discussion)								
27	Surma River System	3	-1	-1	-4	5	-	-1	-1
28	Tangua Haor	-2	-2	-2	0	2	-1	-1	-1
29	Updakhali Haor	-1	-1	-1	-2	1	-2	-1	-1
30	Zilker Haor	-2	-1	-1	-1	3	-2	-2	-2

**No impact (0); Negative Impact (-); Positive Impact (+); Low Impact (1); Medium low Impact (2); Medium Impact (3); High Impact 4; Very High Impact 5.*

Little imbalance has been found in fish species distribution over the area for all the haors. Vulnerability to Beel resident column feeder and bottom dwelling fish species is prominent in case of Nalua Haor, Chayer Haor, Baram Haor, Jamkhola Haor, Matian Haor and Tangua Haor. Lateral fish migration is highly obstructed in case of Kairdala Ratna Haor, Kalner Haor and Surma River System. But in case of Baram Haor, Jamkhola Haor, Nalua Haor and Tangua Haor, there is no significant implication of interventions on fish migration. Gain of fish production is commonly found in all the projects. Among them highest and lowest production gain is found in Hail Haor by 5,031 metric ton and in Sari Goyain Project by 78 metric ton respectively. This increment in productivity may be caused due to adoption of fisheries management like Beel fishery, Beel nursery, increasing fishing activities, fishing commercialization, stocking of culture fish species in Beel fishery, etc.

6.5 Ecological Resources

Impacts on Biodiversity, habitats and ecosystem services of the specific haor areas has been assessed mainly through interviewing of key informants and local elderly people by using structured questionnaire. Beside this, additional information have been acquired from different literatures. A total of 6 major indicators has considered; i.e: terrestrial flora, terrestrial fauna, aquatic flora, aquatic fauna, reedland/ swamp forest and ecosystem services in this regards. Of which, first 4 indicators indicate the overall biodiversity and the fifth one indicates the habitat condition and last one refers the haor ecosystems services to human, wildlife and environment.

Usually, there exist negative impacts on biodiversity and its habitats with improvement of crop production as well as social development. Accordingly, construction of submergible embankment, water control structures and allied facilities with autonomous developments have negative impacts on wild floral and faunal communities. Most of the impacts are more or less similar for all the haors and none of the interventions are directly responsible for the changes of status of the ecological indicators. It is difficult to identify area specific and quantifying information on the indicators as local people are not such aware about biodiversity and wildlife habitats. So, qualitative information have given for all the haors. The major impacts on specific indicator for all haors are as follows:

Terrestrial Flora

- Reduced natural vegetation coverage due to conversion of fallow land into crop cultivation and human habitation
- Karach, Pitali, Barun, Hijal etc have been reduced in the surrounding sites of homestead and kanda areas.
- Over explorations of swamp trees, harbs and shrubs for meeting fuel wood demand
- Changes of vegetation composition as well as introduction of cultivated varieties on settlement platforms that replaced the wild and non-economical valued species
- In some cases, increase terrestrial vegetation coverage with expansion of human settlement
- Reduced wild herbs population from crop field due to application of herbicides for crop cultivation

Terrestrial Fauna

- Destruction of habitat area due to damages of natural vegetation for agricultural expansion and other anthropogenic pressures
- Terrestrial faunal like small indian civet, fishing cat has been decreased/disappeared due to loss of habitat area.
- Reduced population and diversity of wildlife for hunting and application of insecticides
- Change occurrences of wild fauna for habitat disturbance

Aquatic Flora

- Reduced coverage for Squeezing perennial wetland (i.e: Beel) area due to agricultural expansion inside it
- Damages rooted floating and submerged plants by random use of fishing nets inside floodplains and perennial wetlands
- Hamper succession due to wetland siltation and sand carpeting
- Over exploration of edible aquatic plants like water lily, makhna etc.
- Increase coverage of some haors for taking conservation programme

Aquatic Fauna

- Destruction of habitat area due to encroachment wetland for agricultural expansion and other anthropogenic pressures
- Wetland dependent mammal species (Eurasian Otter-Lutra lutra, Fishing Cat-Prionailurus viverrinus), turtle population (Spotted flap-shelled turtle- Lissemys punctata. water dependent frogs etc. have been reduced due to loss of connectivity between haor and river in some areas.
- Reduced freshwater snail abundance for commercial duck rearing
- Hamper dolphin migration due to construction of closure on river outfall
- Decrease amphibian population for application of pesticides
- Diversity and population of migratory waterfowl has been decreased due to habitat exploitation, hunting and toxic trapping.
- Reduced population for hunting

Reedland and Swamp Forest

- Squeeze area for conversion into crop field and human settlement
- Destruction of vegetation due to cattle grazing

Ecosystem Services

- Boosting up provisional pervices like food production
- Reduced regulating and supporting services for random use of pesticides, demolishing natural vegetation and encroaching wetland area

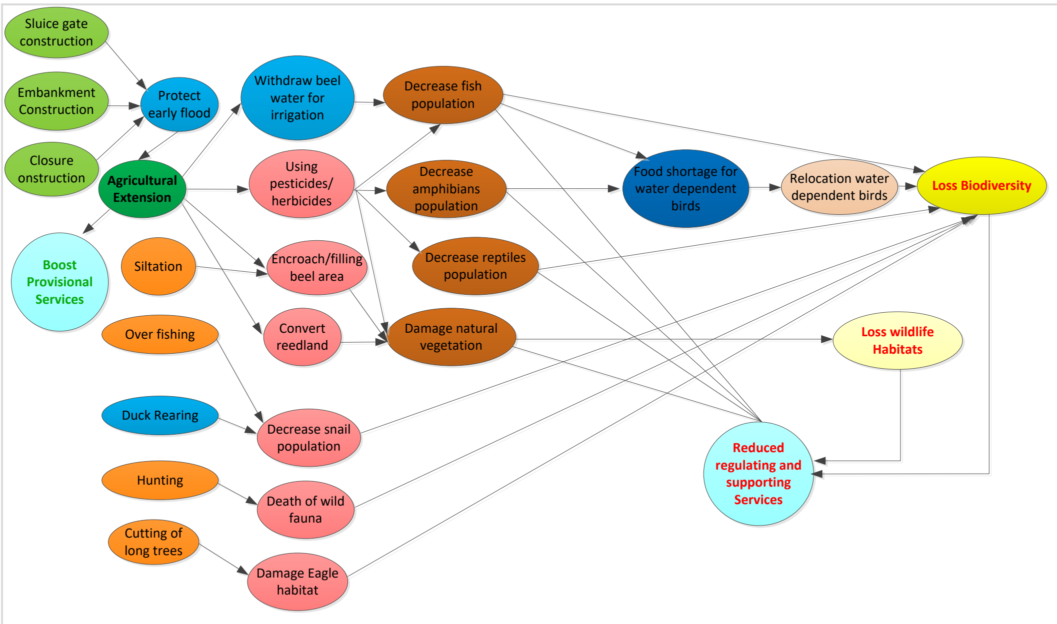


Figure 6.18: Overall impacts on haor ecosystems for implementation of interventions

Table 6.10: Summary of impacts on ecological indicators at different haors

Sl. No.	Scheme Name	Status of Indicator					
		Terrestrial Flora	**Terrestrial Fauna**	**Aquatic Flora**	**Aquatic Fauna**	**Reedlands and Swamp Forest**	**Ecosystem Services**
1	Bara Haor System	Decreased	Reduced	Decreased	Decreased	Disappeared	Boost PS
2	Baram Haor System	Decreased	Reduced	Disappeared	Changed	Decreased	Boost PS
3	Chandra Sunarthal Haor System	Decreased	Decreased	Disappeared	Relocated and Reduced	Decreased	Boost PS
4	Chaptir Haor	Decreased	Reduced	Disappeared	Decreased	Decreased	Boost PS
5	Chayer Haor	Insignificant Changed	Reduced	Decrease	Insignificant Changed	Decreased	Reduced all Services
6	Dhaleswai River	Insignificant change	Reduced	Reduced	Reduced anthropogenic pressures	Decreased	Boost PS
7	Gangajuri FCD Sub-Project	Increased	Reduced	Reduced	Reduced	Not Changed	Boost Ps
8	Gozaria Beel Project	Insignificant Change	Extremely Rare	Disappeared	Relocation and Reduction	Increased	Boost PS
9	Haijda Embankment Sub-Project	Expand Coverage	Reduced	Disappeared	Threat to some Aquatic Floral Species	Disappeared	Boost PS
10	Hail Haor Project	Unchanged	Reduced	Increased	Restore Sanctuary	Create New One	Boost PS
11	Halir Haor System	Decreased	Reduced	Reduced	Disappeared/ Reduced	Reduced	Boost PS
12	Humaipur Haor Project	Insignificant Change	Reduced	Reduced	Reduced	Reduced	Boost PS
13	Jamkhola Haor	Unchanged	No change	Hamper Succession	Reduced	-	Boost PS
14	Kairdhala-Ratna	Reduced	Reduced	Reduced	Blocked Turtle’s Migration Path	Reduced	Boost PS
15	Kalikota Haor Project	Insignificant Change	Reduced	Changed Negatively	Insignificant Change	Disappeared	No Change
16	Kalner Haor System	No Change	No change	Reduced	Reduced	Disappeared	Boost PS

Sl. No.	Scheme Name	Status of Indicator					
		Terrestrial Flora	Terrestrial Fauna	Aquatic Flora	Aquatic Fauna	Reedlands and Swamp Forest	Ecosystem Services
17	Kawadighi Haor	Reduced	Reduced	Reduced	Significantly Reduced	Disappeared	Boost PS
18	Matian Haor System	Changed Positively	Deteriorated	Reduced	Reduced	Dilapidated	Boost PS
19	Mohadao Nadi Embankment	-	Insignificant Change	Reduced	Reduced	-	Boost PS
20	Naidar Haor	Increased	-	Damaged	Reduced	Decreased	Boost PS
21	Naluar Haor System	Changed Natural to Planted	Unchanged	Negative Changes	Reduced	Not exists	Boost PS
22	Nautana Khal Scheme	Increased	Reduced	Threat for Diversity Depletion	Reduced	Disappeared	Boost PS
23	Pagner Haor System	Increased	Reduced	Reduced	Caused Threats	Reduced	Boost PS
24	Re-excavation of Singua River	Insignificant change	Slightly Reduction	Reduced	Reduced	Reduced	Increased
25	Sari Goyain Project	Unchanged	Reduced	Reduced	No Change	Reduced	Boost PS
26	Shanir Haor System	Reduced	Reduced	Reduced	Habitat Converted	Reduced	Unchanged
27	Surma River System	Reduced	Reduced	Reduced	Disappeared	Disappeared	Boost PS
28	Tangua Haor	Increased	Reduced	Disappeared	Reduced	Squeezed	Changed Negatively
29	Updakhali Haor	Insignificant Change	Reduced	Reduced	Changes Occurred (-)	Disappeared	Boost PS
30	Zilkar Haor System	Unchanged	Slightly Reduction	Reduced Coverage	Reduced	Reduced	Boost PS

Note: PS=Provisioning services

6.6 Socio-economic Resources

The Haor system provides a wide range of economic and non-economic benefits to the local people as well as to the people of Bangladesh at large. These include benefits in terms of rice production, fish production, cattle and buffalo rearing, duck rearing, collection of reeds and grasses, collection of aquatic and other plants. This study was conducted at the 33 Haor area located in Sunamganj, Sylhet, Moulavibazar, Habiganj, Mymensingh, Netrokona and Kishoreganj district. A total number of 8 indicators has been taken to analyze the socio–economic impact based on the studied interventions.

Over all Socio-Economic Condition

The total projected population of the seven haor districts is 21.58 million in 2017 (BBS, 2011). There are about 4.05 million households in the haor districts. The overall population density in the haor districts is 987 per sq km, which is lower than the average population density in Bangladesh (1,142 per sq. km). Around 19.6% of people of the haor area live in urban centers.In the haor area, 29.56% (Master Plan of Haor, 2009) of the population live below the Lower Poverty Line (LPL), which is slightly higher than the national average of 29.26%. Currently, only 3% of the haor population has no cultivable area. On the other hand, 81% of non-farm holdings have no cultivable area. In the farm holding category, 34% of farm households are marginal and 51% are small farmers.

Livelihood opportunities in the Haor region are limited and highly seasonal, as they are focused predominantly on agricultural labour associated with the single annual rice cropping cycle. Fishing, which was conventionally an important occupation for in the Haor region, has declined in recent years due to leasing arrangements which are often controlled by local elites resulting in highly restricted access to open water fisheries by the poor. The incidence of livestock husbandry as a livelihood activity in the Haor region has also declined, due to a combination of factors including the conversion of grazing land to paddy cultivation, increased population density on the haatis, and increased disease burden on animals due to increased temperatures associated with climate change. The extended lean season associated with the annual cycle of flooding, results in extensive and severe food insecurity and striking levels of indebtedness.

The settlement area situated in low lying land is characterized by water logging. Wave erosion or *Affal* is one of the major threats to the haor settlements. In certain places, the settlements are protected with boundary walls, which are also subjected to damage from wave erosion. Due to scarcity of land, the people are forced to live in a crowded environment.

Lack of awareness, natural disasters, impoverishment, and insufficient number of development interventions, weak infrastructure, scarce human resources, child labour, gender discrimination and malnutrition are some of the major issues of concern for the education sector in the haor region. The percentage of girl students attending primary school (NAR) and secondary school (NAR) is more than that of boy students. Similarly, the NAR for girls is higher at secondary school than at primary school. One of the reasons for that is girl students receive stipend in cash or kind and therefore are encouraged to attend school. At the same time, the boys by default are engaged in other income earning opportunities.

The health services in the haor area are poor. Shortage of health service centres, drugs and medicines, poor transportation facilities, shortage of doctors/nurses and other staffs, and lack of emergency services are the main pitfalls of health services in this area. Among these, transportation facilities is the main constraint to get access to the health service facilities.

The haor region is mostly inhabited by poor and disadvantaged groups lacking access to basic water supply services. Most of the tube wells are submerged during monsoon and flood periods, creating scarcity of drinking water and threatening the health of the haor community. Apart from the usual sources of water like deep/shallow tube wells/tara pumps, alternate sources of drinking water supply such as the Pond Sand Filter (PSF), ring wells, Rainwater Harvesting system (RWH) etc. have been still insufficiently available or used in the area, especially during flood periods.

Lack of appropriate sanitation facilities in flood-prone areas particularly during the flood period has been the main factor contributing to health problems and severe environmental degradation. Effluent dispersion from latrines into the groundwater is a significant pollution problem. The provision of physical sanitation facilities alone is not enough for the inhabitants of the area to be protected from diseases or for the environment from further degradation. Specific and specialised hygienic sanitation systems are essential for the people of the haor area.

The Transportation system follows a special seasonal calendar. Although navigation is the main means of transportation, it is not possible during dry season due to the reduction of water in the rivers. On the other hand, during wet season road networks cannot be used as the low roads are inundated by flood water. At the beginning of autumn (mid-October) people can communicate neither by road nor by waterways as both roads and navigation routes remain unusable when the huge amount of water starts to decrease. During this period people has to travel mostly on foot.

Most of the haor upazilas are characterised by inadequate number of roads. There is a lack of necessary road networks from upazila level to union level. Moreover, other communication infrastructures such as bridges and culverts are also scarce in important locations of this area. There are very few modern vehicles for road network and navigation. Although boats are mainly used during monsoon, they are a risky means of transportation in bad weather.

Impact Summary on the basis of 30 Schemes

With the period of time, the demographic scenario has been changed and it is estimated that 4,586,433 people are living in this study area presently. Agriculture and fishery are considered as the two major livelihood options for the people in this haor region whereas agriculture is recognized as the prime source of livelihood option, and about 85% people mostly dependent on this prime source. However, the cropped area increased with the project intervention that lead to provide more employment opportunities (about 11% increased) and agricultural production but repeated inundation of the major Boro crop every year, and shrinking of fishing opportunity for fishermen impacted negatively in the households of the Haor regions. The losses of crops and fishing opportunities have created push factor for those who had been dependent on these two livelihood options (agriculture and Fishery) and led them to search alternative livelihood option in and beyond the community.

In addition, agricultural production increased due to change in the crop variety and cropping intensity at the post project period. Presently, agricultural production and agricultural wage labor base income has been increased about 37% on an average but income opportunity based on fishing has been declined and some people from fishing community got access only to do work as a seasonal labor in this particular area. Secured income opportunity from agriculture possess the local people to construct better household for their living. On the other hand, direct impact on literacy and health is marginal but the indirect benefit to education and health services is increased the affordability of small and medium farm households to avail those services. Moreover, the more production opportunity created the value of agricultural land at the time of post project condition and uphold the communication system as comfortable at least in the dry season as most the embankments are used as connecting roads at that period. Furthermore, the lack of participatory governance system in this Haor area created problems and made people concern regarding the damaged roads, embankments and overall socio economic condition in the Haor regions. Finally, the intervention which had been implemented in this Haor region, of course, addressed the social benefit regarding the agricultural production and building affordability to lead their living condition and livelihood status but the lack of participatory governance and monitoring system create obstacles in getting solution for the arising problems on the livelihood issues in the Haor regions.

Table 6.11: Summary of impacts on socio-economic indicators at different haors

Sl. No.	Scheme Name	Status of Indicator							
		Employment Opportunity	Agricultural production and agricultural wage based income	Labor and Seasonal Migration	Land Price	Housing Condition	Health and Education Status	Transportation and Communication	Institution and Governance
1	Bara Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
2	Baram Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
3	Chandra SunarthalHaor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
4	Chaptir Haor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
5	Chayer Haor	Increased	Increased	Decreased.	Increased	Improved	Improved	Improved during dry season	Weak
6	Dhaleswai River	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
7	Gangajuri FCD Sub-Project	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
8	Gozaria Beel Project	Increased	Increased	Decreased.	Increased	Improved	Improved	Improved during dry season	Weak
9	Haijda Embankment Sub-Project	Increased	Increased	Decreased.	Increased	Improved	Improved	Improved during dry season	Weak
10	Hail Haor Project	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
11	Halir Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
12	HumaipurHaor Project	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
13	JamkholaHaor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
14	Kairdhala-Ratna	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak

Sl. No.	Scheme Name	Status of Indicator							
		Employment Opportunity	**Agricultural production and agricultural wage based income**	**Labor and Seasonal Migration**	**Land Price**	**Housing Condition**	**Health and Education Status**	**Transportation and Communication**	**Institution and Governance**
15	Kalikota Haor Project	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
16	Kalner Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
17	KawadighiHaor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
18	Matian Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
19	Mohadao Nadi Embankment	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
20	Naidar Haor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
21	Naluar Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
22	Nautana Khal Scheme	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
23	Pagner Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
24	Re-excavation of Singua River	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
25	Sari Goyain Project	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
26	Shanir Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
27	Surma River System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
38	Tangua Haor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
39	UpdakhaliHaor	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak
30	Zilkar Haor System	Increased	Increased	Decreased	Increased	Improved	Improved	Improved during dry season	Weak

Chapter 7: Compliance Analysis

7.1 Introduction

One of the purposes of conducting the Environmental auditing in this study is to identify the management gaps of the intervention established in different types of haor ecosystem. Assessment of achieving project objectives, performance analysis of the interventions in terms of having impacts on associated sectors and compliance with national policy directives are the integral part of conducting Environmental Auditing. Performance analysis of these interventions in terms of impact assessment has been presented in the previous chapter (Chapter Six) and this chapter focuses on assessment of achieving project objectives and compliance with national policy directives. Compliance with the directives has been checked for the Policy, Act, Rules, Strategy, Plan and International Conventions etc. of all relevant and associated sectors considering the nature of the selected FC/FCD/FCDI projects and their impact on different sectors. Moreover, compliance of a particular project has been checked with the relevant Policy, Act, Rules, Strategy, Plan and International Conventions if they were enacted prior to the initiation of that project. Since, 23 projects were implemented from 1957 to 1990 and only 7 projects were implemented from 1991 to 2006; a few projects were applicable compliance assessment with the Policy, Act, Rules, Strategy, Plan and International Conventions that were formulated after the year 1991.This assessment will identify the gaps of these interventions in complying with the respective project objective and policy directives which will ultimately facilitate in preparing the necessary mitigation measures for compliance with the project objective and policy directives.

7.2 Compliance with Project Objective

7.2.1 Basis of Compliance

Bangladesh Water Development Board (BWDB) implemented many Flood Control/Flood Control and Drainage/ Flood Control, Drainage and Irrigation (FC/FCD/FCDI) schemes/projects in the Haor Region including the 30 schemes which are being considered for this study. Among the 30 projects, 15 are FCD projects and two projects are FC projects. Remaining 13 projects are FCDI in nature. The main objective of the FC/FCD schemes/project was to protect crops from flash flood as well as to protect life and properties from flooding. The objective of the FCDI projects was to facilitate irrigation for increasing the crop production in addition to the objective of protecting crops from flash flood. In order to assess the compliance of these projects with project objective (i.e. whether these projects have been able to fulfill their objectives or not); changes in flooding condition have been checked all these 30 projects as their main objective lied in controlling flood for protecting life and properties from flooding. Installation of irrigation facilities; changes in cropped area, crop production and irrigated area and/or availability of surface water for irrigation were also checked for the FCDI projects to assess their compliance with their further objective of facilitating irrigation for increased crop production.

7.2.2 Compliance Status

Interventions for flood control have been implemented in all 30 schemes/projects. Necessary drainage and irrigation facilities have been installed in the respective schemes/projects (Details of interventions/structures are given in Annex 4). It has been found from the field investigations that, the schemes/projects have been successful in controlling flood in these haors to a great extent and protecting valuable life and properties. Interventions in these haor have reduced the occurance of earlier entrance of flood and saved the crops from damage. However, the drainage of water within the project areas has become slower than before-but has not impacted significantly after implementation of the projects. Table 7.1 shows the compliance status of the FCD and FC projects.

Table 7.1: Compliance with Project Objective for FCD and FC Projects

SL. No.	BWDB Scheme	Scheme Type	Flood Control
1	Bara Haor System	FCD	Complied
2	Naidar Haor	FCD	
3	Chayer Haor	FCD	
4	Halir Haor System	FCD	
5	Baram Haor System	FCD	
6	Chandra Sunarthal Haor System	FCD	
7	Dhaleswari River	FCD	
8	Gangajuri FCD Sub-Project	FCD	
9	Hail Haor Project	FCD	
10	Kawadighi Haor	FCD	
11	Mohadao Nadi Embankment	FC	
12	Nautana Khal Scheme	FCD	
13	Pagner Haor System	FCD	
14	Sari Goyain Project	FCD	
15	Surma River System	FCD	
16	Jamkhola Haor	FC	
17	Updakhali Haor	FCD	

In case of FCDI projects; compliance with the objective of facilitating irrigation for increased crop production needed to be assessed mainly by checking whether irrigation facilities were installed or not. However, information of irrigation facilities installed under these projects was not available except for Zilqar Haor System, Haijda Embankment Sub-Project and Humairpur Haor Project. As such, changes in cropped area, crop production and irrigated area and/or availability of surface water for irrigation were checked to assess the compliance with the objective of facilitating irrigation. Apart from the implicit objective of flood control and facilitating irrigation, the objective of the "Re-excavation of Singua River" project was to increase the water conveyance capacity of the Singua River which was fulfilled through excavation of the river. Summary of changes in cropped area, crop production and irrigated area and/or availability of surface water within the 13 project areas have been presented in Table 7.2. Details of these changes in pre and post project conditions have been described from Annex 5 to Annex 7).

Table 7.2: Compliance of the FCDI Projects with Project Objective

SL. No.	BWDB Scheme	Flood Control	Irrigation Facilities	Total Cropped Area (ha)	Total Crop Production (ton)	Total Irrigated Area (ha)	Surface Water Irrigation Availability	Remarks
1	Humaipur Haor Project	Complied	Complied	Decreased	Increased	Decreased	Deficit during month of February to March	Complied with the objective of increased crop production considering the Total Crop Production
2	Haijda Embankment Sub-Project	Complied		Increased	Increased	Increased	Information Not Available	
3	Zilkar Haor System	Complied		Increased	Increased	Increased	Information Not Available	
4	Gozaria Beel Project	Complied	Information Not Available	Increased	Increased	Increased	Deficit during month of February to March	
5	Kalner Haor System	Complied		Increased	Increased	Increased	Information Not Available	
6	Matian Haor System	Complied		Increased	Increased	Increased	Information Not Available	
7	Naluar Haor System	Complied		Decreased	Increased	Decreased	Information Not Available	
8	Re-excavation of Singua River	Complied		Increased	Increased	Increased	Deficit during month of February to March	
9	Shanir Haor System	Complied		Increased	Increased	Increased	Information Not Available	
10	Tangua Haor	Complied		Decreased	Increased	Decreased	Information Not Available	
11	Chaptir Haor System	Complied		Increased	Increased	Increased	Information Not Available	
12	Kairdhala-Ratna	Complied		Increased	Increased	Increased	Deficit during month of February to March	
13	Kalikota Haor Project	Complied		Increased	Increased	Decreased	Deficit during month of February to March	

It has been found that after implementation of the project interventions, total crop area has been increased in most of the project areas except for Humaipur Haor Project, Naluar Haor System and Tangua Haor. Similarly, total irrigated area has also been found to increase in nine project areas after implementation of the project interventions. However, total irrigated area has decreased in Humaipur Haor Project, Kalikota Haor Project, Naluar Haor System and Tangua Haor. Deficit in surface water for irrigation during the month of February and March has been reported for five projects which are: Humaipur Haor Project, Gozaria Beel Project, Re-excavation of Singua River, Kairdhala-Ratna Project and Kalikota Haor Project. However, total crop production has been reported to increase in all 13 FCDI project areas due to expansion of hybrid and HYV crop cultivated area as well as benefit of the project interventions. Therefore, all 13 FCDI projects can be considered as complying with the objective of increased crop production considering the changes in total crop production.

7.3 Compliance with National Water Policy Directives

7.3.1 Basis of Policy Compliance

The purpose of assessing the compliance of the projects with the national policy directives is to check whether different components or interventions of the schemes/projects followed the national policy directives or not. This assessment will identify the gaps of these projects in complying with the policy directives and will ultimately facilitate in preparing the the necessary mitigation measures for compliance with the policy directives. This study has basically confined its focus on thirty FC/FCD/ FCDI projects of BWDB and these projects have immense impact not only on water resources management of the haor region but also on other sectors like agriculture and land use, fisheries, ecology and socio-economic. Therefore, compliance with the policy directives has not only been checked for the Policy, Act, Rules etc. of the water sector but also with those of other relevant sectors. An important factor for assessing the compliance with policy directives is the year of initiation of the project and the year in which the policy, act, rules were enacted. Compliance of a particular project has been checked with the relevant Policy, Acts and Rules if they were enacted prior to the initiation of that project. Since, most of the projects were initiated before 1991, a few projects comply with the Policy, Act and Rules that were formulated after the year 1991. Name and number of applicable Policy, Acts and Rules for policy compliance for each of the 30 projects has been given in Table A2-1 in Annex 2.

Twenty one among the thirty projects (see Annex Table A2-1 in Annex 2) were initiated on or before the year 1991. Therefore, the Policy, Acts and Rules which were enacted in or after the year 1991 are not applicable for these twenty one projects. As such, only two relevant Acts namely the Embankment and Drainage Act, 1952 and the Protection and Conservation of Fish Act, 1950 are applicable for these twenty one projects. Similarly, considering the year of initiation of the projects, the total number of relevant Policy/Act/Rule which are applicable for assessing the compliance are three, three, four, five, seven and eight (including the above mentioned two Acts) for Kalikota Haor, Chaptir Haor System, Kairdhala-Ratna, Jamkhola Haor, Updakhali Haor and Dhaleswai River Projects respectively. Information regarding the actual year of implementation of three projects namely Bara Haor System, Chayer Haor and Naidar Haor were not available and it is assumed that, they were implemented after the year 1981. Therefore, compliance of these three projects with policy directives have only been assessed for the relevant Policy, Rules and Acts which were enacted before 1981 i.e. the Embankment and Drainage Act, 1952 and the Protection and Conservation of Fish Act, 1950.

Compliance status of the 30 projects with the relevant Policy, Act and Rules i.e. Embankment and Drainage Act, 1952 and the Protection and Conservation of Fish Act, 1950 is presented in Table 7.3. Compliance Status of Kalikota Haor, Chaptir Haor System, Kairdhala-Ratna, Jamkhola Haor, Updakhali Haor and Dhaleswari River Projects which were initiated after the year 1991; with other relevant and applicable Policy, Act and Rules has been presented in Table 7.4.

As mentioned earlier in Chapter 4, findings of the directives of the relevant Policy, Rules and Acts has been has been presented under some thematic issues and these thematic issues were identified based on the sector wise indicators which are directly or indirectly associated with the infrastructure development in the Haor Region. While presenting the compliance status of the projects with the applicable Policy, Rules and Acts; relevant thematic issues have also been mentioned in Table 7.3 and Table 7.4. These thematic issues would provide primary notion in identifying the gaps of these projects in complying with the policy directives and will ultimately facilitate in preparing the the necessary mitigation measures for compliance with the policy directives.

Table 7.3: Compliance Status of the Projects with the Embankment and Drainage Act, 1952 and the Protection and Conservation of Fish Act, 1950

Sl No.	BWDB Scheme	Scheme Type	Year of Start	Year of End	The Embankment and Drainage Act, 1952		The Protection and Conservation of Fish Act, 1950
					Flood and Drainage Management	Regular Maintenance and Rehabilitation of Interventions	Fish Friendly Infrastructure Development
1	Bara Haor System	FCD	Information not available		Complied	Need to be complied on regular basis	Need to be complied
2	Chayer Haor	FCD			Complied	Need to be complied on regular basis	Need to be complied
3	Naidar Haor	FCD			Complied	Need to be complied on regular basis	Need to be complied
4	Baram Haor System	FCD	1987	1993	Complied	Need to be complied on regular basis	Need to be complied
5	Chandra Sunarthal Haor System	FCD	1974	1978	Complied	Need to be complied on regular basis	Need to be complied
6	Gangajuri FCD Sub-Project	FCD	1986	1993	Complied	Need to be complied on regular basis	Need to be complied
7	Gozaria Beel Project	FCDI	1984	1986	Complied	Need to be complied on regular basis	Need to be complied
8	Haijda Embankment Sub-Project	FCD	1981	1989	Complied	Need to be complied on regular basis	Need to be complied
9	Hail Haor Project	FCD	1982	1992	Complied	Need to be complied on regular basis	Need to be complied
10	Halir Haor System	FCD	1964	1988	Complied	Need to be complied on regular basis	Need to be complied
11	Humaipur Haor Project	FCDI	1957	1986	Complied	Need to be complied on regular basis	Need to be complied
12	Kalner Haor System	FCDI	1979	1987	Complied	Need to be complied on regular basis	Need to be complied
13	Kawadighi Haor	FCD	1975	1996	Complied	Need to be complied on regular basis	Need to be complied
14	Matian Haor System	FCDI	1977	1988	Complied	Need to be complied on regular basis	Need to be complied

Sl No.	BWDB Scheme	Scheme Type	Year of Start	Year of End	The Embankment and Drainage Act, 1952		The Protection and Conservation of Fish Act, 1950
					Flood and Drainage Management	Regular Maintenance and Rehabilitation of Interventions	Fish Friendly Infrastructure Development
15	Mohadao Nadi Embankment	FC	1984	1988	Complied	Need to be complied on regular basis	Need to be complied
16	Naluar Haor System	FCDI	1991	1995	Complied	Need to be complied on regular basis	Need to be complied
17	Nautana Khal Scheme	FCD	1985	1991	Complied	Need to be complied on regular basis	Need to be complied
18	Pagner Haor System	FCD	1990	1995	Complied	Need to be complied on regular basis	Need to be complied
19	Re-excavation of Singua River	FCDI	1976	1979	Need to be complied	Need to be complied on regular basis	Need to be complied
20	Sari Goyain Project	FCD	1976	1979	Complied	Need to be complied on regular basis	Need to be complied
21	Shanir Haor System	FCDI	1975	1997	Complied	Need to be complied on regular basis	Need to be complied
22	Surma River System	FCD	1973	1985	Complied	Need to be complied on regular basis	Need to be complied
23	Tangua Haor	FCDI	1990	1995	Need to be complied	Need to be complied on regular basis	Need to be complied
24	Zilkar Haor System	FCD	1989	1990	Complied	Need to be complied on regular basis	Need to be complied
25	Kalikota Haor Project	FCDI	1994	1998	Complied	Need to be complied on regular basis	Need to be complied
26	Chaptir Haor System	FCDI	1995	1998	Complied	Need to be complied on regular basis	Need to be complied
27	Kairdhala-Ratna	FCDI	1997	2006	Complied	Need to be complied on regular basis	Need to be complied
28	Jamkhola Haor	FC	1999	2001	Complied	Need to be complied on regular basis	Need to be complied
29	Updakhali Haor	FCD	2001	2003	Complied	Need to be complied on regular basis	Need to be complied
30	Dhaleswai River	FCD	2005	2006	Complied	Need to be complied on regular basis	Need to be complied

Table 7.4: Compliance Status of Six Projects initiating after 1991 with the applicable Policy, Act and Rules

Sl No.	Name of Policy/Act/Rule	Thematic Issue	**BWDB Scheme** (Implementation period)					
			Kalikota Haor Project (1994-1998)	**Chaptir Haor System** (1995-1998)	**Kairdhala-Ratna** (1997-2006)	**Jamkhola Haor** (1999-2001)	**Updakhali Haor** (2001-2003)	**Dhaleswai River** (2005-2006)
1	The National Water Policy, 1999	Flood and Drainage Management	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied
		Sustainable Use of Surface and Ground Water for Agriculture	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied
		Conservation of Ecosystem and Bio-Diversity	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied
		Preservation and Conservation of Waterbody/Wetlands	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied
2	National Agricultural Policy, 1999	Sustainable Use of Surface and Ground Water for Agriculture	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied
3	The National Fisheries Policy, 1998	Fish Friendly Infrastructure Development	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied	Need to be complied
		Preservation and Conservation of waterbodies/ Wetlands	Not Applicable	Not Applicable	Not Applicable	Need to be complied	Need to be complied	Need to be complied
4	Bangladesh Environment Conservation Act, 1995	Conservation of Ecosystem and Bio-diversity	Not Applicable	Not Applicable	Need to be complied	Need to be complied	Need to be complied	Need to be complied

Sl No.	Name of Policy/Act/Rule	Thematic Issue	**BWDB Scheme** (Implementation period)					
			Kalikota Haor Project (1994-1998)	**Chaptir Haor System** (1995-1998)	**Kairdhala-Ratna** (1997-2006)	**Jamkhola Haor** (1999-2001)	**Updakhali Haor** (2001-2003)	**Dhaleswai River** (2005-2006)
5	The National Environment Policy, 1992	Water Resources Management	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
		Sustainable Land and Water Management	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
		Fish Friendly Infrastructure Development	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
		Preservation and Conservation of waterbodies/ Wetlands	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
6	National Rural Development Policy, 2001	Sustainable Land and Water Management	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied
		Socio-economic Development	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Need to be complied

7.3.2 Compliance Status

Assessment of the compliance status of the 30 projects, as shown in Table 7.3, with the Embankment and Drainage Act, 1952 reveal that, these projects have complied with the directives regarding flood and drainage management by implementing necessary interventions in the project area. Detailed information regarding regular maintenance and rehabilitation of the intervention was not available. Since, maintenance and rehabilitation of interventions should be conducted on a regular basis; the directives in this regard, therefore, should be continued to comply with in future regardless whether such activities have already been carried out or not. The directives of the Protection and Conservation of Fish Act, 1950 regarding development of fish friendly infrastructure need to be complied by all the projects.

The policy directives of the National Water Policy, 1999 is applicable for Updakhali Haor and Dhaleswai River projects only. Its directives regarding the thematic issues “Flood and Drainage Management”, “Sustainable Use of Surface and Ground Water for Agriculture”, “Conservation of Ecosystem and Bio-Diversity and Preservation and Conservation of Waterbody/Wetlands” need to be complied with in these projects. The National Agricultural Policy, 1999 is also applicable for compliance for the above mentioned two projects only and its directives regarding the thematic issue “Sustainable Use of Surface and Ground Water for Agriculture” need to be complied by these projects.

Directives of the National Fisheries Policy, 1998 presented under the thematic issue “Fish Friendly Infrastructure Development” and “Preservation and Conservation of waterbodies/ Wetlands” need to be complied by Jamkhola Haor, Updakhali Haor and Dhaleswari River projects.

Directives of the Bangladesh Environment Conservation Act, 1995; presented under the “Conservation of Ecosystem and Bio-diversity” in Chapter 3; need to be complied by four projects namely Kairdhala-Ratna, Jamkhola Haor, Updakhali Haor and Dhaleswai River. The National Environment Policy, 1992 is applicable for all the six projects which were initiated after 1992. Its directives regarding the issues “Water Resources Management”, “Sustainable Land and Water Management”, “Fish Friendly Infrastructure Development” and “Preservation and Conservation of waterbodies/ Wetlands” need to be complied by six projects in Kalikota Haor, Chaptir Haor System, Kairdhala-Ratna, Jamkhola Haor, Updakhali Haor and Dhaleswai River.

The National Rural Development Policy, 2001 is applicable only for Dhaleswai River Project and its directives regarding “Socio-economic Development” and “Sustainable Land and Water Management” need to be complied by this project.

7.4 Compliance with National Plans and International Conventions

7.4.1 Basis of Compliance

The purpose of assessing the compliance of the projects with the strategies, plans and international conventions is to check whether different components or interventions of the schemes/projects were carried out following the recommendations of these national and international strategies and plan. This assessment will identify the gaps of these projects in this regard and will ultimately facilitate in preparing the mitigation measures through incorporating the aforesaid recommendations. For assessing the compliance, review of the strategies, plans and international conventions has been made first and recommendations which are relevant to the infrastructural development in the Haor Region have been summarized under some thematic issues (Chapter 4). In this section, compliance of the projects with the recommendations of relevant strategies, plans and international conventions has been assessed.

The year of initiation of the projects and the year in which the strategies and plans were launched has played important roles in assessing the compliance of the projects with the recommendations of the strategies and plans. Like policy compliance, compliance of a particular project has been checked with the relevant Strategies and Plans if they were launched prior to the initiation of that project. However, in case of assessing the compliance with international conventions, the year in which Bangladesh has become a member of a particular convention has been considered rather than the year of launching that convention.

7.4.2 Compliance Status

The EWAPDA Master Plan which was launched in 1964 is applicable for assessing the compliance of all the projects except the Humaipur Haor Project as this project was initiated in 1957. The recommendations of the EWAPDA Master Plan, 1964 as described under the thematic issue “Water Resource and Disaster Management” in chapter 3 have been complied with in 29 projects.

There are six projects which were initiated after the year 1993. They are: Chaptir Haor, Kairdhala-Ratna, Kalikota Haor, Jamkhola Haor, Updakhali Haor and Dhaleswai River. Therefore, assessment of compliance of these six projects have only been made with the relevant Strategies, Plans and Conventions which were launched before the year 1993 and their compliance status is presented in Table 7.5.

Compliance of projects on Chaptir Haor, Kairdhala-Ratna, Kalikota Haor, Jamkhola Haor, Updakhali Haor and Dhaleswai River has been checked with the North East Regional Water Management Project (FAP 6), 1993 as this plan was launched before initiation of these six projects. The recommendations of this Plan, as described under the thematic issue “Water Resource and Disaster Management” in Chapter 4, have been complied with in the projects mentioned above.

Table 7.5: Compliance Status with National Plans and International Convention which are applicable for the projects initiating after 1991

SL. No.	BWDB Scheme (Implementation Period)	Name of Plan and Convention with applicable Thematic Issues					
		The National Water Management Plan, 2001	The North East Regional Water Management Project (FAP 6), 1993	The National Environment Management Action Plan, 1995			The Convention on Wetlands of International Importance (Ramsar Convention), 1972*
		Water Resource and Disaster Management	Water Resource and Disaster Management	Water Resource and Disaster Management	Fish Friendly Infrastructure Development	Preservation and conservation of waterbody/ wetlands	Preservation and conservation of waterbody/ wetlands
1	Kalikota Haor Project (1994- 1998)	Not Applicable	Complied	Not Applicable	Not Applicable	Not Applicable	Need to be complied
2	Chaptir Haor System (1995-1998)	Not Applicable	Complied	Not Applicable	Not Applicable	Not Applicable	Need to be complied
3	Kairdhala-Ratna (1997-2006)	Not Applicable	Complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
4	Jamkhola Haor (1999- 2001)	Not Applicable	Complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
5	Updakhali Haor (2001-2003)	Not Applicable	Complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied
6	Dhaleswai River (2005-2006)	Need to be complied	Complied	Need to be complied	Need to be complied	Need to be complied	Need to be complied

**Bangladesh became a member of the convention in 1992*

Recommendations of the National Environment Management Action Plan, 1995 were assessed for only four projects namely Kairdhala Haor Project, Jamkhola Haor Project, Updakhali Haor Project and Dhaleswai River Project as they were initiated after the year 1995. Recommendations of this plan regarding the issues “Water Resource and Disaster Management”, “Fish Friendly Infrastructure Development” and “Preservation and conservation of waterbody/wetlands” need to be complied with. The recommendations of the National Water Management Plan, 2001 is applicable for only one project i.e. Dhaleswai River project since the project was initiated in the year 2005. However, the recommendations of this plan regarding “Water Resource and Disaster Management” need to be complied with.

The Convention on Wetlands of International Importance, called the Ramsar Convention was adopted by the international community in 1972. It is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Bangladesh became a member of the Convention in 1992. Therefore, recommendations of this convention is applicable only for the projects (i.e. Chaptir Haor, Kairdhala-Ratna, Kalikota Haor, Jamkhola Haor, Updakhali Haor and Dhaleswai) which initiated after the year 1992. The recommendation of this conventions, as stated in Chapter 4 under the issue “Preservation and conservation of waterbody/wetlands” need to be complied with.

7.5 Study Observations

Compliance of the projects has been assessed in this chapter with the Policy, Act, Rule, Strategies and Plans which were launched prior to the initiation of the projects. Indication regarding the gaps of these projects in complying with these Policy, Act, Rule, Strategies and Plans has been found from this assessment. This indication will ultimately facilitate the preparation of the necessary mitigation measures for compliance with the directives of the Policy, Act, Rule, Strategies and Plans which were launched prior to the initiation of the projects. Moreover, the directives of the relevant Policy, Act, Rule, Strategies and Plans which have been launched after implementation of the projects should also be addressed while formulating the EMP. Special attention should be given to the directives of the latest Policy, Act, and Rule like the Bangladesh Water Act, 2013; National Land Use Policy, 2001; National Agriculture Policy, 2013; National Forestry Policy, 2016 (draft); KABITA (Cash for Money) Act, 2017; Ecologically Critical Area Management Rules, 2016 and the National Land Use Policy, 2001. Among the recent national plans as well as international plans and conventions special focus should be given for the Sustainable Development Goals 2030; the Haor Master Plan, 2012; the 7th Five Year Plan of the Government of Bangladesh; the Bangladesh Climate Change Strategy and Action Plan, 2009; the National Plan for Disaster Management (2016-2020); the Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (Draft); the Biodiversity Strategy and Action Plan (2016-21) and the National Sustainable Development Strategy (2010-2021). Directives and recommendations of the recent Policy, Act, Rule, Strategies and Plans have already been identified under different thematic issues in Chapter 4 and if needed, these documents can be further reviewed for formulation of the EMP, where required.

Chapter 8: Mitigation Measures

8.1 Introduction

In this section, mitigation measures has been formulated on tha basis of given mitigation and enhancement measures of 30 screened schemes to migitage negative impacts already extered by infrastructural development in those haors.

8.2 Water Resources and Navigation

Existing schemes of BWDB has mainly impacted drainage, sedimentation and pre-monsoon navigation already discussed in Chapter 6. To mitigate these impacts, different mitigation measures have been recommended for each of the screened schemes (Annex 5-Annex 7). On the basis of those recommended mitigation measures a summary of mitigation measures has been outlined, which will not only be beneficial for water resources and navigation, but also for other sectors. Table 8.1 shows summary table of mitigation measures and their respective beneficiary sectors.

Table 8.1: Summary of mitigation measures for water resources and navigation

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
1	Re-excavation of internal Khals and Beels	+++	+		+	++
2	Regular maintenance dredging work in peripheral Rivers	+++	+		++	+
3	Maintain connectivity of inter and intra hydrological network of Haor	++	+	++	+	++
4	Eco-friendly water regulation structures for smooth drainage and navigation	++			++	
5	Review of design crest level of submersible embankments through comprehensive study	++	+	+		++
6	Regular and timely operation and maintenance work	+++	++	+		++
7	Construction of suitable structures over embankment to ensure navigability in pre-monsoon	++		+		+
8	New submersible embankments in required locations	++	+	+		+
9	Awareness raising program against public cuts	++				++
10	Ensure participation of local stakeholders in Haor management	++	+	+		++

(+++ = Very High, ++ = High, + = Moderate)

Following section describes the rationale of measures should be taken for improvement of water resources and navigation for haor area:

Measure 1: Re-excavation of internal Khals and Beels

Internal Khals and Beels inside the haor area should be re-excavated to increase flow carrying capacity and thereby reducing the impact of flooding and drainage. This measure would also facilitate to reduce sedimentation problem. The Khals and Beels should bere-excavated on a need basis.The Noakhali-Joykolosh Khal, Boalia Khal of Baram Haor, internal channels i.e. Rangar Char Khal, Rangpur Khal, Jupkhola Khal, Katakhali Khal, Bara Dair Khal of Kalner Haor, Alamkhali Khal, Boalmara Khal, Jamlabad Khal and Chatorbhuj Khal of Matian Haor, Magura Khal, Kalihari Khal, Shapkhali Khal of Naidar Haor and Birnagar Khal, Gobindasree Khal, Ikrampur Khal, Ahmakkhali Khal, Bogiani Khal, Radhanagar Khal and Beheli Khal of Shanir haor are noteworthy to be re-excavated among visited 30 screened haors. Other than these, re-excavation should perform in regular basis in each of the Khals and Beels, where sedimentation problem is increased and drainage problem is deteriorated.

Measure 2: Regular maintenance dredging work in peripheral Rivers

Usually, increased frequency of flash floods carry huge volume of sediment from upstream along with local erosion. Consequently, river bed increases its height gradually decreasing flow conveyance capacity. Therefore, maintenance dredging work should be done in regular basis to maintain normal flow in different rivers of Haor area and to drain out huge flow of flash floods within short time. All major rivers draining out the floods of haor area like Surma River, Kalni River, Kushiyara River, Baulai River, Kangsha River, Konai River, Dauki River, Sari River, Khowai River, Karanji River, Singua River, Dhalai River, Dhanu River, Narasundar River, Updakhali River etc should be taken under consideration for regular maintenance dredging. The dredging work should be done in a proper way so that the leeves of the rivers do not get eroded.

Measure 3: Maintain connectivity of inter and intra hydrological network of Haor

In many areas, connectivity between rivers and khals, khals and beels becomes lost specially, in pre-monsoon season due to dysfunctional water regulation structures, inlet or outlet. In this contrary, local people frequently do public cut to enter or drain out water. But, it might not be practiced in haor area if it becomes possible to maintain connectivity of inter and intra hydrological network either naturally or by fully functional water regulation structures. Although, public cut is done for navigation purpose. In that case, causeway or other suitable gates can be installed. Therefore, proper slope and connection of local channel with inlet and outlet should be ensured. The estuary of major rivers should always be open for the smooth passage of water to facilitate maintaining connectivity. Some no intervention zone may be delineated to intact ceonnectivity of hydrological network.

Measure 4: Eco-friendly water regulation structures for smooth drainage and navigation

Water regulation structures like sluices, regulators, inlets, outlets, pump house, causeway etc. should be constructed considering environment friendly issues like materials of gates might be changed, provision should be made for fish pass etc. Sometimes, existing structures should be redesigned where needs. Moreover, these structures should be fully operational in all season. These type of structures will facilitate smooth drainage and navigation.

Measure 5: Review of design crest level of submersible embankments through comprehensive study

In recent years, frequency and intensity of flash floods is increased. Flood is reaching its highest peak within very short time. Consequently, peak floods overtops crest level of submersible embankments even if it is in design level. Therefore, it is necessary to review and check design crest level of submersible embankments for every haor through comprehensive study considering surrounding hydrology system of haor. Appropriate return period of crest level should be fixed for designing submersible embankments and rehabilitation of existing schemes should be done accordingly.

Measure 6: Regular and timely operation and maintenance work

There is lack of regular and timely operation and maintenance work in the haor as discussed in different Annex reports of 30 screened schemes. Life and properties of Haor area is suffering a lot due to delayed O&M work in recent years. Therefore, regulators and sluices should be repaired and maintained properly especially the Shaitankhali and Kellai sluice gates in Baram Haor, Katakhali sluice gate in Chandra Sunarthal Haor, Naziapur sluice gate in Chayer Haor, Gujadia Bazar sluice gate in Gazaria Beel, Kagavola sluice gate in Hail Haor, Shympur regulator at Hazida embankment scheme, Regulators at Balanpur and Daudpur in Kalikota Haor, Bongaon and Birampur regulators in Kalner Haor and Bahadia sluice gate surrounding the Singua River. Sedimentation from the bottom of the regulators and sluices should be dredged regularly. The inlet and outlet structure at both upstream and downstream of northern portion of haor region haor system i.e. should be repaired in time as like Alamkhali and Boalmara of Matian haor and Beheli, Barkuri, Ahmakkhali and Bogiani of Shanir Haor. Proper maintenance of pump house should be ensured like in Kawadighi Haor.The construction and repair work of the earthen submersible embankment must be completed within February starting after from mid-December. Adequate fund should be released in time to do O&M within stipulated time. A strong monitoring framework should be formulated to ensure regular and timely O&M work. The local administration should be involved in monitoring the repair work.

Measure 7: Construction of suitable structures over embankment to ensure navigability in pre-monsoon

It is already discussed that, local people do public cuts over earthen submersible embankments to ensure navigability particularly in pre-monsoon season in addition to enter or drain out water according to their necessity in absence of fully functional regulators or sluices. It might not be in practice, because these public cuts facilitate propagation of flash floods within very short time from one haor to another haor and also cause sedimentation problem eroding loose earths of embankments. On the other hand, some provision should be there to ensure navigability in pre-monsoon season. Therefore, some suitable structures like causeway or boat pass can be constructed to ensure navigability in pre-monsoon.

Measure 8: New submersible embankments in required locations

New submersible embankments can be built in required locations after comprehensive feasibility study. According to local people, embankment should be provided on the bank of Chamti River in Chaptir Haor and along the bank of Magura Khal in Naidar Haor. Sometimes, provision of new embankment construction becomes available where old one has been eroded liker Madla and Aynar Gopin Humaipur Haor.

Measure 9: Awareness raising program against public cuts

Awareness raising program should be carried out against public cuts. People should be made aware not to fill the banks of the river for agricultural purpose and also not to make interventions for fish culture.

Measure 10: Ensure participation of local stakeholders in Haor management

Local stakeholders should be engaged in haor management. Representative from local stakeholders may be present in monitoring team of O&M work and also in PIC (Project Implement Committee). Judgment of local stakeholders and fishermen should be taken under consideration. The conflict of fishers and farmers with regard to drainage would be resolved satisfying both sides' needs, if participation of local stakeholders were ensured in Haor management.

8.3 Land and Agriculture Resources

Existing schemes of BWDB has some impacted on land use, cropped area, crop production, crop damage, irrigated area and agro-chemical use already discussed in Chapter 6. To mitigate these impacts, different mitigation measures have been recommended for each of the screened schemes (Annex 5-Annex 7). On the basis of those recommended mitigation measures a summary of mitigation measures have been outlined. Table 8.2 shows summary table of mitigation measures and their respective beneficiary sectors.

Table 8.2: Summary of mitigation measures for land and agriculture resources of haor area

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
1	Strengthen and developed short duration and flood tolerant crop varieties	+	+++	+	+	++
2	Suitable variety selection according to land type	+	+++	+	+	++
3	Strengthening and introducing special system of agricultural practice during monsoon season		+++	+	+	++
4	Regular maintenance of earthen embankment and water control structure	+++	+++	+	+	++
5	Re-excavation of rivers, khals and beels	+++	+++	+++	++	++
6	Encourage to use of organic fertilizers and leguminous crops	+	+++	++	++	++
7	Encourage to use of modern agricultural technology (IPM/ICM/GAP)	+	+++	++	++	++

(+++ = Very High, ++ = High, + = Moderate)

Following section describes the rationale of measures should be taken for improvement of land and agriculture resources for haor area:

Measure 1: Strengthen and developed short duration and flood tolerant crop varieties

In the Haor areas, the transplantation of Boro crops generally delayed due to late recession of flood water. This generally causes delay in transplanting as well as harvesting of crops. Flashflood causes crop damage which is considered as a big threat to the people of Haor areas. Sometimes, the flashflood comes early, just before the rice harvesting and during that time the people of Haor basin, do not even get the time to harvest their crops. In many area of Haor, the Boro crops are damaged due to early flash flood/pre-monsoon flood during Mid April-early May. Most of the HYV rice mature during late April-Mid May. Local farmer switched to cultivate HYV rice (BRRI dhan29) from local Boro rice variety. BRRI dhan29 takes about 30 days more time to harvest compared to other varieties. If the growing periods could be shortened by 15 to 30 days, the maturity day would come before Mid April. The BRRI and BINA has already been released different short duration HYV and Hybrid varieties. These crop varieties should be available to the farmers through strengthening agriculture extension services such as ensure quality seed, training, field demonstrations etc.

The research should be focused to develop early varieties rice (harvest before Mid-Apri). Sometimes, the normal growth and development of the plant suffers due to the climate (coldness). The cold weather ($<18^0$C) causes false grain in the panicles. So, research should be concentrated to develop short duration, cold tolerant but high yielding rice variety which is found suitable in the cultivation of Boro season in Haor basin areas. The Scientists of BRRI, BINA and other Institute would be involved for development of short duration, cold tolerant high yielding rice cultivars which can be grown in Boro season in Haor basin areas.

Measure 2: Suitable variety selection according to land type

Due to late recession of flood water and short height of High Yielding Variety (HYV), cultivation are not possible in the deeper part of Haor areas (low land and very low land). In most of the time crop in lower part of Haor areas is damaged due to heavy rainfall. But height of local varieties are normally long than that of HYV. So local variety should be cultivated in the deeper part of the Haor areas.

Measure 3: Introducing and strengthening special system of agricultural practice during monsoon season

A vast area of Haor region is submerged under water during kharif season. To overcome this situation hydroponics or floating bed vegetables cultivation should be introduced and strengthened. This technology is still new in many areas of Haor. So awareness should be built up through both government and local NGOs to strengthening this technology. Besides this, kanda could be used for vegetable cultivation during rabi and pre-kharif season to increase the overall productivity and income of farmers.

Measure 4: Regular maintenance of earthen embankment and water control structure

Height of the earthen embankments should be improved as per design level. Due to siltation, erosion and lack of maintenance height of these embankments decreased day by day. It has been observed from the field visit most of the embankments are 3-6 feet less than their design height. Among them, by constructing and maintaining these, a significant amount of Boro rice could be saved from early flash flood.

Measure 5: Re-excavation of rivers, khals and beels

High yielding varieties and Hybrid varieties are very much used to increase productivity in Haor areas. But water requirement of these varieties are very high. So, irrigation is becoming a new concern in Haor areas. Besides this, most of the rivers, khals and beels are already silted up. As a result, water carrying capacity is decreased day by day. For ensuring irrigation water, regular re-excavation work should be carried out.

Measure 6: Encourage to use of organic fertilizers and leguminous crops

Fertilizer requirement of high yielding and hybrid varieties are very high. To support these crops over use of chemical fertilization is a common practice in Haor areas. Farmers use same fertilizers for over the years, which ultimately reduce the soil health. So, fertilizer demand is increasing day by day. To overcome this problem, organic fertilization and cultivation of leguminous crop could be an option. Organic fertilizers not only supply nutrients to the crops but also help to improve soil health. On the hand, leguminous crops are not suitable in deeper part of the Haor area. However, in upper part of the Haor areas leguminous crops might be cultivated before transplanting Boro crop which are very helpful for atmospheric nitrogen fixation, chemical requirement of these crops are also less.

Measure 7: Encourage to use of modern agricultural technology (IPM/ICM/GAP)

HYV/Hybrid crop cultivation is agro-chemical intensive. The uses of agro-chemicals (both granular and liquid pesticides) increasing day by day in the Hoar areas. Fertility of the soil decreases due to over /indiscriminate use of agro-chemicals. It is very alarming for the Haor region. For the sustainable agriculture in the Haor region, it is very much necessary to practicing Integrated Pest Management (IPM)/Integrated Crop Management (ICM)/Good Agriculture Practices (GAP). By the practicing of IPM/ICM/GAP techniques restore the fertility of the soil, which ultimately increase the fertility of the soil. Therefore, farmers should be trained on modern agricultural technology (IPM/ICM/GAP).

8.4 Fisheries Resources

Measures for fisheries resources is given below in Table 8.3 and described in following sections:

Table 8.3: Summary of mitigation measures for fisheries resources of haor area

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
1	River Dredging	+++	++	+++	+++	++
2	Re-excavation of internal Khals	++	++	++	++	+
3	Fish friendly water control structures	+		+++	+++	++
4	Re-excavation of Beels	+++	++	+++	++	+
5	Beel Sanctuary	++		+++	+++	+
6	Beel Nursery Program	+		+++	+++	+
7	Ban unconventional fishing appliances			++	++	+
8	Optimum use of agrochemicals and pesticides and fertilizer			++	++	+
9	Stop discharging of untreated industrial effluent	++	++	++	++	++
10	Community based fisheries			+++	+++	++

(+++ = Very High, ++ = High, + = Moderate)

Measures 1: River dredging in regular basis

It improves water condition of the river and the natural connectivity of the river and haor system. Creation of more water room, thereby, would facilitate dry season refuge areas of bigger fishes. It would increase recruitment potential and facilitate the longitudinal migration. It results in facilitating species diversity, composition and distribution.

Measures 2: Re-excavation of internal Khals

It improves water condition of the river and the natural connectivity of the river and haor system. Creation of more water room, thereby, would facilitate dry season refuge areas of bigger fishes. It would increase recruitment potential and facilitate the lateral migration. It results in facilitating species diversity, composition and distribution. Retaining of water in the canal might facilitate canal fishery and recruitment to Beel.

Measures 3: Fish friendly water control structures

This type of structures would highly be beneficial for lateral migration of fish. Consequently, it would improve fish movement around the haor areas resulting in increasing fish diversity and their composition and distribution. Catch susceptibility would become higher which might improve the fish production.

Measures 5: Re-excavation of Beels

Creation of more water room would facilitate dry season refuge areas of bigger fishes and increase recruitment potential. Species diversity might be facilitated.

Measures 6: Beel Sanctuary

Beel sanctuary is important to protect and conserve aquatic biodiversity especially the fisheries resources in open water. The major purposes are as follows:

- Creating opportunities for unobstructed growing up of the brood fish for continuing sustainable fisheries production and maintaining aquatic and avian biodiversity in open water bodies through stock enhancement and development;
- Controlling size and species wise fishing for ascertaining reproduction through fish spawning;
- Conserving and managing water bodies or parts of water bodies for safe habitats for fish;
- Restoring the ecosystem through creating favorable aquatic environment; and
- Creating opportunity for the conservation of fisheries resources through community based management approach.

Measures 7: Beel Nursery Program

Beel nursery is a good and fruitful way of increasing biodiversity and production of pure strain and native fish species through recruitment in the adjacent waterbodies during the monsoon. Increasing the abundances of the carp fishery along with endangered species of fish in the natural waterbodies of the country has been emphasizing through releasing quality fries/fingerlings of different fish species.

Measures 8: Ban unconventional fishing appliances

It is important to ban unconventional fishing appliances at the water control structures. It would facilitate lateral fish migration and free recruitment into the haor system. In this regard, Fisheries Policy, 1998 is applicable for refraining from the use of unconventional illegal fishing appliances.

Measures 9: Optimum use of agrochemicals and pesticides and fertilizer and stop discharging of untreated industrial effluent

It would decrease the possibility to bio-accumulation of different trace elements in different beel resident fish species. It would result in increasing diversity of beel fisheries.

Measures 10: Community based fisheries

Community based fisheries management is aimed to promote environmentally sound management of wetland resources (fish, aquatic vegetation, other wetland products and water) for the sustainable supply of food to the poor people of Bangladesh.

8.5 Ecological Resources

Conservation of natural vegetation, banning encroachment of wetland and reedland/swamp forest, optimum uses of pesticides are the major mitigation measures for minimize the impacts on ecological resources inhaor areas. In addition to this, proper landuse planning, plantation, eco-friendly tourism, commercial snail production and plant nursery rising are the additional enhancement measures to keep sustainability of the haor ecosystems and enhancing all kinds of ecosystems services.

Table 8.4: Summary of mitigation measures for ecological resources of haor area

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
1	Conserve natural vegetation in fallow land, reedland and swamp forests			+	++	
2	Identify the core habitat for the threatened animals and take action to conserve the respective habitats			+	+	
3	Demark every beel's perennial boundaries and enforce law and order to ban agricultural extension and ban fully drying of wetland for fish catch			++	++	
4	Ban leasing or allotment systems for all the khash land with swamp forest and reedlands			+	+	
5	People awareness for wildlife conservation and optimum use of pesticides and fertilizers			++	++	
6	Implement Plantation programme along the river levees, embankment slopes, kandas and other khash lands with the attachment of plant specialist and involve local people for nursery raising				+	
7	Introduction of Eco friendly tourism according the relevant policy and laws			+	+	+

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
8	Initiate commercial production of freshwater snails for meeting up duck feeds			+	+	+
9	Implement proper landuse planning including natural vegetation and wildlife conservation provision			+	+++	
10	Consider design level for keeping minimum water depth inside beels and connecting khals throughout the year			++	++	
11	Consider structure design to ensure better movement of snail and other fishes			+	+	
12	Involvement of Forest Department for conserving every swamp forest				+	

(+++ = Very High, ++ = High, + = Moderate)

Details of measures and benefitted sector are described in below sections

Measure 1: Conserve natural vegetation

Fallow land, reedland and swamp forests consists natural vegetation in haor area supports numerous terrestrial wildlife and provide resting habitats for migratory birds. This natural vegetation is reducing day by day for agricultural expansion, use as fuelwood and other human interventions over the time. So, it is need to take initiatives against destruction of fallow land, reed beds and swamp forest to keep natural vegetation as well as fostering wildlife.

Measure 2: Identification of core habitats for wildlife aquatic fauna

Consequential destruction of natural vegetation threats on wild fauna and caused relocation them and habitat vulnerability all over the country. Still now, haor areas have many core habitats (i.e. perennial beels, ditches, swamp forest, reedbeds and foothills) for various wild animals. These habitats can be identified properly; assess species composition and abundance of wild fauna at there and apply proper management plan for conserve nature.

Measure 3: Demarcation of perennial beel boundaries and enforce law and order for illegal encroachment and fully drying of beel area

Beels are the core habitats for indigenous fishes, water birds and various aquatic animals for round the year which are now squeezing for agricultural expansion. Beels provide many Provisioning, regulating and supporting services through its resources like fisheries, hydrophytes and water. In haor area, beels act as last destination of fishes and gene bank of aquatic flora. People are tending to expand cultivation till to water margins of a beel and seasonally dewatered for maximum fish catch in winter. So, it is urgently needed to demarked beel area and Government actions to protect illegal encroachments and avoided fully drying.

Measure 4: Ban leasing or allotment systems for all the khash land with swamp forest and reedlands

Leasing and government allotments of vegetated khash land are causing natural vegetation damage and wildlife habitat destruction due to over exploration of vegetation. Besides, allotment of khash land triggers crop cultivation and human habitation. So, government leasing and allotment system of khash land inside haor area should be banned.

Measure 5: Increase people awareness for nature conservation

Indiscriminate use of pesticides, herbicides and fertilizers caused population depletion of amphibians, reptiles and fishes. Haor inhabitants are not aware to optimum use of these agricultural additives. So, awareness programme would be reduce excess pesticides application and consist good habitats for all wild fauna.

Measure 6: Implementation of plantation programme and involve local people for nursery raising

Plantation is a major way for enhance vegetation coverage. This activity can be makeup habitat loss of wild fauna. *Kandas*, fallow lands, river levees, beel margins and submergible embankment of each haor can be used as plantation area. Besides, local people can involve in nursery raising for meetup the sapling demand for plantation programme as well as create opportunity for additional livelihood.

Measure 7: Introduce Eco-friendly tourism

Haor area has vast opportunities for tourism development. Number of tourists has been increased cumulatively from last decade. Although there is no remarkable negative impacts due to tourism in haor area, but it is suspected to disturb migratory birds and damage aquatic vegetation in future due to excess tourist movements. Hence, tourism in haor area can be allowed considering zero disturbances to wild fauna and no damage of natural vegetation.

Measure 8: Initiate commercial cultivation of freshwater snails

Commercial duck rearing is common livelihood in haor area and freshwater snails are the staple feed for the duck. It caused severe population depletion of snails. This mollusk have important roles in aquatic ecosystems through contributing fish feeds, water purification and enriched soil nutrient by dead calcareous shell. Commercial cultivation of freshwater snails can meetup huge demand of duck feed, creates livelihood opportunities and lessens the snail population vulnerability in natural habitats.

Measure 9: Implement proper landuse planning

Unplanned use of lands caused habitat degradation and deterioration of population of wild flora and fauna. The haor ecosystems facing vulnerability due to agricultural expansion, agrochemicals use and landuse conversions. These threats can be minimized through proper landuse planning including natural vegetation and wildlife conservation provision.

Measure 10: Consider design level for keeping minimum water depth in khals and beels

Khals and beels are the major perennial waterbodies in haor area. Although a large numbers of these wetlands loss their depthsdue to siltation over the time and re-excavation is needed to revive its actual performance for drainage improvement and irrigation. At the planning phase of re-excavation, keeping provision of minimum depth throughout the year to sustain dweller faunal communities and vegetation.

Measure 11: Consider structure design to ensure better movement of snail and other fishes

Water control structures create barrier for easy movement of aquatic creatures from river to haor basin to river. Provision of fish and snail passin sluice gates can be beneficial to breeding and feeding purpose of these animals. Thus this issue should be considered during structure design.

Measure 12: Involvement of Forest Department for conserving every swamp forest

Most of the haor area, swamp forests are scatter distributed and have no management system. Swamp forested lands are reducing day by day due to agricultural expansion, illegal encroachment and over exploration. It would be better if Forest Department can take management responsibilities for conserving swamp forest.

8.6 Socio-economic Resources

Mitigation measures have been suggested for reducing the negative impact, risks and vulnerabilities of the Haor people. Besides, some enhancement measures (see the annexure) in terms of livelihood, employment, labor and seasonal migration have been suggested bringing a change and providing sustainable solution for the overall socio economic benefits in the coming future.

Table 8.5: Summary of mitigation measure for socio-economic resources of haor area

Sl. No.	Measures	Benefitted Sector				
		Water	Agriculture	Fisheries	Ecosystem	Social
1	A functional PIC and monitoring should be formed and play proactive role considering the all stakeholders concern for O&M in the Haor region	+	+	+		++
2	Local People's feedback should be taken before the implementation of any policy, plan and program in the Haor regions	+	+	+		++
3	Alternative training and soft loan would be provided to enhance resilience for the development of entrepreneurship.					++

(+++ = Very High, ++ = High, + = Moderate)

Measures 1: A functional PIC and monitoring should be formed and play proactive role considering the all stakeholders concern for O&M in the Haor region

A functional PIC would be involved to understand the demand of people and develop strategy for the maintenance of embankments with the cost effective solution. The completion of work would be smooth and helped to protect the people's livelihoods, safety and security through the proactive role and participatory activities of all PIC members in the Haor region.

Measures 2: Local People's feedback should be taken before the implementation of any policy, plan and program in the Haor regions

The experience of people would be incorporated with their feedback that can be very helpful to ensure sustainable planning and programs for the Haor regions. The effective solutions would be come with the feedback that can be considered to make the Haor base planning and programs more successful before the project implementation.

Measures 3: Alternative training and soft loan would be provided to enhance resilience for the development of entrepreneurship

The risks of livelihood will be mitigated in which people can enhance resilience and take initiatives for the income generation through entrepreneurship development and alternative livelihood options. The livelihood security would be ensured and made a way for its sustainability due to climatic hazards like heavy flash flood, seasonality change and unusual rain etc.

References

ACR (1950), Protection and Conservation of Fish Act, (1950), East Bengal Act No. XVIII of 1950; Department of Agriculture Co-operation and Relief, Government of East Bengal.

BP (2017), Bangladesh Biodiversity Act, 2017, Bangladesh National Parliament, Government of the People's Republic of Bangladesh, Dhaka 1207.

DoE (2016), Biodiversity Strategy and Action Plan (2016-21), Department of Environment, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1207.

EPWAPDA (1953), East Bengal Embankment and Drainage Act, 1952, (E.B. Act No. I of 1953); East Pakistan Water and Power Development Authority Ordinance; Former EPWAPDA.

EPWAPDA (1964), East Pakistan Water and Power Development Authority Master Plan, Former EPWAPDA.

FAP (1993), Northeast Regional Water Management Plan, Bangladesh Flood Action Plan 6 (IEE NERP FAP 6), Government of the People's Republic of Bangladesh, Dhaka 1212

GED (2015), 7th Five Year Plan (2016-2020), General Economics Division (GED), Bangladesh Planning Commission, Government of the People's Republic of Bangladesh, Dhaka 1207.

MoA (1999a), National Agriculture Policy, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoA (1999b), National Agriculture Policy, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoA (2013), National Agriculture Policy, Ministry of Agriculture, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoDMR (2017), National Plan for Disaster Management (2016-2020), Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (1992) National Environment Policy, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (1994), National Forestry Policy, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (1995a), Bangladesh Environment Conservation Act, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (1995b), National Environment Management Action Plan, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (1997), Environmental Conservation Rules, Ministry of Environment and Forestry, Government of the People's Republic of Bangladesh, Dhaka 1212.

MoEF (2009), Bangladesh Climate Change Strategy and Action Plan, Ministry of Environment and Forestry, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoEF (2016a), Ecologically Critical Area Management Rules, Ministry of Environment and Forestry, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoEF (2016b), National Conservation Strategy (2016-31), Ministry of Environment and Forestry, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoEF (2016c), National Forestry Policy (draft), Ministry of Environment and Forestry, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoEF (2016d), The Bangladesh Environment, Forestry, Climate Change Country Investment Plan, The Ministry of Environment and Forests, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoFL (1998), National Fisheries Policy, Ministry of Fisheries and Livestock, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoL (2001), National Land Use Policy, Ministry of Land, Government of People's Republic of Bangladesh, Dhaka 1212.

MoL (2009), National Jalmohal Management Policy, Ministry of Land, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MPHA (2012), Master Plan of Haor Area (Vol II), Department of Bangladesh Haor and Wetlands Development, Ministry of Water Resources, Government of the People’s Republic of Bangladesh, Dhaka 1215. 260pp.

MoWR (1999), National Water Policy, Ministry of Water Resources, Government of the People’s Republic of Bangladesh, Dhaka 1212.

MoWR (2012), Bangladesh Delta Plan 2100, Ministry of Water Resources, Government of the People’s Republic of Bangladesh, Dhaka 1212.

PCB (2013), National Sustainable Development Strategy (2010-2021), Planning Commission, Government of the People’s Republic of Bangladesh, Dhaka 1207.

RDCD (2001), National Rural Development Policy, Rural Development and Cooperatives Division, Government of the People’s Republic of Bangladesh, Dhaka 1212.

UN (1992), Convention on Biological Diversity, United Nations, USA.

UN (2016), Sustainable Development Goals, United Nations, USA.

UNESCO (1971), The Convention on Wetlands of International Importance especially as Waterfowl Habitat. Ramsar (Iran), 2 February 1971. UN Treaty Series No. 14583. As amended by the Paris Protocol, 3 December 1982, and Regina Amendments, 28 May 1987.

WARPO (2001), National Water Management Plan (NWMP), Water Resources Planning Organization, Ministry of Water Resources, Government of the People’s Republic of Bangladesh, Dhaka 1215.

WARPO (2013), Bangladesh Water Act, Water Resources Planning Organization, Ministry of Water Resources, Government of the People's Republic of Bangladesh, Dhaka 1215.

WARPO (2017), Bangladesh Water Rule (Draft), Water Resources Planning Organization, Ministry of Water Resources, Government of the People's Republic of Bangladesh, Dhaka 1215.

Annex 1: List of Screened Schemes

Table A1-1: Screened BWDB Schemes

SL. No.	Projects	Water System	Haor Type	Project Type	District	Project Area (ha)	Project Completion Year
1	Haizda Embankment Sub-Project	Surma-Kushiyara System	Deeply Flooded	FCD	Netrakona	16019	1992
2	Jamkhola Haor Sub-Project	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	2108	2001
3	Pagner Haor System	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	17020	1995
4	Naluar Haor System	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	12859	1995
5	Matian Haor System	Meghalaya System	Deeply Flooded	FCD	Sunamganj	5490	1988
6	Kairdhala-Ratna FCDI Project	Surma-Kushiyara System	Deeply Flooded	FCDI	Habiganj	11900	2006
7	Kalikota Haor Project	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	17799	1998
8	Tangua Haor System	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	4528	1995
9	Baram Haor System	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	5069	1993
10	Chaptir Haor System	Surma-Kushiyara System	Deeply Flooded	FCD	Sunamganj	5065	1998
11	Chayer Haor	Surma-Kushiyara System	Deeply Flooded	FCD	Kishoreganj, Netrokona	8498	
12	Shanir Haor System	Meghalaya System	Deeply Flooded	FCD	Sunamganj	8164	1997
13	Humaipur Haor Project	Upper Meghna System	Deeply Flooded	FCD	Kishoreganj	5224	1986
14	Chandra Sunarthal Haor System	Surma-Baulai System	Deeply Flooded	FCD	Sunamganj	6334	1978
15	Halir Haor System	Meghalaya System	Deeply Flooded	FCD	Sunamganj	8774	1988
16	Nautana Khal Scheme	Surma-Baulai System	Deeply Flooded	FC	Netrakona	3523	1991

SL. No.	Projects	Water System	Haor Type	Project Type	District	Project Area (ha)	Project Completion Year
17	Mohadeo Nadi Embankment	Meghalaya System	Flood Plain	FC	Netrakona	4299	1988
18	Surma River System	Barak System	Flood Plain	FCD	Sylhet	38142	1985
19	Re-excavation of Singua River	Old-brahmaputra System	Flood Plain	FCDI	Kishoreganj	15545	1979
20	Zilkar Haor System	Surma-Kushiyara System	Flood Plain	FCD	Sylhet	4344	1990
21	Kawadighi Haor	Surma-Kushiyara System	Flood Plain	FCD	Sylhet, Maulvibazar	11169	1996
22	Bara Haor System	Surma-Kushiyara System	Flood Plain	FCD	Sylhet	15887	
23	Updakhali Project	Meghalaya System	Flood Plain	FCD	Netrakona	8005	2003
24	Gozaria Beel Project	Surma-Kushiyara System	Flood Plain	FCD	Kishoreganj	3157	1986
25	Sari Goyain Project	Meghalaya System	Foot Hill	FCDI	Sylhet	2395	1979
26	Hail Haor Project	Tripura System	Foot Hill	FCD	Moulvibazar	21635	1989
27	Kalner Haor System	Meghalaya System	Foot Hill	FCD	Sunamganj	7341	1987
28	Dhaleswari River System	Meghalaya System	Foot Hill	FCD	Sylhet	1443	2006
29	Gangajuri FCD Project	Tripura System	Foot Hill	FCD	Habiganj	20441	1993
30	Naidar Haor	Meghalaya System	Foot Hill	FCD	Sunamganj	9335	

Annex 2: List of Reviewed Policies, Acts, Rules, Strategy and Plans

List of Policy Reviewed

- National Water Policy, 1999
- National Environmental Policy, 1992
- National Agriculture Policy, 1999
- National Agriculture Policy, 2013
- National Forestry Policy, 1994 & 2016 (draft)
- National Jalmohal Management Policy, 2009
- National Land Use Policy, 2001
- National Rural Development Policy, 2001

List of Act and Rules Reviewed

- Bangladesh Water Act, 2013
- Bangladesh Biodiversity Act, 2017
- KABITA (Cash for Money) Act, 2017
- Bangladesh Environment Conservation Act, 1995
- The Protection and Conservation of Fish Act, 1950
- Wildlife (Conservation and Security) Act, 2012
- Embankment and Drainage Act, 1952
- Bangladesh Water Rule, 2017 (Draft)
- Environmental Conservation Rules, 1997
- Ecologically Critical Area Management Rules, 2016

List of Strategy and Plans Reviewed

- 7th Five Year Plan (2016-2020), 2016
- Bangladesh Delta Plan 2100 (draft)
- Haor Master Plan, 2012
- National Sustainable Development Strategy (2010-2021)
- Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (Draft)
- Bangladesh National Conservation Strategy, 2016-31
- Biodiversity Strategy and Action Plan, 2016-21
- Bangladesh Climate Change Strategy and Action Plan, 2009
- EPWAPDA Master Plan, 1964
- National Environment Management Action Plan, 1995

List of International Convention Reviewed

- Ramsar Convention, 1992
- Convention on Biological Diversity, 1992
- Sustainable Development Goals (2016-2030), 2016

Table A2-1: Name and Number of Policies, Acts and Rules which are applicable for assessing the compliance

Sl No.	BWDB Scheme	Scheme Type	Year of Start	Year of End	No. of Policy/Act/Rule Applicable	Name of Policy/Act/Rule Applicable
1	Bara Haor System	FCD	Information Not Available		At least 2	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950
2	Chayer Haor	FCD			At least 2	
3	Naidar Haor	FCD			At least 2	
4	Baram Haor System	FCD	1987	1993	2	
5	Chandra Sunarthal Haor System	FCD	1974	1978	2	
6	Gangajuri FCD Sub-Project	FCD	1986	1993	2	
7	Gozaria Beel Project	FCDI	1984	1986	2	
8	Haijda Embankment Sub-Project	FCD	1981	1989	2	
9	Hail Haor Project	FCD	1982	1992	2	
10	Halir Haor System	FCD	1964	1988	2	
11	Humaipur Haor Project	FCDI	1957	1986	2	
12	Kalner Haor System	FCDI	1979	1987	2	
13	Kawadighi Haor	FCD	1975	1996	2	
14	Matian Haor System	FCDI	1977	1988	2	
15	Mohadao Nadi Embankment	FC	1984	1988	2	
16	Naluar Haor System	FCDI	1991	1995	2	
17	Nautana Khal Scheme	FCD	1985	1991	2	
18	Pagner Haor System	FCD	1990	1995	2	

Sl No.	BWDB Scheme	Scheme Type	Year of Start	Year of End	No. of Policy/Act/Rule Applicable	Name of Policy/Act/Rule Applicable
19	Re-excavation of Singua River	FCDI	1976	1979	2	
20	Sari Goyain Project	FCD	1976	1979	2	
21	Shanir Haor System	FCDI	1975	1997	2	
22	Surma River System	FCD	1973	1985	2	
23	Tangua Haor	FCDI	1990	1995	2	
24	Zilkar Haor System	FCD	1989	1990	2	
25	Kalikota Haor Project	FCDI	1994	1998	3	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Environment Policy, 1992
26	Chaptir Haor System	FCDI	1995	1998	3	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Environment Policy, 1992
27	Kairdhala-Ratna	FCDI	1997	2006	4	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Environment Policy, 1992 • Bangladesh Environment Conservation Act, 1995
28	Jamkhola Haor	FC	1999	2001	5	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Environment Policy, 1992 • Bangladesh Environment Conservation Act, 1995

Sl No.	BWDB Scheme	Scheme Type	Year of Start	Year of End	No. of Policy/Act/Rule Applicable	Name of Policy/Act/Rule Applicable
						• The National Fisheries Policy, 1998
29	Updakhali Haor	FCD	2001	2003	7	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Water Policy, 1999 • National Agricultural Policy, 1999 • The National Fisheries Policy, 1998 • Bangladesh Environment Conservation Act, 1995 • The National Environment Policy, 1992
30	Dhaleswai River	FCD	2005	2006	8	• The Embankment and Drainage Act, 1952 • The Protection and Conservation of Fish Act, 1950 • The National Water Policy, 1999 • National Agricultural Policy, 1999 • The National Fisheries Policy, 1998 • Bangladesh Environment Conservation Act, 1995 • The National Environment Policy, 1992 • National Rural Development Policy, 2001

Annex 3: Meeting Minutes of Local Workshops

For environmental auditing as well as impact assessment of structural interventions in haor ecosystem, perceptions of local stakeholders is very important tool to measure and validate our findings of the study which are also based on participoatory approach. In this regard, several local workshops were held at 14 selected upazilla premises of Sunamganj, Sylhet, Moulavibazar, Habiganj, Netrokona, Mymensingh and Kishoreganj District from 3 December 2017 to 7 December 2017. Based on the prepared checklist, all concern stakeholders from respective Upazilla administrations, LGI representatives, and community representatives delivered their feedbacks on the impacts of existing structures like submergible embankments, sluice gates, flood protection embankments, roads, culverts, dredging and any other intervention in the Haor regions.

The Upazilla Nirbahi officer (UNO) of the respective upazillas presided over the workshops with the presence of upazilla chairman as the Chief Guest. The Director General of Bangladesh Haor and Wetlands Department (DBHWD) attended in some workshops and delivered his speech on the respective issues of workshop objectives. The Project Director also visited some workshops and take feedbacks of local stakeholders. The participation of both primary and secondary stakeholders was remarkable and provided insights on existing structure’s impact as a whole.

Figure A3-1 to Figure A3-5 show the representation of feedbacks from around 350 participants who were directly participated in quiestionnaire survey on various indicators of five sectors i.e. water resources and navigation, land and agriculture resources, fisheries resources, ecological resources and socio-ecoomic resources. Figure A3-1 illustrates that 80% respondant has expressed their concern that flooding situation has beomce worse than before in consideration of recent years flooding. Participants also expressed that drainage and navigation has been deteriorated but appreciable dredging activities has reduced sedimentation problems in recent years.

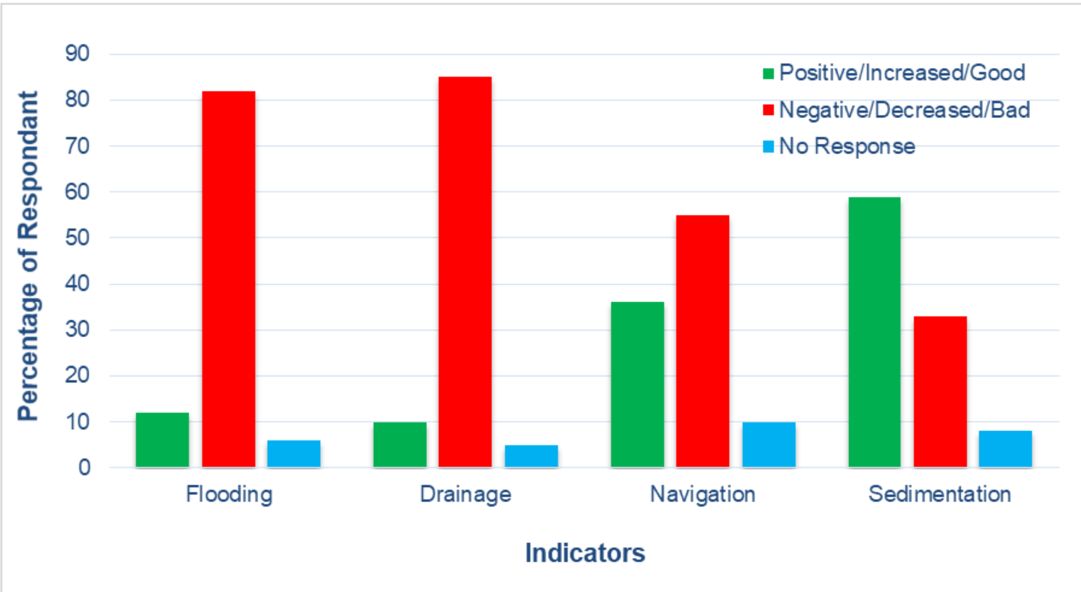


Figure A3-1: Response of local stakeholders on water resources and navigation

Figure A3-2 shows that maximum respondant has voted that beel area, cultivable land and irrigation water availability have been decreased than before due to different structural interventions and agriculture expansion. Consequently, reflections has been found in Figure A3-2 that crop production has been increased although crop damage and use of agro-chemicals has been increased.

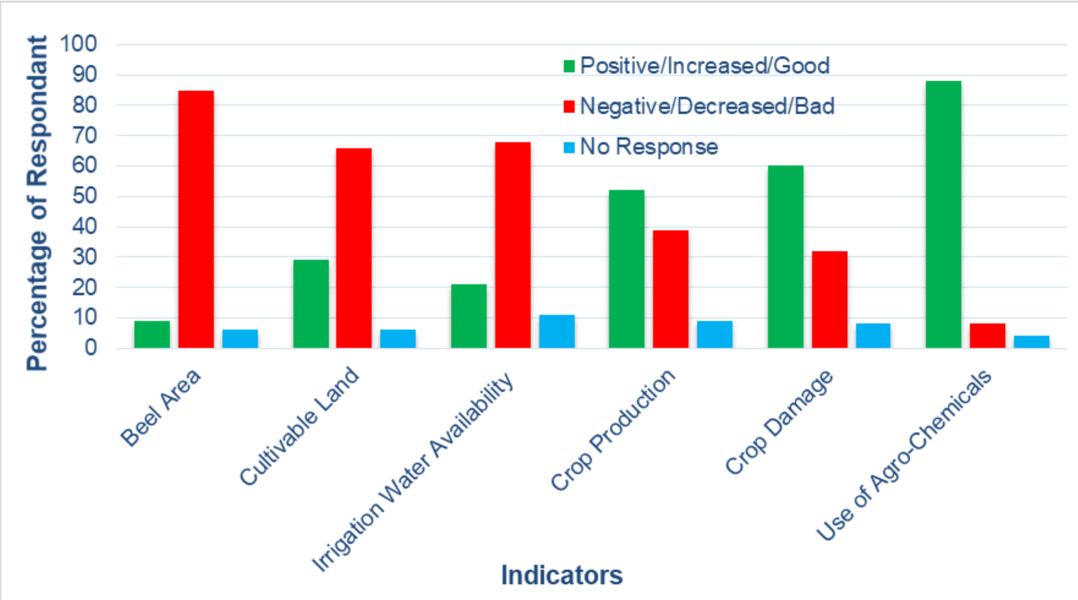


Figure A3-2: Response of local stakeholders on land and agriculture resources

Figure A3-3 illustrates overall negative response for different indicators of fisheries sectors like fish production has been decreased in recent years as per local stakeholders response, fish diversity has been reduced, fish habitat condition has been deteriorated, fish migration has been increased, use of unconventional net has been increased due to structural interventions. According to their reponse, number of professional fisheres has been reduced. Problem in fisheires management has been increased due to fragmented managment system.

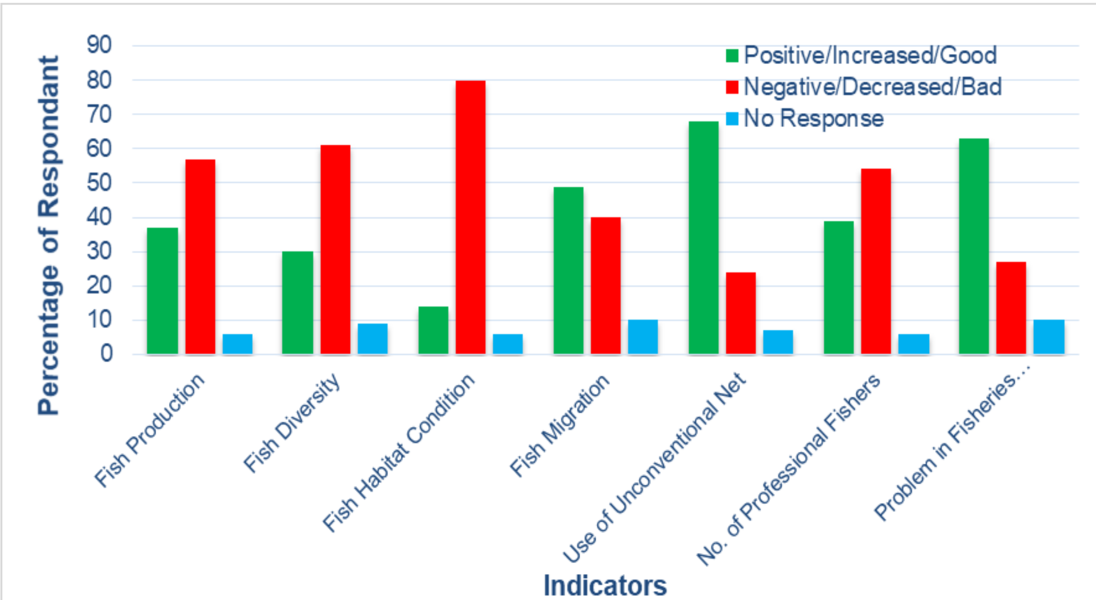


Figure A3-3: Response of local stakeholders on fisheries resources

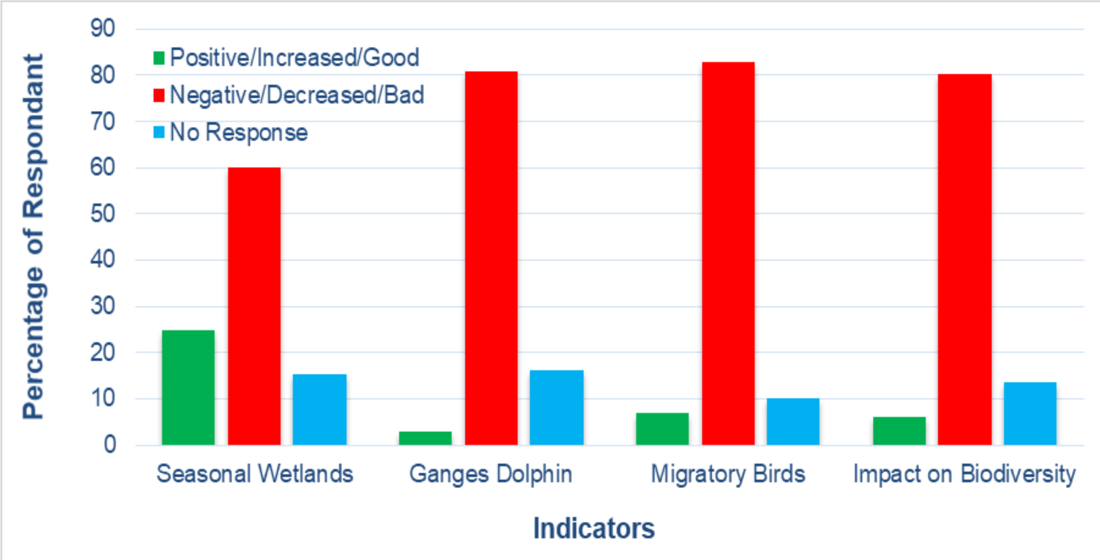


Figure A3-4: Response of local stakeholders on ecological resources

Figure A3-4 depicts reflection of serious negative impacts in ecological resources according to most of the respondant. However, overall socio-economic scenario has been schanged positively due to structural interventions in haor ecosystem as reflected in local stakeholder's feedback in Figure A3-5. Overall livelihood status has been improved, employment opportunities has been created, health and eductation services have been improved and communication has been improved according to local stakeholder's perceptions. However, they have shown their concern about poor institution and governance.

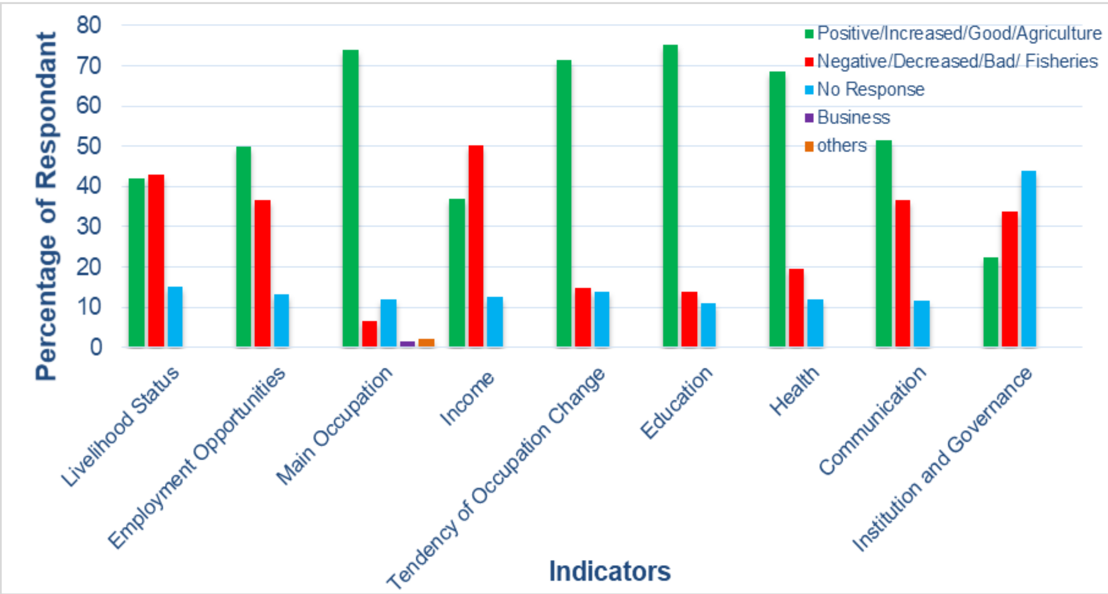


Figure A3-5: Response of local stakeholders on socio-economic resources

Overall findings of these 14 local workshops validate our study findings almost. In some cases, perceptions of local stakeholders have been deviated from our findings because of emphasizing on recent years occurence more.

In terms of environmental auditing following statements and suggestions came from the workshops to mitigate negative impacts and enhance positive impacts.

Water Resources and Navigation

- River should be dredged and internal khals should be re-excavated properly in regular basis for smooth drainage and improved navigation
- Existing earthen dam should be repaired in time
- Survey the entire area and construct dam where necessary
- Flyover might be constructed instead of soil road
- Haor bed should be dredged where sedimentation rate is high
- Bridge culvert should be constructed at a proper design level in order to facilitate water drainage
- The water drainage path should be maintained and road should be constructed without disturbing the drainage and haor or beels
- Available water resources should be used wisely and properly
- Awareness raising program should be taken among people
- The development works should be distributed to each of the representative government organizations
- Water velocity and flow pattern should be monitored
- River, khal, beel should be free from illegal grabber
- Measure should be taken for permanent solution of flood and water logging

Land, Agriculture & Livestock Resources

- Flood related precautions should be taken by the locals to reduce loss of crop production, where the local government should provide necessary tools to the people
- Measures should be taken to increase the amount of agricultural land and to facilitate irrigation water for crop cultivation
- Conduct meeting with local representative and agricultural in-charge and discuss the problems
- Intensive irrigation management should be started
- Natural water bodies should be preserved
- Encourage people for animal husbandry
- Encourage people for using bio fertilizer
- Construct a water reservoir to facilitate irrigation water availability
- Cropping pattern should be changed like farmers should focus on cultivation of Aush and Aman instead of boro or on other various types of crops
- Focus on hybrid crops production
- Respective authority should be careful during land acquisition for construction of infrastructure
- Implementation agencies should follow proper guideline during construction of structures
- Land fertility should be maintained and increased by using fertilizer
- Technological advancement as well as mechanization should be introduced in agricultural field for better crop production
- Decreasing the use of pesticides
- Agricultural land should be increased according to proper planning
- Grab of Khas land should be stopped
- Conservation of agricultural land
- Animal husbandry should be promoted for alternative employment

- Organize training for local people of haor in a planned way.

Fisheries Resources

- Internal Khals and Beels should be re-excavated in regular basis
- Measures should be taken to stop illegal fishing
- Fisheries office should take necessary steps to preserve fish
- Suitable place for fish processing should be constructed
- Uses of unconventional net should strictly prohibited and law should be imposed on using illegal net
- Proper timeframe and area should determine for leasing of water body
- Alternative income source should be arranged for fishermen
- Restrict fishing during fish breeding
- Unplanned construction of infrastructure should be prohibited
- Widening of pond should be done according to plan
- Sufficient water reservoir should be selected for fisheries
- Water reservoirs should be cleaned and monitored on a certain time interval to maintain the water quality
- Water quality of ponds, canals and beels should be tested to certify whether it is suitable for fisheries or not
- Suitable fish habitat should be selected for the increment of reproduction
- Fish conservation law should be established and proper implementation of that law should be ensured
- Knowledge regarding fisheries should be spread among the fishermen
- Proper training and financial help from government should be ensured
- Alternative system should be done instead of using pesticides in agricultural land
- Eco-friendly structures should be constructed to reduce hampered migration
- License system for professional fisheries should be introduced
- Priority should be given for landless fishermen in any kind of fish related involvement
- Grabbing of Khas land should be stopped
- Conserve open wetland according to policy
- Ensure production of fish naturally
- Excess fish farm should be closed
- Fisheries territory should be established and fishermen should be united.

Ecological Resources

- Seasonal wetlands should be conserved
- Migratory bird hunting should be prohibited
- Government laws should be followed strictly
- Steps should be taken to conserve bio-diversity
- Excessive use of pesticide should stop
- Eco-system should be balanced while implementing a project
- Level of awareness of local people should be increased
- Natural vegetation should be protected and allowed to grow properly
- Mitigation measures should be taken for the welfare of the ecosystem
- Climate change related awareness should be spread among the locality
- Tree should be planted more for migratory bird.

Socio-economic Resources

- River dredging will reduce the proportion of road damage and will ultimately be beneficial for communication system
- Sustainable measures should be taken to increase the standards of life
- The supplied water quality is not at a satisfactory level and affects the health of the local people
- Arrangement should be made for construction of floating school
- ‘Haor Allowance’ may be introduced to ensure full time presence of teachers and doctors
- Responsible role of BWDB and LGED should play in necessary
- Communication related construction should be implemented as per design level
- Local government should take active part regarding government projects
- Illegal household on agricultural land should be eradicated
- Job opportunity should be increased and new form of business sector should be established
- More communication system should be developed
- Compensation and support should be given to affected people due to flood and water logging
- Haor master plan should be implemented

Overall, local participants also suggested some key measures regarding overall haor area are as following:

Key Suggested Measures

i. All internal khals/canals and connecting big and small river should be dredged regularly.

ii. A strong monitoring cell should play proactive role for operation and maintenance of existing infrastructure with the participation of local stakeholders in the Haor region.

iii. Local people’s concern needs to be granted during operation and maintenance for the particular areas.

iv. Coordination among the all concern authorities and stakeholders should be maintained properly.

v. The sluice gates, submergible embankments, roads should repaired analyzing the current flood level of respective Haor basin.

vi. Operation and Maintenance (O&M) work should be monitored intensively.

vii. Any plan should be taken regarding the Haor as the distinct areas due to its diversified nature and ecosystem.

viii. The leasing arrangement of connecting rivers should be stopped.

ix. Fisheries should be taken care by the original fishermen.

x. Topo survey, fish pass, fish migratory route, fish breeding survey, environmental impact assessment should be conducted properly.

xi. Bridges, culverts and sluice gates should be designed up to the edge of khal or river area.

xii. The approach road should be constructed without squeezing the khal and river area.

xiii. Public cut would be ensured for reducing the needs of dredging and decrease the erosion.

xiv. Haor ecosystem friendly grasses/plants should be planted for better strengthening of embankments.

xv. Dredging should be started before starting the fish culture process.

xvi. Bottom-up approach should followed during design, operation and maintenance of the project.

Photographs of Local Workshops

Figure 1: Consultation Workshop at Tahirpur, Sunamganj

Figure 2: Consulation Workshop at Jamaganj, Sunamganj

Figure 3: Consultation Workshop at Derai, Sunamganj

Figure 4: Consulation Workshop at Ajimiriganj, Habiganj

Figure 5: Consulatation Workshop at Mohonganj, Netrokona

FIgure 6: The Directorate General of Department of Bangladesh Haor and Wetlands Department delivered his speech, at Mohonganj, Netrokona

Figure 7: Consultation Workshop at Mohonganj, Netrokona

Figure 8: Consultation Workshop at Kalmakanda, Netrokona

Figure 9: Consultation Workshop at Kishoreganj Sadar, Kishoreganj

Figure 10: Consultation Workshop at Bajitpur, Kishoreganj

Figure 11: Consultation Workshop at Gowainghat, Sylhet

Figure 12: Consultation Workshop at Kanaighat, Sylhet

Figure 13: Consultation Workshop at Rajnagar, Maulvibazar

FIgure 14: Consultation Workshop at Sreemangal, Maulvibazar

Figure 15: Consultation Workshop at Bahubal, Habiganj

Quaiestionnaire Survey for Local Workshop

<u>প্রশ্নমুলক জরপি-১</u>

বাংলাদশে পানি উন্নয়ন বোর্ড (বাপাউবো) পানি ব্যবস্থাপনা ও সচেরে সুবধিার জন্য ষাটরে দশক থকে যসেকল অবকাঠামো নর্মিাণ করছে অথবা যসেকল পদক্ষপে গ্রহণ করছে যমেনঃ ডুবন্ত বাঁধ, স্লুইস গটে, রগেুলটের, বক্স কালভার্ট, পানি নষ্কিাশন নালা, সচেরে জন্য খাঁড়ি, ড্রজেং ইত্যাদি, সগেুলো পরবিশেরে উপর করিূপ প্রভাব ফলেছে বলে আপনি মনে করনে।

এ সম্পর্কে বলতে নচিে উপযুক্ত জায়গায় টকি চহ্নি দনি ও আপনার নজিস্ব মতামত লখিুন।

<u>পানি-সম্পদঃ</u>

বন্যার অবস্থাঃ ভাল/খারাপ **পানি নষ্কিাশনরে অবস্থাঃ** ভাল/খারাপ **নাব্যতাঃ** বড়েছে/কমছে **পলি জমাঃ** বড়েছে/কমছে	**খারাপ প্রভাব প্রশমনে আপনার মতামতঃ**

<u>ভুমি, কৃষি ও পশুসম্পদঃ</u>

বলিরে পরমিানঃ বড়েছে/কমছে **কৃষযিোগ্য জমঃি** বড়েছে/কমছে **সচেরে পানরি প্রাপ্যতাঃ** বড়েছে/কমছে **শস্য উ□পাদনঃ** বড়েছে/কমছে **শস্য উ□পাদনে ক্ষয়ক্ষতঃি** বড়েছে/কমছে **কীটনাশক সাররে ব্যবহারঃ** বড়েছে/কমছে **গৃহপালতি পশুপালনঃ** বড়েছে/কমছে	**খারাপ প্রভাব প্রশমনে আপনার মতামতঃ**

<u>ম□স্য সম্পদঃ</u>

মাছ উ□পাদনঃ বড়েছে/কমছে **মাছরে প্রাপ্যতাঃ** বড়েছে/কমছে **মাছরে বাসস্থানরে অবস্থাঃ** ভাল/খারাপ **মাছ স্থানান্তরঃ** হয়/হয়না **নষিদ্ধি জালরে ব্যবহারঃ** বড়েছে/কমছে **পশোদার ম□স্যজীবীর সঙ্খ্যাঃ** বড়েছে/কমছে **ম□স্য ব্যবস্থাপনায় সমস্যাঃ** বড়েছে/কমছে	**খারাপ প্রভাব প্রশমনে আপনার মতামতঃ**

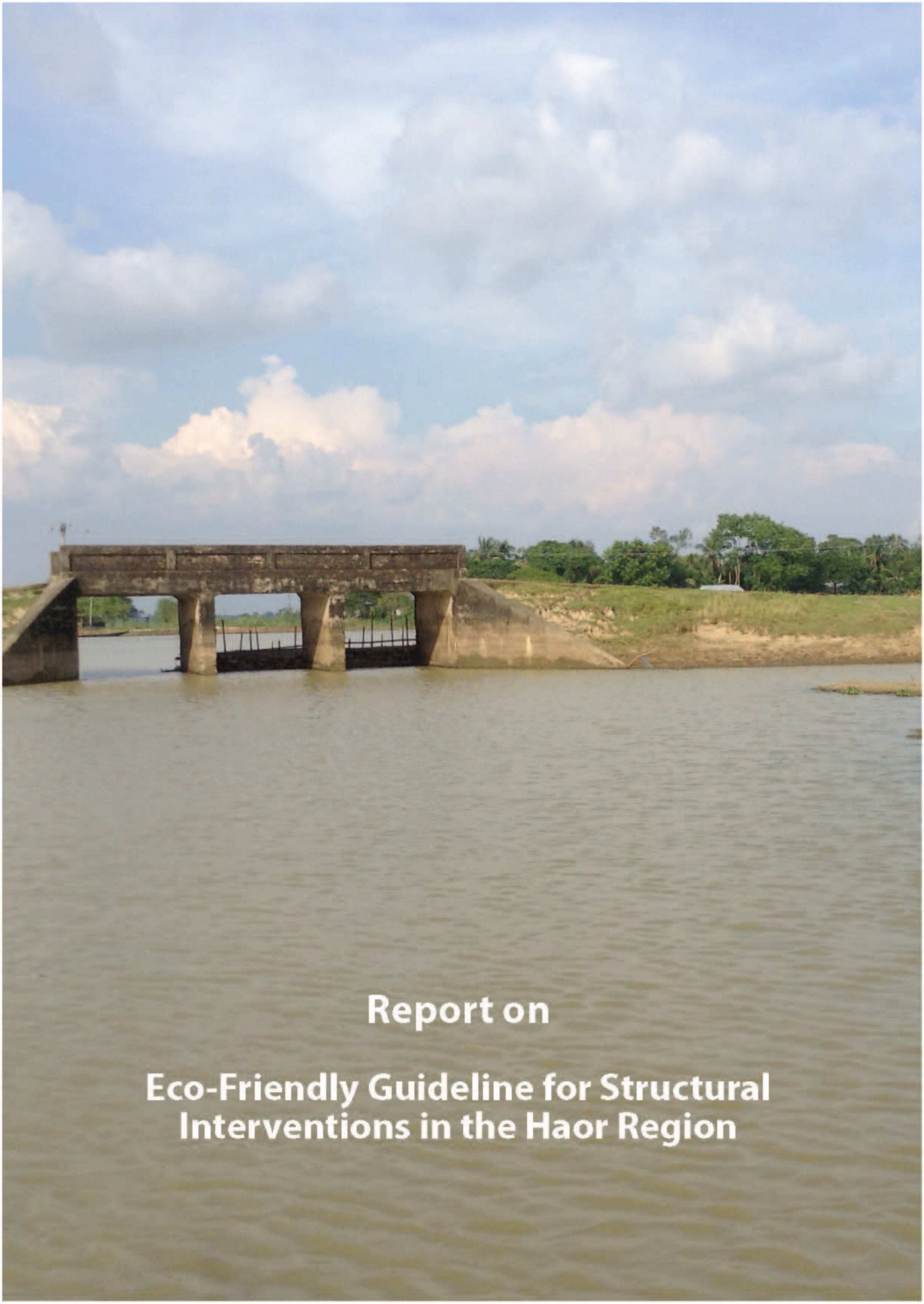
বাস্তুতন্ত্রঃ

মৌসুমি জলাভূমিঃ বেড়েছে/কমছে **গঙ্গীয় ডলফিনের দেখাঃ** যায়/যায়না **অতিথি পাখিঃ** বেড়েছে/কমছে **জীববৈচিত্র্য-এর উপর প্রভাবঃ** ভাল/খারাপ	**খারাপ প্রভাব প্রশমনে আপনার মতামতঃ**

আর্থ-সামাজিক অবস্থাঃ

বাসস্থানের অবস্থাঃ ভাল/খারাপ **কর্মসংস্থানের সুযোগঃ** বেড়েছে/কমছে **প্রধান পেশাঃ** কৃষি/মৎস্য/ব্যবসা/অন্যান্য **প্রধান পেশার আয়ঃ** বেড়েছে/কমছে **পেশা পরিবর্তনের প্রবণতাঃ** বেড়েছে/কমছে **শিক্ষা খাতে উন্নতিঃ** হয়েছে/হয়নি **স্বাস্থ্য খাতে উন্নতিঃ** হয়েছে/হয়নি **যোগাযোগ ব্যবস্থাঃ** ভাল/খারাপ **পানি ব্যবস্থাপনায় নিয়োজিত প্রতিষ্ঠানের ভূমিকাঃ** প্রশংসনীয়/উল্লেখযোগ্য	**খারাপ প্রভাব প্রশমনে আপনার মতামতঃ**

নাম	পেশা ও পদবী	মোবাইল নাম্বার	স্বাক্ষর ও তারিখ



Report on

Eco-Friendly Guideline for Structural Interventions in the Haor Region

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Abbreviations and Acronyms

BCAS	Bangladesh Centre for Advanced Studies
BCF	Billion Cubic Feet
BDP	Bangladesh Delta Plan
BWDB	Bangladesh Water Development Board
CAD	Command Area Development
CEGIS	Center for Environmental and Geographic Information Services
CIP	Country Investment Plan
CNRS	Center for Natural Resources Studies
CO_2	Carbon dioxide
CWBMP	Coastal and Wetland Biodiversity Management Project
DAE	Department of Agriculture Extension
DBHWD	Department of Bangladesh haor and Wetlands Development
DoE	Department of Environment
DPHE	Department of Public Health Engineering
ECA	Ecologically Critical Area
EFCC	Environment, Forestry, Climate Change
EIA	Environmental Impact Assessment
EIP	Early Implementation Project
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development Board
ETP	Effluent Treatment Plant
FAP	Flood Action Plan
FC	Flood Control
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FMD	Flood Management and Drainage
FPFS	Fish Pass and Fish Friendly Structures
FRP	Fiber Reinforced Polymer
GBM	Ganges-Brahmaputra-Meghna
GDP	Gross Domestic Product
HR	Human Resource
HRS	Haor Rehabilitation Scheme
HYV	High Yielding Varity
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IPM	Integrated Pest Management
IRRI	International Rice Research Institute

IUCN	International Union for the Conservation of Nature
IWM	Integrated Wetlands Management
IWRM	International Water Resources Management
KKRMP	Kalni-Kushiyara River Management Project
LGED	Local Government Engineering Department
LPL	Lower Poverty Level
MoEF	Ministry of Environment and Forest
MoL	Ministry of Land
MoWR	Ministry of Water Resources
NACOM	Nature Conservation Management
NCSIP	National Conservation Strategy Implementation Project
NGO	Non-Government Organization
NWMP	National Water Management Plan
NWP	National Water Policy
O&M	Operation and Maintenance
PLC	Program Logic Controller
PSCM	Participatory Scheme Cycle Management
RHD	Roads and Highways Division
SDG	Sustainable Development Goal
SIA	Strategic Impact Assessment
SIS	Small Indigenous Species
SMIT	System Improvement and Management Transfer
SRP	Systems Rehabilitation Project
SUST	Shahjalal University of Science and Technology
UNDP	United Nations Development Programme
UNO	Upazilla Nirbahi Officer
VOC	Volatile Organic Compounds
WARPO	Water Resources Planning Organization
WMIP	Water Management Improvement Project
WTP	Water Treatment Plant

Executive Summary

Hosting the confluence of such enormous a system at the heart of such small a country, Bangladesh consists one of the most active and dynamic hydro-morphological characteristics and has accordingly been divided up into eight unique hydrological regions. Among these, the haor basin is one of the most prominent and diverse of regions, with their unique hydro-ecological characteristics and large low-lying floodplains, are located in north-eastern Bangladesh, covering about 1.99 million ha (19,998 sq km) of area and accommodating about 19.37 million people. The potential of haor wetlands to contribute to livelihoods and economy of the country is closely related to their ability to maintain ecosystem functions owing to their unique hydrological characteristics. Bangladesh Water Development Board (BWDB) has implemented 118 FC/FCD/FCDI/IRR schemes from early '60s for water as well as flood management in haor area in a view to facilitate boosting up of agricultural production, improvement of communication and saving life and properties from distress of flash floods. Monitoring the environmental management plans (EMP) for existing structures and enforce reassessed measures wherever necessary through an eco-friendly framework will not only ensure smooth functioning of structure but also of ambient environment.

A comprehensive eco-friendly guideline has therefore been prepared, to provide the necessary means that can complement all future structural interventions.This guideline has been prepared to provide environmentally friendly means for project design and implementation for both existing and future interventions. Its sole purpose is to be able to portray the “bigger picture” to any project implementation scheme and thus help manage the planning, design, implementation and O&M of existing and future interventions in the haor region in a manner so as to ensure mutual benefit to all involved sectors. This guideline has been developed taking into consideration the multi-sectoral issues and impacts exerted over the lifespan and functioning of the different interventions in the past few decades. It aims to provide means of modification of existing structures and directives to future interventions for boosting water resource/ agricultural practices whilst simultaneously preserving the natural biodiversity in terms benefit to the fisheries and ecology sector.

In order to check the policy guidance regarding eco-friendly development; policy directives have been reviewedin this study considering the existing as well as future infrastructural development in the Haor region. Keeping focus on eco-friendly development in the haor region; directives for various issues relevant to the eco-friendly development like water resource and disaster management, sustainable land and agricultural water management, fish friendly infrastructure etc. have been sought in the Policy, Act, Rules, Strategy, Plans and International Conventions of the relevant sectors and the findings of the policy review have been summarized under some thematic issues. Moreover, while reviewing the above mentioned literatures, the scope of possible future modification in the policy directives for accommodating necessary guidance regarding eco-friendly development has also been investigated and the recommendations in this regard has been made in the proposed principles.

Water resources management in haor region over the years has leaned more towards application of hard engineering measures which ultimately has proved detrimental in the long run.The existing interventions in haor have had a vast number of impacts on the governing sectors of the region.Haors in recent times have been facing numerous natural, structural and non-structural hitches. Natural problems include flash flood, increases flash flood level and sand carpeting. Water logging, excess flooding, poor maintenance of embankment, malfunctioning of regulators and embankment breaching is the example of structural problem. Non-structural problems are little or no participation of stakeholder, conflicts of interest between stakeholders and no community based organization etc. Eco-friendly measures has to be implemented with provisions for enhancing the resource base through whilst also ensuring mutual gains to agriculture and navigation are the most sought after priority. Key parameters such as geometry of structure and also design bounds such as gate opening, vent size, nos. of vent, depth of allowed flow, velocity of flow etc.hasto be maintained to preserve a balance among fisheries and ecology with agriculture and water resources.

Design principles proposed in this guideline has taken a holistic approach in considering not only applicable engineering measures, but also non-structural soft measures that would supplement the hard measures in developing an effective management system. True value of the haor region lie in comphehending its pivotal role in preserving the natural balance as well as, as a strong economic resource. Eco-friendly measures have been provided such that certain aspects of the flow can be controlled to an extent so that it can be utilized and its potential can be harnessed. Measures proposed include the use of eco-friendly construction materials for both embankment construction and road carpeting. The use of Geosynthetics has been proposed as component of upstream or downstream slope protection, crest roads, toe drain wrappings, and upstream water barriers. Automated dredging process have been proposed so that benthic substrates do not get dislodged and injected into water columns thus hampering ecological balance. Modifications to both vertical and lateral flap gate sluice and regulators have been proposed to aid routine fish migration through floodplain and also facilitate drainage such that whereby agriculture and fisheries sector are mutually benefitted. Environmentally friendly construction materials such as wood, recycled plastic composite ‘timber’, combinations of geo-jute and vetiber grass have been proposed both as materials for fish friendly infrastructural development as well as supplement at the structure slopes to support fisheries and other wildlife and sustaining the structure itself. Options for providing fish pass facilities in existing FCD/I interventions have been provided through assessing the potential merits and criteria. These options include pool and weir fish way, vertical slot fish way, denil or steep fish passes, fish locks/ lifts etc. Fish species wise length and corresponding cruising and maximum speeds considered/allowable for establishing fish pass/ friendly structures have been provided for consideration during project implementation.

Water resources management in haor region does not usually permit practices of preventive measures for the natural calamities that befall, but rather encourages the ability to withstand and utilize the beneficial aspects of a would-be disaster; to turn the tides and thrive through attaining natural and infrastructural resilience. This guideline has thus been prepared taking into account the variety of issues stemming from implementation of different interventions in the past few decades on the prominent sectors such as agriculture, fisheries, ecology and water resources itself.It has taken into consideration the existing institutional framework as well as the relative plans and policy directives and also the views of the root level stakeholders that comprise the inhabitants of this region in providing a combined set of “solutions”. It is therefore perceived that by using this guideline prior, during and post project implementation, the pertinent authority will obtain means of approach, not only for an individual intervention, but also for any regional development plan; so that this unique natural resource base is not lost or depleted in the face of infrastructural development.

Chapter 1: Introduction

1.1 Background

Haors are a source of immense beauty and are rich with natural resources. The potential of haor wetlands to contribute to livelihoods and economy of the country is closely related to their ability to maintain ecosystem functions owing to their unique hydrological characteristics. An assortment of interventions has been set up in the region over the years for flood protection as well as to harness the natural resource base. To assess the current status of overall impacts exerted by the interventions, an initiative has recently been taken up by the government to monitor the existing environmental management plans (EMP) for existingas well as any future structures and imply reassessment wherever necessary to ensure smooth functioning of not only said structure but also of the ambient environment. A comprehensive eco-friendly guideline will therefore, provide the necessary means that can complement all future structural interventions in the future.

Bangladesh, the largest delta in the world is formed at the tail end of the mighty Ganges-Brahmaputra-Meghna river system. Hosting the confluence of such enormous a system at the heart of such small a country, Bangladesh consists one of the most active and dynamic hydro-morphological characteristics and has accordingly been divided up into eight unique hydrological regions. Among these, the haor basin is one of the most prominent and diverse of regions, with their unique hydro-ecological characteristics and large low-lying floodplains, are located in north-eastern Bangladesh, covering about 1.99 million ha (19,998 sq km) of area and accommodating about 19.37 million people. There are some 373 haors located in the districts of Sunamganj, Sylhet, Habiganj, Maulvibazar, Netrakona, Kishoreganj and Brahmanbaria. These cover an area of about 859,000 ha which is close to half the total area of the haor districts. It is a mosaic of wetland habitats including rivers, streams, canals, large areas of seasonally flooded cultivated plains and beels.

On a geophysical note, haors can be considered as bowl shaped depressions of considerable aerial extent and unique hydro-ecological characteristics lying between natural levees of the rivers or high lands. It is a mosaic of wetland habitat including rivers, streams, canals, large areas of seasonally flooded cultivated plains and beels, sporting rich ecosystem that naturally prevails and provides ecological safety net to all lives. The north-eastern haors cover an area close to about 15% of the country and 44% of the total haor region. Haors provide the most valuable and productive ecosystems on earth and offer important opportunities for sustainable development. The diverse nature of haors provide livelihood opportunities for the people that reside in the region and in doing so actively supports the sustainable economic development of the country.

The haor region itself has been lagging behind mainstream national development despite the steady upward incline economic development and thus the government, over the years, has taken many initiatives which have been implemented through the infrastructural development of the region by means of numerous FCD/I projects. These interventions, from the 60s has contributed a great deal in bringing the flash flooding nature of the haors into a state-of-order and has boosted agricultural production. But as reliance upon structural means only has certain detrimental effects in the long run towards achieving sustainability, an account of physical impacts exerted by these interventions is necessary in planning a long term management plan for the area.This report presents the formulated eco-friendly guideline that has been developed taking into consideration the numerous sectoral impacts of existing structures and. It provides means with existing structures can be modified to ensure environmentally friendly mode of operation as well as, provide innovative alternatives should there be future interventions in the region.

1.2 Rationale

Being a riverine country, water has always played a vital role in governing infrastructural development in Bangladesh. Haors, being submerged for half the year is thus also fundamentally attached to this notion. This also makes livelihoods extremely vulnerable and limits the potential for agriculture production and rural enterprise growth. A large group of people are directly or indirectly linked to the productivity and sustainability of haors which provide immediate as well as implicit benefits to local people of that area. Every infrastructural intervention in the haor area is thus done keeping this imminent submergence into calculations. For example, a road network thus has to house not only bridges wherever required but also a predefined number of culverts that might remain dry for a portion of the year, sluice gates operate on periodic regulation of water allocation etc.

Bangladesh Water Development Board (BWDB) has implemented 118 FC/FCD/FCDI/IRR schemes from early ‘60s for water as well as flood management in haor area in a view to facilitate boosting up of agricultural production, improvement of communication and saving life and properties from distress of flash floods. Submergible embankments, regulator or sluices, culverts, irrigation inlets and drainage outlets, fish pass, rubber dam etc. have been constructed under these schemes. Interventions made under these schemes have both positive and negative impact on different components of haor ecosystem. Whereas, an account of physical impacts exerted by these interventions is necessary in planning a long term management plan for the area, this has to be supplemented by an established means of ensuring the sustainability of the environment. Monitoring the environmental management plans (EMP) for existing structures and enforce reassessed measures wherever necessary through an eco-friendly framework will not only ensure smooth functioning of structure but also of ambient environment.

Degradation of wetland resources in Bangladesh has been somewhat increasing due to lack of proper operation and maintenance of infrastructures, water management structures, irrigation and flood management structures, and associated disturbances. Continuous degradation is creating threats for the living condition of local people and deteriorating their livelihoods, socio-economic condition and the wetland-based ecosystem. Considering the severity of rapid wetland degradation and losses, ecosystem resilient or eco-friendly infrastructural development may be a suitable alternative to reducing negative impacts on environmental components and to conserve the biotic and abiotic components of the haor ecosystem which will also escalate the social and economic benefits. These great number of interventions although made keeping a probable submerged scenario in mind, exerts impact upon the dry period ecosystem and livelihood which necessitates an environmental mandate to not only supplement the study for assessing their physical and environmental impact on the surroundings, but also to steer any future development on a region with this fragile an eco-system.

1.3 Objectives

The primary objectives of this guideline is –

- To provide environmentally friendly means for project design and implementation; and
- To portray the “bigger picture” and help manage the planning, design, implementation and O&M of existing and future interventions in the haor region in a manner so as to ensure mutual benefit to all involved sectors.

1.4 Study Approach and Methodology

This guideline has been formulated based on two principles which are –

- Taking into consideration the multi-sectoral issues and impacts exerted over the lifespan and functioning of the different interventions in the past few decades; and
- Provide means of modification of existing structures and directives to future interventions for boosting water resource/ agricultural practices whilst simultaneously preserving the natural biodiversity in terms benefit to the fisheries and ecology sector.

Figure 1.1 illustrates the methodology adopted in formulating this guideline.

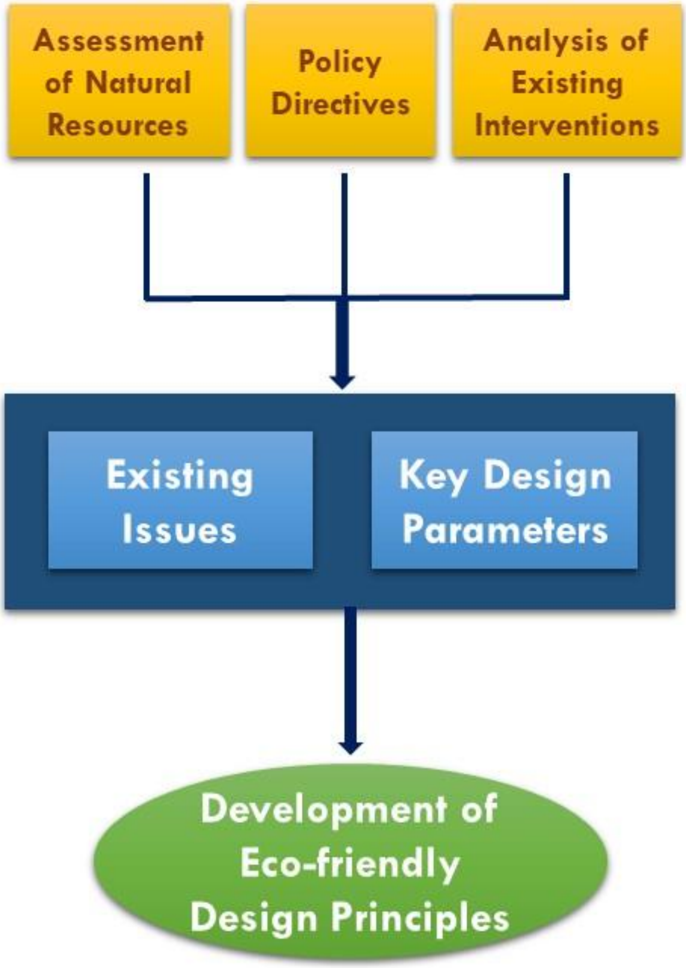


Figure 1.1: Approach for development of eco-friendly guideline

1.5 Structure of the Report

The first chapter of this report presents the introduction in which a background is set for the development of this guideline. This is followed by a rationale and necessity of formulation an eco-friendly guide and its impact on the existing and future development scenario. The second chapter provides a thorough description of the haor region, assessing the delicate eco-system balance that has prevailed over the years as well as the vast natural resources base that ultimately is to bear the brunt of any development interventions. The third chapter looks into the existing policy directives to assess the current state of means in addressing impacts. The fourth chapter portrays the decadal development thrust in the haor region, looks at the local initiatives that have been taken and briefly reviews the existing development structural inventory. The fifthand final chapter addresses the existing sectoral issues that is in existence in the haor region from an environmental perspective, and in doing so, comes up with some key parameters which are to be prioritized during operation of existing structure and implementation of any new structures before ultimately presenting the formulated guideline that stems as a culmination of topics covered in the previous chapters and aims to provide a concrete basis of evaluating existing operational and maintenance schemes and help navigate the implementation process of all future interventions.

Chapter 2: Haor Ecosystem

2.1 Introduction

The northeast region of Bangladesh, comprising the floodplains of the Meghna tributaries, has a distinct type of wetland that is known as the Haor Basin.Normally haors are tectonically depressed and marshy lands. Originally the word “haor” is derived from the Sanskrit word “Sagor” which means sea. The haor areas of Bangladesh with unique hydro-ecological characteristics are large bowl shaped floodplain depressions located in the north-eastern region of Bangladesh.This basin comprises an area of about 2,450,000 hectares or 17.5 per cent of the area of Bangladesh and consists of wetland ecosystem considered to be of international ecological importance due to the extensive waterfowl population that uses the basin as its habitat. The haor basin is bounded by the hill ranges of India – Meghalaya on the north, Tripura and Mizoram on the south, and Assam and Manipur on the east. The basin extends north to the foot of the Garo and Khasia Hills, and east along the upper Surma Valley to the Indian border. There are 373 haor located in the districts of Sunamganj, Habiganj, Netrakona, Kishoreganj, Sylhet, Maulvibazar and Brahmanbaria. These 373 haor cover an area of about 8,585 square kilometres which is around 43% of the total area of the haor districts (19,998 sq km).

The main characteristics of haors are flooding by normal flood during rainy season in every year. Haors remain submerged for more than six months and with the passage of rainy season some deep beel areas at the deepest point of the haor region still remain submerged. Annual rainfall ranges from 2200 mm along the western boundary to 5800 mm in its north east corner and is as high as 12000 mm in the headwaters of some catchments extending to India. The region receives water from the catchment slopes of the Shillong Plateau across the borders in India to the north and the Tripura Hills in India to the south-east. Flash flood is the main disaster in the haor area which engulfs the primary production sector (e.g., agriculture and fisheries) and thus threatens the lives and livelihoods of the people. Excess rainfall in the upstream hilly areas and subsequent runoff, sedimentation in the rivers, deforestation and hill cuts, landslide, improper drainage, unplanned road and water management infrastructure and the effect of climate variability are the main reasons for the devastation caused by flash floods.

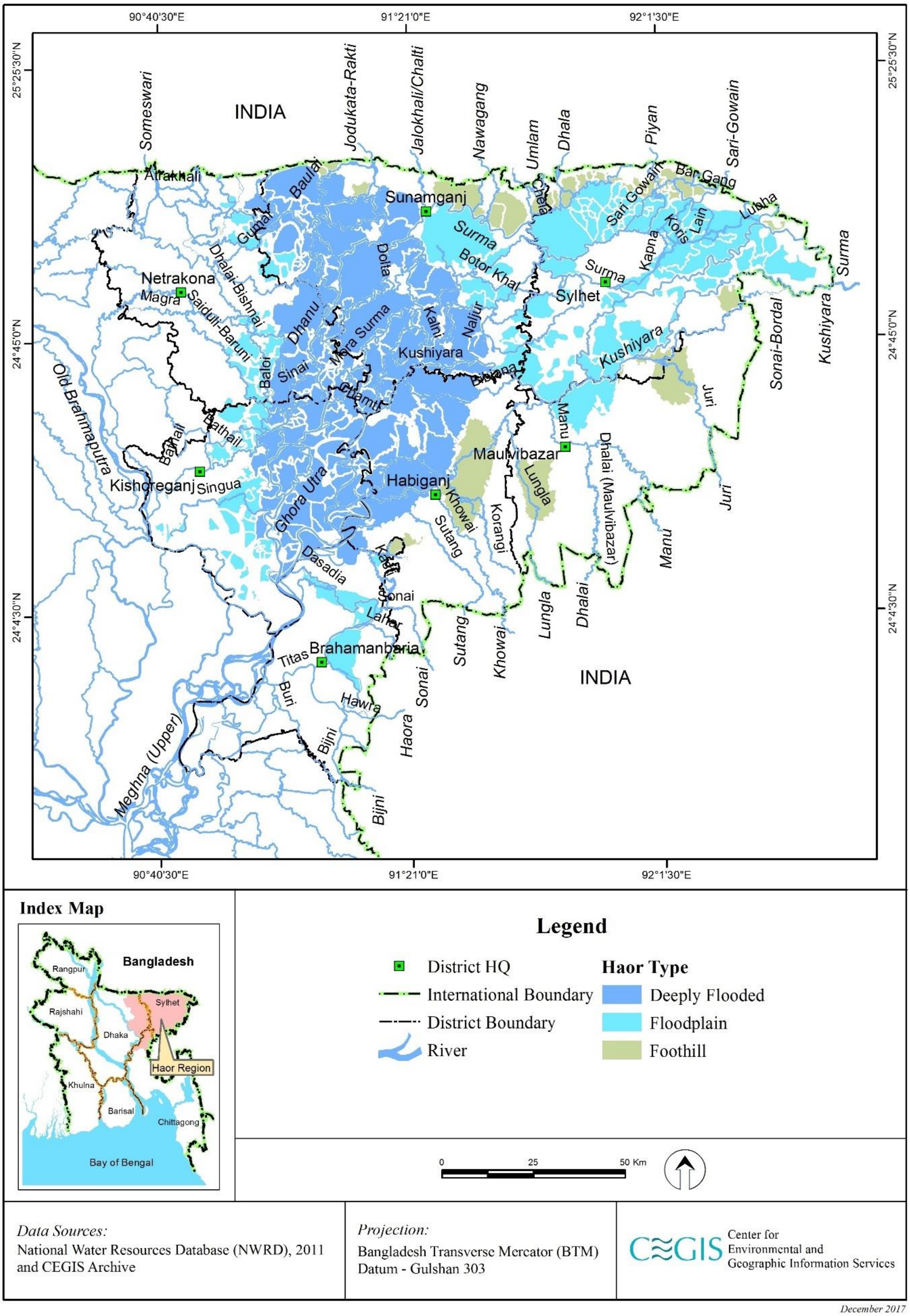


Figure 2.1: Haor of North East Region of Bangladesh

2.2 Physiography

Mainly physiography of this area was classified based on the combination of the geological material in which particular kinds of soil have formed and the landscape on which they occur. The physiographic units which comprises in seven haor districts are Eastern Surma-Kusiyara Floodplain, Sylhet Basin, Northern and Eastern Piedmont Plains, Old Meghna Estuarine Floodplain, Old Brahmaputra Floodplain, Northern and Eastern Hills, Young Brahmaputra and Jamuna Floodplain, Middle Meghna River Floodplain, Akhaura Terrace, Active Brahmaputra-Jamuna Floodplain and Madhupur Tract. But most of the haor comprises mainly Sylhet Basin and Eastern Surma-Kusiyara Floodplain, and very few are in Old Meghna Estuarine Floodplain, Old Brahmaputra Floodplain and Northern and Eastern Piedmont Plains. The general soil types in the haor area are mainly Noncalcareous Grey Floodplain Soils (non-saline), Noncalcareous Dark Grey Floodplain Soils and Acid Basin Clays.

2.3 River System

In north eastern haor region of Bangladesh, 23 transboundary rivers pass through the region which has great influence on water resources system of Haor area in Bangladesh. Major parts of the catchment of these rivers are outside the country. The major catchments on the Indian side are the Meghalaya, the Barak and Tripura. Around 70% of the total catchments of the rivers of the haor area lies in India. In the haor area, three major river systems govern: the Surma-Baulai, the Kalni-Kushiyara and the Kangsa-Dhanu. The Barak River (Indian River) feeds the Surma and the Kushiyara. Consequently, it plays an important role in two major systems (the Surma-Baulai and the Kalni-Kushiyara). The major three river systems of the haor area as well as the Barak system are briefly described in the following sub-sections.

Barak System

The Barak-Surma-Kushiyara river system is one of the three major river systems of Bangladesh. The Barak enters into Bangladesh from northeast India at Amalshid (Indo-Bangladesh border) where it is divided into two rivers: the northern branch is the Surma River and the southern branch is the Kushiyara River. Two-thirds of the average flow of the Barak passes into the Kushiyara, and the rest flows into the Surma. From its source in the Nagaland Hills of India, the river is known as the Barak until it enters Bangladesh. Near its source, the river receives numerous little hill streams, including the Gumti, the Howrah, the Kagni, the Senai Buri, the Hari Mangal, the Kakrai, the Kurulia, the Balujhuri, the Shonaichhari and the Durduria. It then flows westward through Manipur State from where it moves southwest leaving Manipur and entering the Mizoram State. In the Mizoram State the Barak flows southwest and then turns abruptly to the north when joined by a north flowing stream and flows into the Assam State where it turns westward again near Lakhipur as it enters the plains. It then flows west passing the town of Silchar where it is joined by the Madhura River. After Silchar in Bangladesh at the India border it divides into the Surma and the Kushiyara and enters Bangladesh. The principal tributaries of the Barak in India are the Juri, the Dhaleshwari, the Singla, the Longai, the Madhura, the Sonai (Tuirial), the Rukni and the Katakhal. The length of the Barak River is 460 km inside India. The catchment area of the Barak is 26,165 km^2 which lies entirely within India.

Surma-Baulai System

The transboundary rivers Jadukata, Jalokhali, Nawagang, Umlam, Dhala, Piyan, Sari-Gowain and Surma enter into Bangladesh from India in this system. The Baulai is another important river of this system which flows entirely within Bangladesh. Moreover, Surma is the core river of this system which is fed by the Barak River.

Kalni-Kushiyara System

The Sonai-Bordal, the Juri, the Manu, the Dhalai, the Laungla, the Sutang, the Khowai, the Sonai, the Haora and the Bijni are transboundary rivers which enter into Bangladesh and flow through this river system. Furthermore, the Kushiyara is the most important river of this system which is fed by the Barak. Inside Bangladesh, the Kushiyara carries the flows of the Sonai-Bordal, the Juri, the Manu and the Dhalai. The lower part of the Kushiyara is the Kalni. In this river system the Gangaijuri River carries the combined flow of the Laungla and the Sutang.

Kangsa-Dhanu System

The Malijhi, the Chillakhali, the Bhogai and the Nitai enter through the Bangladesh border and feed this river system along the periphery of the haor area. The Someswari River enters at Durgapur of Netrakona district touching the left boundary of the haor area.

2.4 Human Resources

The total population of the seven haor districts is 19.37 million (2010, projected from BBS, 2001 census). The population growth rate per annum for the overall haor region is 1.09% which is lower than the national rate. The overall population density in the haor districts is 987 per sq km which is lower than the average national population density of 1142 per sq km.

In haor area 29.56% of the population lives below the Lower Poverty Level (LPL), which is slightly higher than the national average of 29.26%. About 61.84% of the economically active population (age above 15) in the haor area can serve in the labour force which is higher than the national average (58.74%) and 28.5% of the population of the haor area is not engaged in any kind of employment. The major occupation of the people of the haor districts is agriculture. Half of the population (53.67%) depends on agriculture for their subsistence. There is a remarkable variation in the occupation of the haor population. A large portion of the population earn their livelihood from business (12.52%) followed by non-agricultural labour (6.13%), service (5.65%), fishery (2.59%), and transport (2.39%). A significant part of the population (3.41%), especially in Sylhet (10.32%), Maulvibazar (4.64%) and Brahmanbaria (4.56%) depends on remittances coming from abroad.

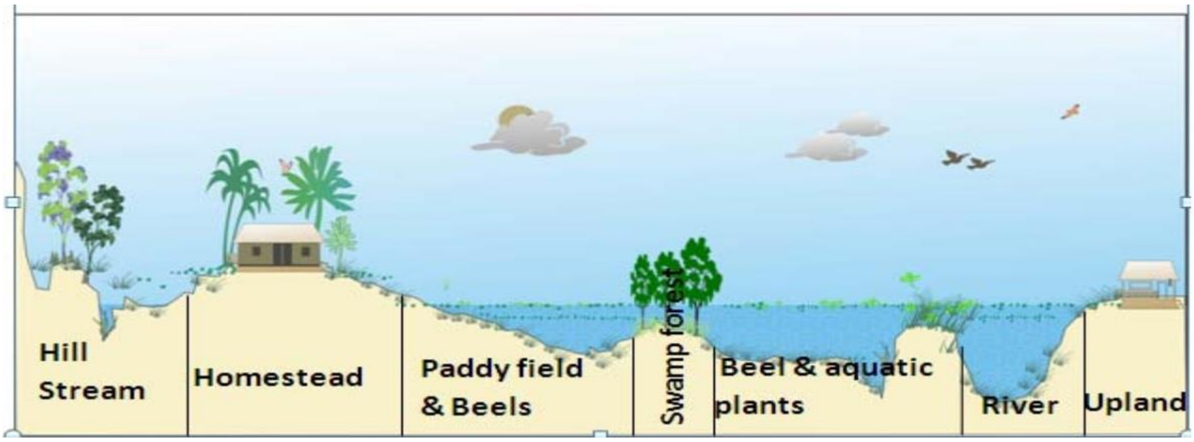
The total house holdings of the haor area can be considered as two types: Non-farm (48%) and farm holdings (52%). In case of non-farm holdings, it has been observed that “Holding with no operated area” is about 2.9% in the haor region while the national figure is 13.9%. Percentage of holdings with “No cultivated area” is about 81.1% in haor in comparison with national percentage of 74.71%. “Holdings with 0.01-0.04 acre cultivated area” is about 16% in the haor region, while the national figure is 11.40%. In case of farm holdings, comparison between haor and national percentage are for marginal holdings 33.69% and 38.63%, for small holdings 51.2% and 49.9%, for medium holding 13% and 10.3% and for large holdings 2 % and 1.2% respectively.

The tenure pattern depends on the prevailing practices of land use and crop cultivation. There are three types of tenure groups in the area such as tenant (4%), owner (68%) and owner-cum-tenant (25%). Landowners either cultivate their land themselves or/and have them cultivated by hired labour. The owner-cum-tenant cultivates land of other people along with their own land while tenant farmers (7%) cultivate land belonging to others only.

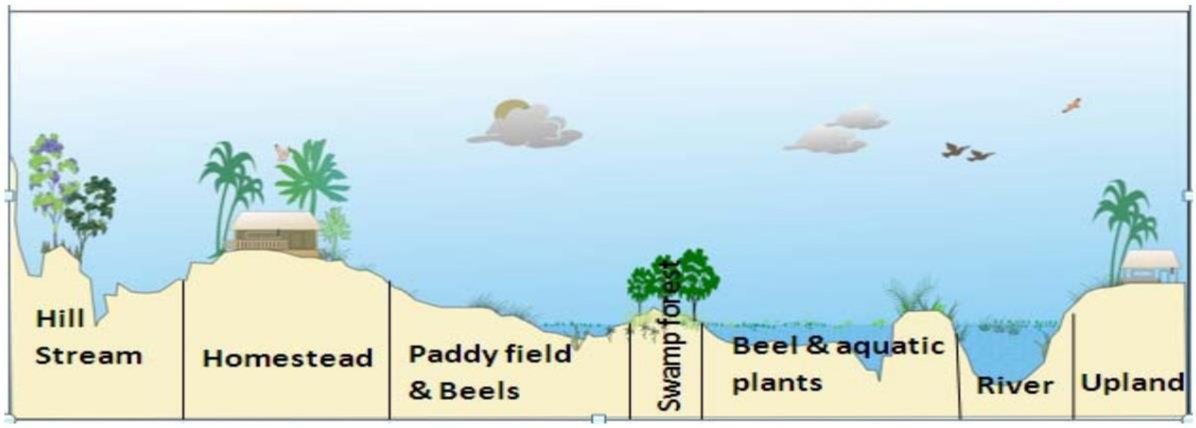
2.5 Natural Resources

2.5.1 Ecosystem Resources

Due to the unique characteristics of the haor Basin, anaerobic conditions inhibit normal plant growth and only the plant groups known as hydrophytes have adapted to thrive there. Haor is a great reservoir of aquatic biological resources and acts as the ecological safety net to the nature as well as to the dwellers of the haor. These wetlands have high socio-cultural value and enormous economic functions for the people, including commercial and non-commercial uses of resources. These haors can be divided into some ecological zones based on depth and duration of water, moisture and holding capacity of soil, topography and vegetation. The haor belong different ecosystem like shallow aquatic ecosystem as well as seasonal wetlands, river and canal ecosystem, cropland and settlement ecosystem and other perennial waterbodies like beels and ditches etc. **Figure 2.2** illustrates the wet and dry season ecosystem for the haor region.



(a) Wet Season



(b) Dry Season

Figure 2.2: Schematic Representation of Haor Ecosystem (Master Plan of Haor Area, 2012)

The different ecosystems prevalent in the haor region supports diversified terrestrial and aquatic flora and fauna. These flora and fauna enriched the overall biodiversity of the haor basin. It is factual that, the haor basin biodiversity was very rich in the past but recently it is diminishing since the environment has degraded remarkably. The pristine ecosystem has disrupted in presence of human induced pressure like agricultural expansion, human population growth, over exploitation of resources etc. The unwise activities of the haor inhabitants have broken ecosystem integrity for several decades. Natural calamity and anthropogenic pressure has triggered to the ecosystem functions and on wild habitats. Despite massive habitat losses, the northeast region of the country is still an important place for migratory waterfowl, principally ducks and shore birds. A total of 284 species of waterfowl were recorded in the haor basin (FAP 6, 1993). Various other wildlife, also finds this place safe for their feeding and nesting, as well as for breeding. Existence of numerous waterbodies and seasonal floodplains favored significant succession of different aquatic flora within the haor basin. Perennial and deeply flooded seasonal wetlands usually possess diversified submerged, free floating and rooted floating plants including sedges and meadows. The area supports enormous phytoplankton and zooplankton and different species of mollusks, insects, crustaceans, amphibians, reptiles and most importantly diverse fish species. A complex interdependent aquatic ecosystem is present in haor from the very old period of time. That's why the haor basin alone produces a remarkable quantity of freshwater fish and each haor acts as a fish sanctuary for several indigenous fish species.

The haor area is a critical source of income and nutrition (derived through agriculture, fisheries and collection of other aquatic resources), maintain the health of the local aquifer, reduce flood severity, and improve water quality from the ancient period. On the whole the ecosystem goods and services are remarkable from haor basin. The cycle of economic activities in the haor region also varies significantly with changes in the seasons. It is the only region in Bangladesh where remnant patches of freshwater swamps and reed lands still exists. Once extensive swamp forests of Hijal (Barringtonia acutangula) and Koroch (Pongamia pinnata) in the area used to provide an important source of firewood and fish grazing those are now almost completely destroyed due to various anthropogenic demands. Besides, in recent times, various herbs and aquatic plants are being collected for use as fuel and fertilizers. Only a few patches remain of the swamp forests that dominated the area earlier, featuring flood tolerant trees. Though, in some parts of haor, the social tree plantation takes place which is producing good results towards the ecosystem of the area.

Establishment of Different types of intervention in haor area like the embankment; sluice gate/regulator may be paving the way to enhance the production of rice but these structures also have some indirect negative role towards overall ecosystem services. To grow more rice present use of pesticides and population density in the particular area causing harm towards the aquatic flora and fauna. To meet the demand of growing population, people of this area are harvesting excessive amount of fish. Over harvesting of fishes, dewatering of beel areas are the major causes for deterioration of fisheries and other ecological resources. Thus the interventions have been indirectly triggered flora and fauna into diminishing in an alarming rate. Access to more people to harvest natural resources as per demands has been leading depletion of terrestrial floral coverage and faunal relocation as well. However, haor ecosystem is a multiple-resource base which demands an integrated sustainable development approach. The ongoing management approach is biased to only rice production through FCDI. Thus this primitive mode of action is diminishing other resources having more economic potential ever thought. It is required to make a regime shift from primitive resource use practice to a modern and progressive one for better resource management and sustainable eco-friendly economic growth of haor region.

2.5.2 Water Resources

The haor region lies in the Meghna basin which is part of the Ganges-Brahmaputra-Meghna (GBM) basins. Flow from about 66,640 km^2 of the Meghna basin is drained ultimately into the Bay of Bengal through the Kalni-Kushiyara and Surma-Baulai river system. Of this area 35 %, or 23,137 km^2, lies in Bangladesh. The estimated outflow of water from this region into the Bay amounts on average to 162,619 million m^3/year. Fifty seven percent of this flow is generated at the upstream of Bangladesh while 43% is generated within the country.Trans-boundary flow from India is 70%, 60%, 37% and 80% of total flow in pre-monsoon, monsoon, post-monsoon and dry season respectively. This inflow (mainly premonsoon flow) from India into Bangladesh is the main cause of flash flood in the haor area.

2.5.3 Forest

In the haor basin districts there are hill forest, social forest, fresh water swamp forest, reed lands, murta and cane bush, bamboo grove and homestead vegetation etc. Each type is an aggregated assemblage of particular plant species, and is a characteristic of particular environmental conditions (hydro-period, flow regime, water quality and soil). Wetland condition ranges from perennial aquatic lowlands to seasonally dry uplands. It has been found that 1308 ha of land and 145 km of (strip) area are being planted each year in the haor area. The average trend is about 1% of land being planted each year. The type of plantation is strip plantation which includes bamboo, cane, murta, shegun, agar, etc.

2.5.4 Biodiversity and Wetland

The most significant wetlands in the haor area are Hakaluki Haor, Tanguar Haor, Hail Haor, Matian Haor, Pasuar Beel Haor, Dekar Haor, Baro Haor, Gurmar Haor, Sonamorol Haor, Baram Haor, Kalnir Haor, Kawadhighi Haor, and Pagner Haor. These wetlands have a rich wildlife community including 257 species of bird, 40 species of reptile, 29 species of mammal and 9 species of amphibian. Most of the important haor areas are also enriched by wetland plants and lowland plantation.

2.5.5 Mineral Resources

Various types of mineral and energy resources are deposited in the haor area. The mineral resources discovered here are natural gas, crude oil, limestone, white clay, glass sand, peat, coal, gravel, and sand as construction material. A projection has been made based on the daily gas production and total remaining reserve of the different wells in haor districts. Up to 2010 the cumulative gas production from gas wells in the haor districts is 8,095 Billion Cubic Feet (BCF) and the remaining reserve is 8,717 BCF.

2.6 Economic Resources

The agriculture and fisheries are the main base of the diversified economic resources of the area. Besides, livestock, industry and tourism are also contributing the national economic growth. The contribution of the haor region has been on average around 6-8% of the national GDP. Considering the regional growth, the current GDP contribution of the haor region in the base year of 2010 is 263 billion, which is 6% of the total GDP of the country. Thirty six percent of which is from the agriculture sector, 27% from the industrial sector and 37% from the service sector. The annual average growth rate of GDP of the haor region is 5% whereas the national average is 6.1%. The major economic resources of the haor region are described below.

2.6.1 Agriculture

In the higher part of the haor region, HYV T Aman is the major crop grown in the Kharif II season under provision of irrigation. This crop is preceded by Aus crop in the Kharif I season and followed by Vegetables and Boro crops in the Rabi season. But where irrigation facilities could not be ensured, single T Aman crop is grown in kharif II season and in a few area it is preceded by Aus crop in the kharif I season. In between higher and deeper part, where wave action is not severe, B Aman crop is practiced followed by Boro crop. In the basin areas, single Boro crop is grown during the rabi season. In Kharif season, most of the areas are submerged by water. The total area in the seven district considered under the Master Plan is about 1.99 million ha of which net cultivated area is about 1.31 million ha. Total cropped area is about 1.93 million ha, of which rice is covered by 1.74 million ha (90.2%) and the rest 0.19 million ha (9.8%) is by non-rice crop. The total rice area of Bangladesh is 11.35 million ha of which 15.3% falls in the haor area. The cropping intensity in the haor area is about 147% which is much below the national average of 182%. About 5.25 million metric tons of rice is produced which is 16.5% of the total rice production of Bangladesh. Among the rice production Boro contributes 60%, Aman 33% and Aus 7%. The average rice yield is 3.02 ton/ha.

2.6.2 Fisheries

The haor region comprises a wide variety of fin fish including 143 indigenous and 12 exotic species along with several species of freshwater prawns. Fish species are broadly grouped into two categories, large and small fish. The estimated fish habitat area in the haor region is nearly 966,900 ha. The fish habitats in the haor area produce about 0.432 million ton of fish per year of which 73.7% is contributed by capture fishery and the remaining is shared by culture fishery. Wetlands are breeding, nursing, feeding and overwintering grounds of the resident as well as most of the freshwater migratory fish species. Culture fish ponds in the haor area produce about 0.114 million ton which is 26.3% of the total production.

2.6.3 Livestock

The livestock resources of the haor region are mainly cattle, buffalo, goat, sheep, chicken and duck, with poultry and duck constituting the major types of livestock population. In fact, more than 24% of the country's total duck population exists in the haor region. Mostly cattle, duck and chicken are reared by the haor people. There are around 32.68 million head of livestock (cattle, goat, sheep, duck and poultry) in the community farms of the haor area constituting approximately 22% of the total cattle population in the country. Milk production in the haor districts for 2010 has been estimated to be about 0.62 million ton. Similarly meat production has been estimated as 0.14 million ton in the year 2010. Presently about 989 million pcs. of egg are being produced in the haor districts.

2.6.4 Industry

Industrialization has not taken place to a great extent in the haor area and consequently the number of industries and people engaged in this sector has been low (1.33% of the total population only). The tea estates of the country have widened the scope of tea processing industries in this region. The major industrial products include fertilizer, cement and liquefied petroleum (propane) gas. Other industries include textiles and leather, chemical and plastic and non-metallic mineral products. The area is endowed with ample natural resource to develop food and beverage which may include fish can product, pineapple and lemon beverage, and cottage industries including shitol pati, bamboo and cane furniture, Agar oil and agar wood are the most exalted perfumery raw materials and herbal medicine factories, etc.

2.7 Harmonization

There exists a keen relationship among the resource components in the *haor* region. Each of the resource base function independently within their own bounds as well as work in conjunction to function as an integrated system. Sustenance of livelihood and development demands that, natural and human resources present has to be harnessed to its full capacity in order to maximize economic resources. This can be visualized through the below hypothetical mathematical equation form:

Natural Resources + Human Resources -----> Economic Resources

Whenever any one of the components from the left hand side of this equation is given excess emphasis, the other one suffers. And if that happens, the right hand side of this equation cannot ultimately be realized. In reality, recipient of this one sided priority in the *haor* region is the human resource (HR). Thus nature is suffering and the consequences are being felt in recent times with the natural disasters and subsequent loss of resources. There has to exist an inevitable balance among the two resources otherwise the ecosystem suffers. This study aims to identify the issues that have risen in lieu of existing interventions in the region through assessing impacts on the identified sectors and provide necessary measures for not only said interventions. While they are to an extent geared towards the more structural aspect, this particular guideline hopes to act as a catalyst in terms of the above equation in that it harbors the thriving of natural resources at its core through not only ensuring maximum benefit to the ambient environment of existing interventions but also providing a clear direction in regulating any future development works.

Chapter 3: Policy Directives

3.1 Introduction

A number of infrastructures have been developed in the Haor Region to minimize the adverse effect of the natural disasters. Considering the need to mitigate the flood damage and improve the living environment through the implementation of flash flood management, improvement of the rural infrastructure, and promotion of the agriculture and fisheries; further infrastructural development in the Haor Region is required. However, such development should be eco-friendly and comply with the directives existing policies, acts, rules and plans of the country which are relevant to the development of the Haor area. Therefore, the directives regarding eco-friendly development as mentioned in different policies, acts, rules, strategies and plan have been reviewed and articulated under different thematic issues. Due to cross-cutting nature of many directives; they are applicable for more than one issue.

3.2 Water Resources and Disaster Management

Directives regarding water resources management and flood and drainage management in various plans, strategies and conventions are often overlapping in nature. Therefore, directives regarding coordinated development and management of water and related resources as well as the directives for mitigating the risk and damages due to water induced disasters in the Haor Region i.e. flood and drainage congestion have been sought under this issue which have been presented below:

Policy directives regarding flood and drainage management are found in several Policies, Acts and Rules. Bangladesh Water Act, 2013 provides directives for demarcation of flood control zone in wetlands to ensure smooth passage of flood water. Similarly, Bangladesh Water Rule, 2017 (Draft) has instructed to identify 'Flood Flow Zone' or 'Sub Flood Flow Zone' for smooth passage of flood and restriction has been outlined to do any development. Moreover, Bangladesh Water Act, 2013 has asked for protection of flood control embankment, especially which protects property, life and crops by restricting construction any house, establishment or any other structure on or on the slope of such embankment. This Act has also asked to ensure normal flow in water course prohibiting any kind of diversion through construction of structures without feasibility study. The National Water Policy, 1999 has advised to preserve natural water bodies like haors, baors and beels for sustaining the aquatic environment and facilitating drainage. According to the National Land Use Policy, 2001 Government would be responsible for reservation of large water bodies like haor, baors, beels, rivers etc. Also, water bodies should be used in a way that does not contradict the Fisheries Policy and does not hamper the fish production while contributing for agricultural. Moreover, this policy recommends for regular maintenance and rehabilitation work of the wetlands as well as of the embankments and other relevant structures. The Policy also calls for plantation of trees along embankments and provision of drainage facility for embanked areas. The Embankment and Drainage Act, 1952 has instructed to make better provision for the construction, maintenance, management, removal and control of embankments and water-courses for the better drainage of lands and for their protection from floods, erosion or other damage by water. Environmentally sound water resource management is suggested in the National Environmental Policy, 1992 through utilization and development of water resources, construction of irrigation network and embankments, dredging of water courses and in-taking measures against water pollution.

Conducting Environmental Impact Assessment has also been outlined as a requirement before undertaking projects related to water resource development and flood control measures.

Water resources management and measures for flood and drainage management has been outlined in many strategies and plans. The strategies under the thematic area “Improved water and disaster management” of the Haor Master Plan, 2012 (MPHA, 2012) suggests to safeguard the water resources and to preserve the natural characteristics of the whole basin with special attention to ecologically important areas. The strategies and plans of the National Water Management Plan (NWMP), 2001 for water sectors also provide direct and indirect directives which are related to Haor. They are: development and management of river system and embankments; integrated development and management of haors and wetland; flood proofing rather than flood control of the rural population living in haor basin; reduction of encroachment and exploitation of ecologically sensitive haor basin; and integrated river management plan covering erosion control, dredging and other elements of river maintenance such as pollution control, abstraction, navigation and environmental needs.The 7th Five Year Plan of the Government of Bangladesh has shown a way to conservation of wetlands including Jalmohals and rivers in dry season; several strategic directions and policy framework have been outlined in this five year plan, where watershed management and resilience against climate change got special emphasis in relation to haor area. BWDB/LGED coastal FCD/FCDI projects and submersible embankment projects in Haor area have been identified as the first stage defense in case of climate change.

The guiding principles of North East Regional Water Management Project (FAP 6), 1993 which are related to the study are: protection of rural infrastructure and controlling floods to meet the needs of agriculture, fisheries, navigation, urban water flushing and annual recharge of surface and ground water resources; effective land and water management in protected and unprotected areas; strengthening flood preparedness and disaster management; improvement of flood forecasting and early warning system; channel improvement and structures to ensure efficient drainage; co-ordinated planning and construction of rural roads, highways and railway embankments with provision for unimpeded drainage etc.

The Bangladesh Climate Change Strategy and Action Plan, 2009 established programmes of action on six main pillars for the five-year period (2009-2013). Programmes which are relevant to haor under these six pillars are stated: improvement of flood forecasting and warning system, adaptation against floods to make flood prone areas more resilient by flood zoning and management. The Bangladesh Delta Plan (BDP) 2100, (Draft) has suggested for building roads and railways keeping adequate space for flood passage; modification of existing FCD/I projects with Boat passes/navigation locks/ Fish Pass; and re-excavation of khal; modification/reconstruction of bridges and culverts keeping adequate free board for plying waterways and developing water fronts on the river banks in urban areas. The National Environment Management Action Plan, 1995 in its "Water resources Issues" section has suggested for flood proofing and flood protection work. The National Plan for Disaster Management for 2016-20 has asked for awareness raising, preparedness and risk communication on natural disasters.

3.3 Sustainable Land and Water Management for Agriculture

Considering the high demand of land in this riverine country for human settlement, agriculture, industrialization etc. and scarcity of water for irrigation; directives for sustainable land and water management are found in different Policy, Acts and Rules. The National Agriculture Policy, 2013 has advised for sustainable land-water management and expansion of integrated crop management activities by protecting agriculture related biodiversity. Advanced agro-technologies should be introduced to tackle adverse climate condition like flooding, drought, storm, salinity, erosion, disease, insect onslaught etc. The National Rural Development Policy, 2001 has discouraged the construction of building, new settlement etc. on cultivable agricultural land and has asked to take measures for planned construction of houses. The Environmental Policy, 1992 encouraged environmentally sound agricultural practices and asked to and ensure for attainment of self-sufficiency of food. Activities that cause or result in land erosion, salinity and alkalinity, and loss of soil fertility are prohibited.

Bangladesh Water Rule, 2017 (Draft) has advised the preparation of a guideline for the extraction and proper use of surface and ground water. The National Agricultural Policy 2013, an updated version over the National Agricultural Policy 1999, has stated that irrigation from surface water would get priority and suitable programmes would be taken up for the expansion and consolidation of appropriate technology. Moreover, importance would be given on the conjunctive use of ground and surface water in accordance with the National Water Policy, 1999 and Water Resources Development Plan of the government. The government will promote re-excavation of canals, ponds and other water bodies for conservation and utilization of surface water through inter-agency coordination. Advanced agro-technologies should be introduced to tackle adverse climate condition like flooding, drought, storm, salinity, erosion, disease, insect onslaught etc.

Development of climate resilient cropping system appropriate for different agro-climatic regions and sub-regions has been recommended by the Bangladesh Climate Change Strategy and Action Plan, 2009. It also asked for raising productivity of agricultural land and lowering emissions of methane by efficient use of water The North East Regional Water Management Project (FAP 6), 1993 asked for protection of rural infrastructure and controlling floods to meet the needs of agriculture, fisheries, navigation, urban water flushing etc. Strategic directions of the 7th Five Year Plan of the Government of Bangladesh (2015-16 to 2019-20) regarding agriculture sector which are also applicable to the haor areas, are: development and refinement of technologies which may bridge yield gaps and promote diversification, sustainable natural resources management etc. and introducing saline or drought tolerant, short duration or submergence varieties to withstand with climate change.

3.4 Fish Friendly Infrastructure Development

Acknowledging the negative impact of different interventions on fish habitat, fish habitat condition, fish production etc.; directives have been found for fish-friendly development in several Policies and Acts. The National Fisheries Policy, 1998 has stated that lakes, beefs, ditches-canals, beels and other open water bodies should not be completely dewatered which may threaten fish species. It has also stated that renovation of water bodies like haor, baor and beel should be done for fish culture and any reduction in size of these water bodies shall not be made. It has also asked to take proper care during the execution of all developmental activities such as flood control, irrigation and drainage (FCDI) projects, agriculture, industries, road and urban development projects to conserve fish habitats from damage. It has also asked for conservation of fisheries, livestock and other ecosystems and prevention or re-evaluation of activities that poses threats to wetlands and natural habitats for the fishes.

The National Environmental Policy, 1992 has asked for re-evaluation of activities that poses threats to wetlands and natural habitats for the fishes. Similarly, the Protection and Conservation of Fish Act, 1950 has advised for environment friendly infrastructure development in haor area to facilitate the conservation and preservation of fishes ensuring comfortable growing, breeding or migration. Moreover, it has specifically advised for protection and conservation of fishes by prohibiting and regulating the construction (temporary or permanent) of weirs, dams, bunds, embankments and other structures which may destroy fishes and/or cause depletion of fisheries. The National Land Use Policy, 2001 includes a prohibition against encroachment of existing wetlands. It has stated that regulation should be imposed over the wetlands with regular maintenance and rehabilitation so that they are not filled up but kept available for fish culture. It has also advised that re-excavation is to be done in filled-up wetlands.

Several strategies and recommendations regarding development of fish friendly infrastructure have been outlined in various plans, strategies and conventions. The Sustainable Development Goals in its Goal 15 has signified on protection, restoration and promotion of terrestrial and inland freshwater ecosystems and halting biodiversity loss. It is also mentioned in Target 15.1.2, that by 2020, important sites for terrestrial and freshwater biodiversity that are covered by protected areas shall also be prompted, by ecosystem type.

The National Sustainable Development Strategy (2010-2021), acknowledging the development aspiration, has provided some sustainable development strategies. The strategies specifically mentioned for haor area for ensuring wise use of wetlands are as following:

- Set aside at least 10% of wetland areas as fish sanctuaries. In important fish resource areas such as haor, the protected area it should be at least 20%
- Establish and maintain sanctuaries which will comprise complete ban on fishing in certain eco-sensitive areas like the Sundarbans, parts of Kaptai Lake, and several sections of the Halda river, selected beels in haor areas and certain sections of the Bay of Bengal etc.
- Identify key habitats that ensure ecosystem integrity and connectivity (migratory flyways of birds, fish passes, etc) and support actions to maintain and promote such connectivity between the earmarked critical and sensitive areas

The Biodiversity Strategy and Action Plan (2016-21) has suggested that, by 2021, stock assessment of fish, invertebrate stocks and aquatic plants should be undertaken keeping in mind the safe ecological limit. It has also advised for raising awareness of the stakeholders so that aquatic biodiversity can be managed and harvested sustainably.

The following directives regarding the fisheries resource management are found in the 7th five year plan of the Government of Bangladesh:

- Prevent deterioration of water logging, blockade of water-flows and shrinkage of water-bodies by infrastructures like embankment, roads, urban housing projects and industrialization. Such projects must follow the environmental rules and regulations (including EIA, SIA, etc.) and incorporate adequate mitigation measures in consultation with the Ministry of Fisheries and Livestock

- Projects and programmes should be implemented to construct and maintain fish-passes, fish-friendly regulators, re-excavate canals and rivers restoring and conserving productivity as much as possible
- Establish and maintain fish and wetland sanctuaries which would comprise complete ban on fishing in certain eco-sensitive areas like Sundarbans, parts of Kaptai Lake, and several sections of the river Halda, selected beels and haor areas
- Daudkandi model of seasonal floodplain aquaculture should be further promoted to expand all over the country but with added emphasis to combine maintaining sanctuaries in the important beel and haor areas

The National Environment Management Action Plan, 1995 identified the key environmental issues, and the actions required to halt or reduce the rate of environmental degradation, improve the natural and manmade environment, conserve habitats and bio-diversity, promote sustainable development and improve quality indicators of human life. The strategies and associated action plan as mentioned under the water resources sector directly or indirectly relate to the fisheries management. They are: re-designing the projects for creating infrastructure for facilitating fish migration to and from floodplains and conducting research development activities on the fish migration and natural recruitment in the FAP area.

3.5 Conservation of Ecosystem and Bio-Diversity

Conservation of ecosystem and biodiversity has been acknowledged through a number of policy directives. In this regard, the National Water Policy, 1999 has stated that only those water related projects would be executed which will not hinder the aquatic characteristics of haors, baors and beels. Haors that naturally dry up during the winter will be developed for dry season agriculture. It also calls for the development water resources of the major rivers for multipurpose use including irrigation, fisheries, navigation, forestry, eco-tourism and aquatic wildlife as well as delineation of water-stressed areas based on land characteristics and water availability. It also recommends for taking steps to protect water quality and ensure efficiency in its use.The National Environmental Policy, 1992 has asked for conservation and expansion of forest zones, conservation of wildlife and bio-diversity and conservation of wetland which are exclusive to fish culture and prevention of encroachment of wetlands. Water transport systems and other related transport systems should be operated without polluting the environment. EIA is required before undertaking any projects in these sectors. The National Fisheries Policy, 1998 has called for conservation and expansion of forest zones, conservation of wildlife and bio-diversity and conservation of wetland which are exclusive to fish culture and prevention of encroachment of wetlands.

Bangladesh Biodiversity Act, 2017 has prohibited any development works which may interrupt safe living of bio-diversity or impose adverse impact. It also refers to the conservation of existing biodiversity and genetic resources in in-situ or ex-situ environment. Bangladesh Environment Conservation Act, 1995 has asked to declare Ecologically Critical Area if any ecosystem is in the state of critical situation and also stated that no interventions should be undertaken in this designated area. The Ecologically Critical Area Management Rules, 2016 has asked to designate “Ecologically Critical Area” after fixing some indicators like degradation of natural condition of river, khal, haor, baor, wetlands, biodiversity related to them, sanctuary etc.The National Forestry Policy, 1994 & 2016 (draft), in its directive regarding land-based public development initiatives has asked to incorporate appropriate initial environmental investigations and environmental impact assessments to avoid the fragmentation of wildlife and biodiversity habitats and minimize environmental damage.

Conservation of ecosystem and bio-diversity has been given priority in various global and national plans. Goal 15 of the Sustainable Development Goals signifies on protection, restoration and promotion of terrestrial and inland freshwater ecosystems and halt biodiversity loss. It is also mentioned in Target 15.1.2 that by 2020, important sites for terrestrial and freshwater biodiversity that are covered by protected areas shall also be prompted, by ecosystem type. It is narrated in Target 6.6 of Goal 6 of the Sustainable Development Goal that by 2020, the water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes will be protected and restored. Ensuring the availability of fresh water across the world is another target of this goal. The National Conservation Strategy, 2016-31 was formulated to foster development in the country through the conservation, development and enhancement of natural resources in the country within the framework of sustainable development, particularly as envisioned under the Sustainable Development Goals (SDG). This strategy expected to create a conducive policy environment and strategy for conservation, development and enhancement of natural resources in the country. The strategy is divided into 17 chapters on the basis of sectoral issues. Some strategies relevant to this study are as following:

- Prepare management plan for all ecosystem of the country including the Wildlife Sanctuary, National Parks, and Ecologically Critical Areas etc.
- Improvement of the understanding the species diversity of different inlands water bodies like Beels, lakes, rivers and streams of Bangladesh
- Management plans incurred from human causes and natural disaster

The Haor Master Plan, 2012 (MPHA, 2012) suggested forbiodiversity enhancement and wetland management to maintain ecological balance, protect the environment and improve livelihoods of the poor people of the area. Bangladesh Delta Plan 2100 in its "Sustainable Haor Ecosystem and Biodiversity Management" has asked for improvement of water quality by establishing ETP and WTP for every industry as well as by establishing environmental monitoring cell. The Biodiversity Strategy and Action Plan (2016-21) which is a guiding framework for biodiversity conservation, ensuring sustainable use of its components along with fair and equitable sharing of benefits arising out of utilization of genetic resources. Twenty national targets have been proposed to be taken into action during the fiscal year 2015-2016 to 2020-2021. Following targets among 20 national targets are found relevant to this study

i. By 2021, studies on the rate of habitat loss will be furnished towards promoting implementation of land use policy and enforcement of relevant legislations on conservation of natural habitats

ii. By 2021, Bangladesh's 3% area under terrestrial ecosystem (forests), 3% area under inland wetlands and coastal ecosystems and 5% of total marine area will come under PAs or ECAs with development and implementation of management plan for these areas

iii. By 2021, initiate implementation of restoration plan for degraded ecosystems, especially, forest lands and wetlands for addressing climate change mitigation, adaptation and combating desertification

Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (draft) is a five-year framework that provides a strategic framework for the national and international investments for the Environment, Forestry, Climate Change (EFCC) sectors in Bangladesh for sustainable development of the country. The Country Investment Plan (CIP) related to EFCC has elaborated four investment pillars of which (1) Sustainable development and management of natural resources and (2) Adaptation, mitigation and resilience to climate change are related to haor area. This strategy has indicated some guidelines for the preservation of the ecosystems of the water bodies, including haor, which is the home to a number of species of fishes and a great source of nutrition for the people of the country. Relevant programmes and sub-programmes taken in CIP for EFCC sector include: i) Develop and enhance conservation of protected areas through joint government-community co-management; ii) Improve biodiversity monitoring (including strengthen monitoring capacities of institutions; iii) Endangered species conservation and management; iv) Support implementation and scaling up of the Master plan for Haor and flood prone areas; v) Support implementation and scaling up of the Aquaculture development strategy and action plan; vi) Strengthening climate change resilient buildings, roads and storage facilities; vii) Sustainable infrastructure development etc.

3.6 Preservation and Conservation of Waterbodies/Wetlands

The importance on preservation and conservation of wetlands and different types of water bodies has been given in many policy directives. Many directives have already been discussed under previous issues due to cross-cutting nature of the directives. The National Water Policy, 1999 has stated that natural water bodies like haors, baors and beels should be preserved for sustaining the aquatic environment and facilitating drainage. The National Land Use Policy, 2001 includes a prohibition against encroachment of existing wetlands. It has also advised that re-excavation is to be done in filled-up wetlands. According to this policy, Government will be responsible for reservation of large water bodies like haor, baors, beels, rivers etc. it also opines that water bodies should be used in a way that does not contradict the Fisheries Policy and still contributes in agricultural irrigation. It has also asked to establish consistent maintenance of the existing water bodies. As mentioned earlier under the issue “Fish Friendly Infrastructure Development”; National Fisheries Policy, 1998 has stated that lakes, beefs, ditches-canals, beels and other open water bodies should not be completely dewatered which may threaten fish species. It has also asked for renovation of water bodies and taking proper care of the water bodies during the execution of all developmental activities. The National Environmental Policy, 1992 has also asked for re-evaluation of activities that poses threats to wetlands.

Preservation and conservation of wetland and waterbodies has been outlined as a major concern in many plans and conventions. The Haor Master Plan, 2012 has called for biodiversity enhancement and wetland management to maintain ecological balance, protect the environment and improve livelihoods of the poor people of the area. The National Environment Management Action Plan, 1995 has identified key environmental issues, and the actions required to halt or reduce the rate of environmental degradation, improve the natural and manmade environment, conserve habitats and bio-diversity, promote sustainable development and improve quality indicators of human life. The "Wetland Issues" section of the NEMAP emphatically pointed out that "the reduction of wetlands is one of the marked features of environment degradation in Bangladesh and asked for implementation of wetland conservation laws and creation of sanctuaries. It has also asked for development of a comprehensive wetland management policy.

The National Conservation Strategy, 2016-31 expected to create a conducive policy environment and strategy for conservation, development and enhancement of natural resources in the country. This strategy calls for inventory preparation for wetland protection and recovery along with fish, migratory species of birds and wildlife. Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (draft) has suggested to support implementation and scaling up of the Master plan for Haor and flood prone areas for Sustainable management of wetlands and rivers. The Biodiversity Strategy and Action Plan (2016-21) has asked to develop and implement restoration plan for degraded wetlands and rivers taking into account the needs of vulnerable people and local communities by 2021. It has also asked to initiate, by 2021, implementation of restoration plan for degraded ecosystems, especially, forest lands and wetlands for addressing climate change mitigation, adaptation and combating desertification

The Convention on Wetlands of International Importance, 1972 which is also called the Ramsar Convention is the only global environmental treaty that deals with a particular ecosystem At the center of the Ramsar philosophy is the “wise use” concept. The wise use of wetlands is defined as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development". The pioneering ‘Wise Use Guidelines’ emphasized the importance for the contracting parties to:

- Adopt national wetland policies, involving a review of their existing legislation and institutional arrangements to deal with wetland matters
- Develop programmes of wetland inventory, monitoring, research, training, education and public awareness.
- Take action at wetland sites, involving the development of integrated management plans covering every aspect of the wetlands and their relationships with their catchments
- The Wise Use Guidelines also emphasised the benefits and values of wetlands for sediment and erosion control, flood control, maintenance of water quality and abatement of pollution; maintenance of surface and underground water supply; support for fisheries, grazing and agriculture; outdoor recreation and education for human society; and climatic stability

Considering the ecological value of the haor, Tanguar haor and Hail-Hakaluki haors - have been declared as Ramsar sites under the Ramsar Convention for protection of wetlands.

3.7 Regular Maintenance and Rehabilitation of Interventions

Emphasis on regular maintenance and rehabilitation of interventions has been found in different policies. Embankment and Drainage Act, 1952 has provided such emphasis regarding in time repair or construction of embankment or sluices or gates etc. for the protection of cultivable land or life of property. The National Land Use Policy, 2001 has advised for regular maintenance of the embankments to avoid drainage congestion.

The programmes of action formulated under the thematic area "Infrastructure" of the Bangladesh Climate Change Strategy and Action Plan, 2009 provided suggestions regarding regular maintenance and rehabilitation of interventions are given below:

- Repair and maintenance of existing flood embankments and ensuring continued flood protection by repairing and rehabilitating existing flood embankments and ancillary infrastructure.
- Adaptation against floods to make flood prone areas more resilient by flood zoning and management.
- Planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work.

The Bangladesh Environment, Forestry, Climate Change Country Investment Plan, 2016 (Draft) has advised for Strengthening coastal and inland embankments and improve drainage capacity and also for Support for operation and maintenance of water management.

3.8 Conclusion

The directives regarding eco-friendly development as mentioned in different policies, acts, rules, strategies and plan and as presented in this chapter under different thematic issues would help in formulation of an eco-friendly guideline for future development. Moreover, review of these directives and the measures suggested in the eco-friendly guideline may also identify the need of formulating new directives acknowledging the existing problems and future challenges of different sectors which are closely associated the development of the water resources.

Chapter 4: Infrastructural Development of the Haor Region

4.1 Introduction

History of water management infrastructures in Bangladesh is very old and predates to several thousands of years. The concept of water resources management in the haor region of Bangladesh is versatile in that it deals with cross cutting issues and has been fragmented across several organizations and departments that have been formed through a number of rules and laws.Recent infrastructural development began by means of Krug Mission which submitted a report following the devastating floods of 1953 and 1954; after which, remarkable progress was achieved in the pre independence period of Bangladesh was the preparation of IECO, Master plan for the country (in 1964) and Large Scale Coastal Embankment Project (in 1960s). Erstwhile EPWAPDA (East Pakistan Power and Water Development Authority) and later on BWDB started implementing small scale FCD project after the publication of the Land and Water Resources Sector study report 1972 by World Bank (IBRD/ IDA). Interventions in haor area were made by BWDB through EIP, SRP, FAP, Haor Rehabilitation Schemes etc.

During 1975-76 to till date about 118 schemes have been implemented in the haor area. These schemes are maintained every year by BWDB to the required extent to facilitate food production with the allocated budget by GoB. The National Water Policy (NWPo) of Bangladesh has endorsed IWRM as the major strategy to attaining national goals of economic development, poverty alleviation, food security and protection of the natural environment and thus to attain sustainable development in the country. There are numerous structures that have been implemented by LGED and RHD that are currently in existence in the haor region. All these have been comprehensively documented and a subsequent inventory has been developed under Environmental Auditing section of this study. This chapter progresses more along the line of providing a brief historical background to the development of these structures before briefly summarizing the local institutional initiatives taken and then following up with a description of existing interventions.

4.2 Historical Development of Haor Infrastructure

The implemented submersible embankment projects date back to the early to mid-1900s and were constructed through local initiatives or works program of the local government. An 8 vent regulator was constructed in Shanir Haor in 1915 with steel gates. In 1976, BWDB reconstructed this embankment and replaced the existing regulator with a 6 vent regulator equipped with fall boards. BWDB also started intervention in haor areas under Early Implementation Project (EIP) in 1975 which started as a cooperation program started between the Government of Bangladesh and the Government of the Netherlands. This project possessed a rehabilitation and relief character and was initially conceptualized to be require limited technical preparation for implementation. Following its inception, some 88 schemes were implemented under the EIP covering an area of 463,250 ha across Bangladesh, which included the development agenda for the haor region by means of excavation of canals, construction of sluices, closures, and embankments.

Sustainable flood control and food production however, demanded the continuous smooth operation of the implemented structures and thus the Systems Rehabilitation Project (SRP) was initiated by BWDB in 1982. The main aim of the project was to protect and increase agricultural production and incomes and to raise the standards of living through rehabilitation and improved O&M of BWDB's existing sub-projects. Rehabilitation under the SRP was carried out for selected haor projects in the Sunamganj District which also included a full feasibility study. Major achievement of this project includes the redesigning of the submersible embankments for a 1 in 10 year pre- monsoon flood, expected to occur before 15 May with an extended freeboard; with regulators designed to satisfy both post monsoon drainage criteria and pre-monsoon flushing criteria.

Although river flood levels were measured under the SRP, the unprecedented floods of 1988 changed all existing equations and forced the launching of comprehensive studies such as the Flood Action Plan (FAP). One of the more important initiatives under FAP 6 for haor region was the Kalni-Kushiyara River Management Project, primarily aiming to improve the stability of the rivers, reduce pre-monsoon flood damage, reduce erosion damage and improve all weather navigation along the river. The feasibility study under KKRMP proposed construction of loop cuts, channel re-excavation, channel re-alignment by dredging point-bars, construction of bank protection works, construction of embankments and construction of regulators on two off-take channels for river stabilization, flood control and drainage.

Of the more recent interventions in haor region, the Haor Rehabilitation Scheme (HRS) in 2004 and the Water Management Improvement Project (WMIP) in 2007 are prominent. Under the HRS, BWDB selected 37 haor schemes for rehabilitation on the wake of damage to Boro crop within structure safe bounds that took place due to 2004 flood. This rehabilitation scheme further reinforced the embankments design criteria of resisting a 1 in 10 year pre-monsoon flood up to 15th May, as well as, to fill and drain out haors. Primary considerations included sedimentation of rivers and its impact on navigation and drainage congestion for which, large scale dredging was carried out accompanied by redesign of embankments. WMIP consists of three components: (i) System Improvement and Management Transfer (SIMT); (ii) O&M Performance Improvement; and (iii) Institutional Improvement. The combination of these components would see to the rehabilitation and improvement of existing medium and large FCD and FCD/I schemes of BWDB through a systematic approach of Participatory Scheme Cycle Management (PSCM) as well as ensure the sustainability of the schemes that are currently functioning well and have already undergone major rehabilitation and improvement.

4.3 Local Initiatives

Organizational versatility and Institutional complexity is an absolute prerequisite for integration across different sectors and spatial boundaries in considering interdependency of natural systems and are among the most challenging issues in establishing governance regarding water issues. Jurisdiction over wetlands ecology in most nations is spread among federal, provincial (state), territorial and municipal governments, and among different government departments and agencies. In Bangladesh, government agencies with the opportunity to provide leadership to wetland conservation programmes are often poorly supported with few resources in terms of staffing and funding and also politically less influential. Government organizations like Ministry of Water Resources (MoW), Ministry of land (MOL), Department of Fisheries, Fisheries Management, National Herbarium and National Botanic Garden, Wild Floral Research and Conservation, Ministry of Water Resources, Bangladesh Water Development Board (BWDB), Water Resources Planning Organization (WARPO), Department of Public Health Engineering (DPHE), , Shahjalal University of Science and Technology (SUST), Department of Environment (DoE), Department of Forest, Local Government Engineering Department (LGED) etc have been involved with haor biodiversity, wetland management, research and projects work. Also, several international and national

NGO's such as International Union for the Conservation of Nature (IUCN), Wetlands International, Center for Natural Resources Studies (CNRS), Nature Conservation Management (NACOM), Bangladesh Centre for Advanced Studies (BCAS), CARITAS Bangladesh, CONCERN Bangladesh etc. have played key roles in the creation of international and regional agreements, wetland resources and flora which have been immeasurable values in assisting Asian countries, including Bangladesh, to address national biodiversity concerns. Various projects have been already implemented by different National and International Organizations in recent times. Department of Environment in Association with UDNP/GEF had undertaken "Coastal and Wetland Biodiversity Management Project (CWBMP)" project in four Ecologically Critical Areas (ECAs) namely Teknaf Peninsula, Sonadia Island, St. Martins Island and Hakaluki Haor for building capacity of Local people on biodiversity and restoration of habitats according to developed ECA wise. CMPs. Department of Fisheries and BCAS has worked on Redland Afforestation Project in Reedland areas of Sylhet Division which was mainly focused on socio-economic survey based on participatory Rural Appraisal Method supplemented by statistical data. The Community Based Haor Resource Management Project is being implemented by IUCN Bangladesh, in two well-defined degraded haors in the north-eastern region of Bangladesh, with support from the Ministry of Environment and Forest (MoEF) and the UNDP. The major focus of the programme is to involve the community people in planning and implementation of the project activities for the management of natural resources with a view to restoring and maintaining biodiversity as well as human wellbeing in a sustainable manner. Also, NACOM has undertaken some projects entitled "Coastal and Wetland Biodiversity Management Project (CWBMP)" at Cox's Bazar-Teknaf Peninsula, ECA in Association with MoEF and DoE, Monitoring and Conservation of Wildlife Diversity in Tanguar Haor, Wetland Biodiversity Assessment and Development of Management Plan in association with Northwest Hydraulic Consultants, Lavalin International & Bangladesh Engineering and Technology Services. Completion period: June 1993 to July 1995.

Community Based Sustainable Management of Tanguar Haor Program is ongoing by IUCN Bangladesh. Under the National Conservation Strategy Implementation Project – 1 (NCSIP – 1), MoEF initiated a pilot project in Tanguar Haor. Under that project, a management plan developed with technical assistance from IUCN Bangladesh in 2000. The programme aims at building the capacity of the rural communities around Tanguar Haor to share in the management of water, fisheries, forest and reed bed and other resources of Tanguar Haor for generating income from the management, harvesting and selling of these

Programs under National Water Management Plan for N-E region includes: Improved Water Management in the Haor Basins of the North East Region with purpose of safeguarding the water resources and preserve the semi-natural characteristics of the whole basin with special attention being paid at ecologically important sites. Environmentally Critical Areas and Integrated Wetland Management is intended to provide the necessary protection and sustainable use measures in the water sector as part of a wider integrated wetlands management (IWM) programme.

4.4 Existing Interventions

There are numerous large and small scale interventions that are in operation in the haor region from the early 60s. Although this study aims to document these projects and prepare a structured, information on all projects were not available. The ones that were available however, were enlisted in the inventory and can be broadly categorized and can be attributed to three implementing organizations. These include schemes from primarily BWDB, LGED and RHD. Now, whereas these interventions are listed and appropriate description is provided in detail in the auditing report, a brief summary is given in this section to familiarize the user with them.

The Bangladesh Water Development Board (BWDB) by far outnumbers other implementing organizations with 118 implemented projects in the haor region that include Flood Control (FC), Flood Control and Drainage (FCD), Flood Control, Drainage and Irrigation (FCDI) and Drainage Control or Irrigation projects/schemes. These projects has been formulated and subsequently implemented from as early as 1960s and encompasses some approximately 430 different water management structures (MPHA, 2012). These include around 2000 km of submersible embankments, 128 regulators, 65 sluices, 157 inlets, 21 outlets, 28 closures and 3 cross dams. **Figure 4.1** shows some of the existing structures in the haor region.

Figure 4.1: Existing Interventions in the haor region

While BWDB projects focus more on flood control and flood management, the Local Government Engineering Department (LGED) on the other hand, focuses more on flood management. Drainage and ensuring rural connectivity. Till date LGED has 184 implemented subprojects in the haor area that relate to partial flood management, drainage and water management (MPHA, 2012). Among those projects, 111 subprojects are identified as FMD/ drainage type subprojects and the rest are for water management, irrigation/CAD subproject in the periphery of Haor area. Furthermore, LGED have developed vast network of roads in this region that includes LGED has constructed 24,948 km rural roads. Additionally, 8 rubber dams, 123 regulators, 17 sluices, 23 inlets and outlets, 55 water retaining structures have also been constructed under these projects.

Roads and Highways Department (RHD) has developed a vast network of national and regional highway roads for improvement of communication facilities in the haor region. These also include numerous bridges and culverts to facilitate drainage between among the region. To ensure connectivity in the haor region, RHD has constructed 430 km national highways, 578 km regional highways, 937 km district roads that also houses some 1005 number of bridges and 2074 number of culverts for smooth passage of water.

Chapter 5: Eco-Friendly Design Principles

5.1 Introduction

The true value of the haor region boasting with diverse ecological resources lie in its pivotal role in preserving the natural balance as well as, as a strong economic resource. Traditionally, infrastructural development in the water resources management sector were done along the lines of flood damage and flood risk reduction, followed with flood control to ensure better food production. So, in a way, purpose the implemented FCD/I projects in haor region goes hand in hand with agricultural development. If not properly managed, the increase in agricultural productivity usually comes at the expense of loss in fisheries resource and ecological balance. So, if a scheme is to be planned for the overall sustainable infrastructural development in the haor region, it not only has to boost agricultural sector, it has to do so with minimal, if not, zero damage to the existing fisheries and ecological resources. The goal remains however, to increase these sectoral gains even with increased crop production. To do so, poses a unique challenge to project planners and designers alike this requires keen consideration on a set of key parameters. These key parameters will have to be developed carefully and will weigh in factors that relate not only to boosting water resource/ agricultural practices but also simultaneously keeping certain aspects in check so that the natural biodiversity can be preserved in terms benefit to the fisheries and ecology sector.

Water resources management over the years in this region has leaned more towards application of hard engineering measures which ultimately can prove detrimental in the long run. This guideline has been prepared taking into account the variety of issues stemming from implementation of different interventions in the past few decades on the prominent sectors such as agriculture, fisheries, ecology and water resources itself. Water resources management in this region poses a somewhat unique challenge in that it does not permit practices of preventive measures for the natural calamities that befall, but rather encourages the ability to withstand and utilize the beneficial aspects of a would-be disaster; to turn the tides and thrive through attaining natural and infrastructural resilience. So, if looked at as an integrated system, implemented structural interventions should not hamper this lush natural setting, but rather act as a supplement in facilitating and exploiting the annual flood flow received. To do this, the entirety of this system has to be able to function as a whole throughout the year and therein lies the primary purpose of this guideline. This guideline has been prepared after close inspection of existing structural intervention and their diversified impacts upon the natural biota. It has taken into consideration the existing institutional framework as well as the relative plans and policy directives and also the views of the root level stakeholders that comprise the inhabitants of this region. All these factors have been combined in coming up with a set of “solutions” that hope to provide a means of approach not only for an individual intervention, but also for any regional development plan; so that this unique natural resource base is not lost or depleted in the course of infrastructural development.

5.2 Existing Issues

Haors in recent times have been facing numerous natural, structural and non-structural hitches. Natural problems include flash flood, increases flash flood level and sand carpeting. Water logging, excess flooding, poor maintenance of embankment, malfunctioning of regulators and embankment breaching is the example of structural problem. Non-structural problems are little or no participation of stakeholder, conflicts of interest between stakeholders and no community based organization etc. Various projects and invests of BWDB and Government Departments couldn't solved these problems which causes damage to agricultural and socio–economic resources.The existing interventions in haor have had a vast number of impacts on the governing sectors of the region. A brief summary of the major impacts are presented below and are illustrated in **Figure 5.1**:

- The onset of the climatic shift in the past decade has altered rainfall patterns both in terms of frequency and intensity. As a result, the submersible embankments that have been made previously cannot hold off the flood for the prolonged periods of time as was intended. This is damaging planted crops, causing damage to life property and biodiversity of the region.
- Annual flash floods bring with it a substantial amount of sediment load that cannot pass through properly and is being deposited overland and on riverbeds alike. This is silting up the river bed and is directly affecting fish habitat as well as indirectly facilitating the failure of the submersible embankments as the conveyance capacity of the river decreases.
- Exchange of pre-monsoon nutrients between river and haor is being hindered or restricted to some extent due to delaying water entry in to the haors because of submergible embankments. This also hampers the required breeding stimulation for the small indigenous species (SIS) of fish. In some cases eggs are deposited in the fish body, lowering breeding success and increasing fish mortality. This ultimately results in declining trend in fish biodiversity and less sustainable fish production.
- The pressure of demand on fisheries is in constant rise not only in local market but also foreign markets and this is having its toll on the haor fish resources as well. Over exhaustive fishing in the waterbodies is followed by illegal fish catching. Such over exploitation in conjunction with indiscriminate fishing at the water control structures is constantly degrading habitat suitability condition of rivers, khals and beels in terms of quality.
- Enhanced crop production demands the use of agrochemicals and pesticides for higher yields (Highly Variety IRRI/Hybrid). Extensive use of these toxic chemicals is however, is exerting damaging effect on aquatic habitat. This when coupled with obstruction of fish migration route due to construction of road/embankments, are hampering the thriving of this resource. Moreover, use of unconventional fishing methods such as the use of small mesh "moshari" nets, dewatering of beels in pre-monsoon are having negative impact on habitat quality and quantity.

(a) Fish net on structure

(b) Unregulated fish passing

(c) Public cut

(d) Haphazard dumping of dredge spoils

Figure 5.1: Existing issues in the haor region

- Implemented FCD/I projects have created apparent fishing spots at water pockets adjacent to project location during post-monsoon season, though without creating proper awareness and integrating with regular operation and maintenance. Improper O&M is also responsible for increased critical water velocity, particularly for SIS of fishes at critical water depth due to high discharges during pre-monsoon period. This can result in an abrupt water level drop at outlet, for which small to medium sized fishes are unable to migrate through gate openings and culverts during pre-monsoon.
- Although there is no direct impact of water resources project implementation on the terrestrial flora of the region, there are however numerous significant indirect impacts stemming from irregularity in operation and maintenance as well as long term functioning of the interventions. This is only exacerbated by over exhausted use of the natural resources due to population increase and subsequent increase in settlement and improperly planned agricultural extension.

5.3 Key Parameters

Overall sustainable development of the haor region can be envisioned to be a state where the water control structures that have been implemented so that flood control and agriculture can function with minimal if not, zero negative impact on the two most vital resources namely, fisheries and ecology. As a matter of fact, eco-friendly measures thus ought to be taken with provisions for enhancing these resource base through whilst also ensuring mutual gains to agriculture and navigation are the most sought after priority. Some key parameters have thus been identified this chapter based on the issues discussed above. It has to be noted however, that the primary function of these parameters will be to maintain a balance among fisheries and ecology with agriculture and water resources. To preserve the existing fish resources as well as generate fish resource, some design parameters of existing structures and structural interventions to be built in the future have to be maintained. These parameters include geometry of structure and also design bounds such as gate opening, vent size, nos. of vent, depth of allowed flow, velocity of flow etc.

5.4 Design Principles

Haors experience annual flash flooding phenomenon and prolonged submergence. This natural phenomenon acts as pre-requisite in sustaining the rich eco-system. The problem lies in the shifting of both spatial and temporal extent of events, partially caused due to mismanagement of existing hard measures. Rather than preventing flow of water altogether, if certain aspects of the flow can be controlled to an extent so that it can be utilized and its potential can be harnessed; would provide for the ideal scenario and therein lies the effectiveness of eco-friendly measures. In addition, interventions that are resilient and has certain adaptive capability to climate change are required to ensure sustainable development for the region. As such, the design principles furnished in this guideline have been developed taking a holistic approach and considering not only applicable engineering measures, but also non-structural soft measures that would supplement the hard measures in developing an effective management system. Additionally, suggestion for policy integration and existing institutional framework have been provided. Finally, measures for building a climate resilient resource base have been suggested.

5.5 Engineering Measures

Flooding in haor is a regular occurrence and is a requirement for preserving natural balance. At the onset of monsoon each year, heavy runoff from northern hilly terrain floods the entire region. The objective of any measure should therefore not fixate on flood mitigation, but on flood accommodation. As such any and all structural “hard-engineering” measures should focus on this purpose. The necessary measures has to be taken in order to accommodate the annual flood flow in an environmentally friendly manner.

5.5.1 Embankment

Embankments provide the very first line of defense against the advancing flood flow. Embankments established in the haor region are not built to obstruct flow altogether, but impede its advance. The benefits of this delayed flow gained through submersible embankments is multi-folds. This helps in agricultural practices, fish passage as well as helps to minimize the damaging effect of flooding.**Figure 5.2** shows some of the embankment measures described below that are already in practice.

- Earthen submersible embankments are currently in use in haor region. This structure itself is an eco-friendly structure and the use of earth is more eco-friendly compared to concrete. Embankments can be constructed using reinforced earth technique using coal ash as primary fill material. Coal ash has high shear strength that comes from interlocking of particles which is further reinforced through its age hardening and pozzolanic behavior in presence of lime. This material has a high consolidation rate and thus can be compacted over a wide range of moisture content. It has a lighter weight than earth and also possesses quick draining properties. This material is eco-friendly as it conserves agricultural land.
- The inherent unpredictability of haor hydrology undermines the viability of using hard fast engineering measures for water regulation. For this reason, alternatives such as rubber dams can be built as substitute to regulators. Rubber dams can be deployed for water retention purposes for agricultural practices as well as for rural water supply. The bodies of these dams are reinforced by woven synthetic fabrics which provides the tensile strength with rubber acting as the adhesive and water-proofing element.

These dams are more eco-friendly in that, not only does it not restrict river widths, but also provides better navigation options during the monsoon.

- Geosynthetics can be used as embankment materials as they possess wide range of physical properties and are akin to an extensive assortment of practical applications. They can be manufactured to meet a given set of specifications and can be used as barriers, filters, separation, drainage, protection from mechanical damage, and erosion control. Geosynthetics are also environmentally friendly as the drastically reduce the CO_2 emission associated from construction work. Geosynthetic can be deployed near the surface of the dam, as a component of upstream or downstream slope protection, crest roads, toe drain wrappings, and upstream water barriers. They can also be used in term of reinforcement and drainage in embankments, soil reinforcement in dam embankments, separation of materials and filtration, and internal drains or internal water barriers.
- Constructed embankments should have provisions for easy renovations if need be. Embankments play a vital role during crop season in keeping fields submerged enough for crops to grow. It is imperative that an existing embankment work be able to be raised to a few feet to accommodate increasing flood levels.
- Any rehabilitation and repair work on the embankment should be repaired during December to February. This is to ensure that all preparations are completed before the onset of the pre-monsoon season. Rehabilitation works for the embankments have to be done without hampering ecological activities in naturally existing reed-lands. It would serve best purpose if rehabilitation works for embankments utilized the excess dredge materials.
- Multimodal use of embankments can be done through construction of submersible roads over the embankments. This will on one hand provide more accessibility in terms of transportation of both people and goods, and also it will provide protection against erosion and subsequent damage to crops and aquatic habitat.
- Public cuts in embankments are a major concern in haor region. The apparent warrant of their necessity is quickly overshadowed by the long term detrimental implication as it causes instability to the entire retaining structure. Public costs have to be avoided entirely. Existing cuts have to be sealed completely. Wherever this poses environmental concerns, water regulation has to be done by means of installing wooden gates operated by the local people. This will ensure the retaining properties of the structure as well as allow passage during dry season.


(a)Use of eco-friendly embankment materials

(b) Use of geo-synthetics

Figure 5.2: Existing issues in the haor region

5.5.2 Dredging/ Sedimentation

Annual flooding of the haor region brings with a hefty amount of sediment laden flow. Deposition of this sediment in riverbeds and haors alike can cause disastrous events due to the elevated topography it instills. Dredging is therefore of importance in maintaining not only land levels but in cases, slope stability and ensure unhindered passage of flow up to requirement. But dredging itself has environmental consequences that have to be taken care of.

- Being first and foremost a natural process, sedimentation can be an unwanted facilitated occurrence due to unplanned interventions, lack of proper maintenance and also through temporal accumulation. Therefore planning of every structural intervention should have a comprehensive dredging plan built into devised maintenance scheme.
- Dredging has to be conducted periodically at key locations both within haor bounds as well as in perennial and seasonal water bodies to ensure continuous smooth passage of flood flow. Predefined dumping sites for dredged material has to be carefully laid out so that spoils do not cause hindrance for natural processes.
- Close monitoring has to be ensured of dredging activities so as to manage toxic chemicals present in dredge spoils and minimize disturbance to aquatic ecosystems. Disposal area for dredged spoils has to be selected in such as fashion so that no harmful effect befalls the ambient environment.
- Automated dredging processes should be regulated so that benthic substrates do not get dislodged and injected into water columns thus hampering ecological balance. Temporal regulatory bounds have to be in place for prolonged dredging sessions to dampen the effect of short sparks of turbidity, and thus reduce injurious effects on aquatic species metabolism and spawning. Suction dredging activity should only be allowed during fish species non-spawning time.
- Dredging can create disturbance to aquatic ecosystems, often with adverse impacts. In addition, dredge spoils may contain toxic chemicals that may have an adverse effect on the disposal area; furthermore, the process of dredging often dislodges chemicals residing in benthic substrates and injects them into the water column.

- Necessary decontamination procedures should have to be placed to manage toxic dredging spoils and ensure their safe usage. This can include simple procedures such as transporting and dumping the contaminated dredged material to a regulated landfill, then reuse. Aeration of dredged river bed materials can be done should there be presence of volatile organic compounds (VoCs).
- Being more of a low profile accumulation zone, sedimentation along flood control structures can be dredged manually by means of utilizing locally available labor. This can be followed with subsequent usage of excavated materials for rehabilitation of embankments.

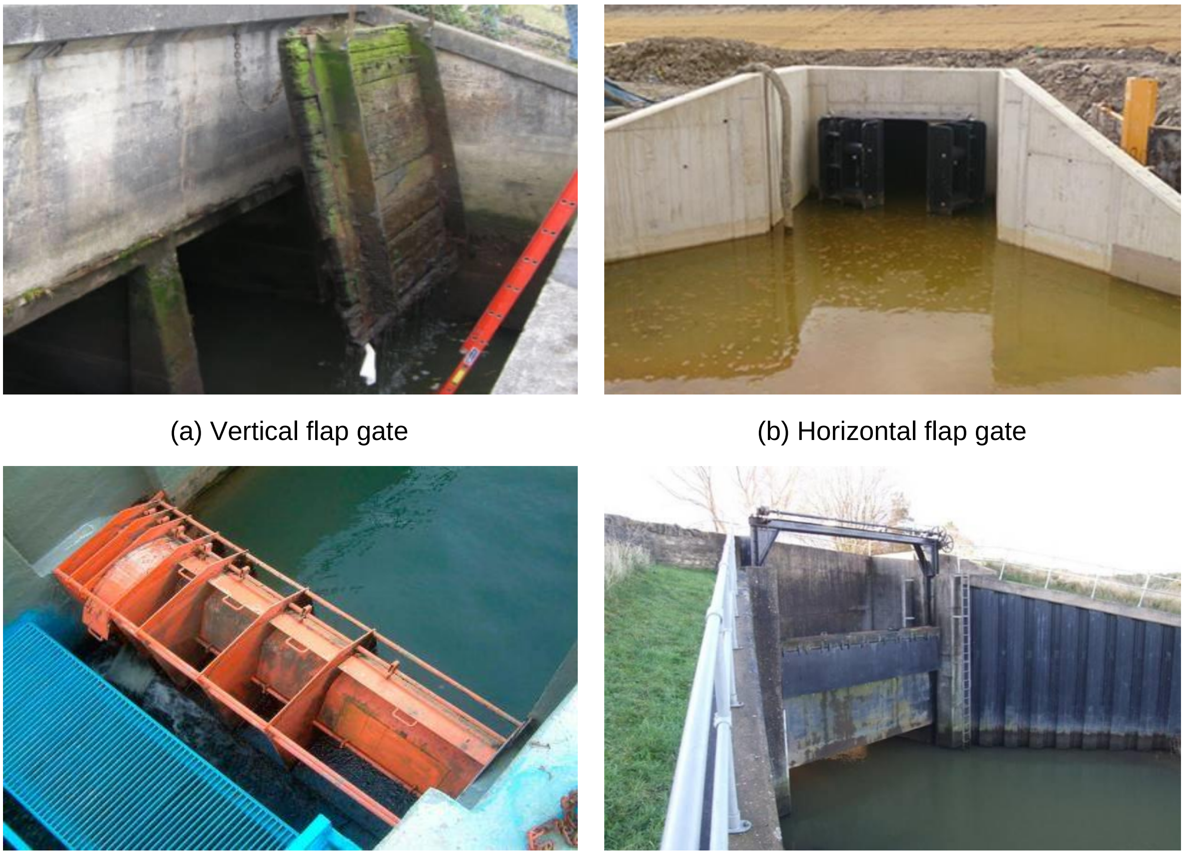
5.5.3 Regulator/ Sluice

Historically, living with flooding has prompted governing authorities in building sluice gates and regulators flood control and irrigation drainage purposes. While this has greatly benefitted irrigation through the past decades, adverse impacts have been observed for the indigenous fish resources. More so, it has also reduced rice and jute crop production due to flooding. Proper maintenance and operation of existing sluice gates and other regulatory structures is of order in a manner whereby agriculture and fisheries sector are mutually benefitted. **Figure 5.3** shows some of the enhancements that can be done to existing as well as future regulatory structures.

- Routine fish migration through regulators and inlets from one floodplain to another has to be ensured as it is essential for both food and breeding purposes. Influence of both hydrological as well as sluice gate operational factors on passage success through sluice gates has to be monitored. These can include sluice gate aperture, current velocity, water pressure, turbulence etc.
- Proper and timely operation/ management of existing regulators and sluice gates have to be ensured for the fish migration into the floodplain thus increasing production of fish and biodiversity. Velocity of flow to and from flood plain have to be regulated so that it provides for safe fish passage. This can be monitored by using marked fish (citation) that will be released on both sides of the flood plain. Recapturing them after a certain period of time can provide valuable information as the nature of fish movement.
- Opening and closing times for sluice and regulator gates have to be planned ahead and closely monitored in a strict manner so that gates can be opened prior to breeding season for fish but not so much as to hamper crop production. The devised O&M schedule has to take into consideration the varying water needs at upstream and downstream sections including for different seasons. Comprehensive operation and maintenance guidelines have to be prepared and adhered to.
- Top hinged flap gates can be used as an alternative sluice gates in selected locations. These gates can be made of wood, fiber reinforced polymer (FRP), fiberglass as opposed to the more traditional metallic gates which makes for easy operation. More so, being light weight in comparison, the unidirectional opening mechanism of this structure can be utilized to incorporate automated flow whenever water level pressure is high enough.
- Side hinged flood gates can be installed atop base culverts at high profile locations with smaller top hinged fish flaps installed on the larger gates. This smaller gates can be regulated manually by local people during fish migration season. Care has to be

taken to counter the fact that a smaller opening enforces larger flow velocities which would harm fish species.

- Motorized vertical lift sluice gate can be used to allow flood flow induced flushing as well as prevent flooding during extreme monsoon. A Program Logic Controller (PLC) can be programmed to operate the electric motor which raises and lowers the sluice gate along with water monitoring sensors for upstream and downstream levels for input to the PLC.



(a) Vertical flap gate (b) Horizontal flap gate

(c) Automated gate opening (d) Vertical lift sluice gate

Figure 5.3: Existing issues in the haor region

5.6 Fish Friendly Structures

5.6.1 Fish Pass/ Fish Friendly Structures

Fish pass or fish friendly structures generally protect fisheries resources from the adverse effects of the unplanned flood control embankments, roads, different water resources development schemes, etc. by facilitating fish movements. Structures of the FCDI schemes usually block natural movement of fish and other aquatic species between rivers and floodplains and adversely affect their life cycle. Delayed inundation of floodplain due to restriction of riverbank overspill may disrupt breeding cycles of 'white fish' whereas reduction of flood depth may promote 'blackfish' species. In addition, restricted access to the floodplain through channels and regulators allows application of more efficient fishing techniques, leaving fishery more susceptible to over-fishing with a consequent fall in production. Inadequate natural flushing of floodplain and resultant poor water quality can also lead to a decline in fish production. As a technical remedy to these problems, fish pass and fish friendly structures (FPFS) may be built particularly on important fish migration routes. The comparison of basic features of FPPS are as follows:

Table 5.1: Basic features of fish pass and fish friendly structures

Sl. No.	Fish Pass	Fish Friendly Structures
1	Suitable for all seasons	Generally workable in monsoon season
2	Effective in both partial and full flood control embankment projects	Effective in full flood control embankment projects
3	Ensure safe movement of all kinds of fish round the year	Ensure safe movement of fish fry, fish hatchling and fingerling.
4	A relatively bigger structure and expensive	Relatively small structure and less costly.
5	Built as an independent structure.	May be built as an amendment to an existing structure.

Fish need to able to bypass embankments to carry out migratory phases of their life cycles. Especially, egg-bearing fish species of beels intend to go to rivers for laying eggs and vice-versa, and fish fries/fingerlings intend to go to beels for feeding to grow up. Fish pass/friendly structure is set on the embankment between two waterbodies by maintaining water velocity which is passable for most of the concerned fish species in intact and tired less condition. Fish can freely bypass the submersible embankments once they are overtopped, but at the breeding time fish cannot migrate to suitable place and other times they can only be bypassed via the project's hydraulic structures(s) and/or by public cuts. The latter applies to full flood control embankments at all times. There are six types of hydraulic structures which, when open, allow the flow of water pass an embankment or into a project area (and thus provide some opportunities for fish to do the same). These are: hydraulic regulator with (i) fall-boards; (ii) vertical lift gates; and (iii) flap gates along with (iv) river barrage; (v) drainage pipe sluice and (vi) irrigation inlet.**Figure 5.4** shows some examples of fish friendly structures along with a conceptual design.

The dimension of the fish pass and fish friendly structures will depend on the catchment area of the scheme, topography of the area, head difference of the inside and outside water bodies, canal width, etc. Gate opening should be based on the discharge and flow velocity of the catchment area along with the size of fish species passable through the structure.

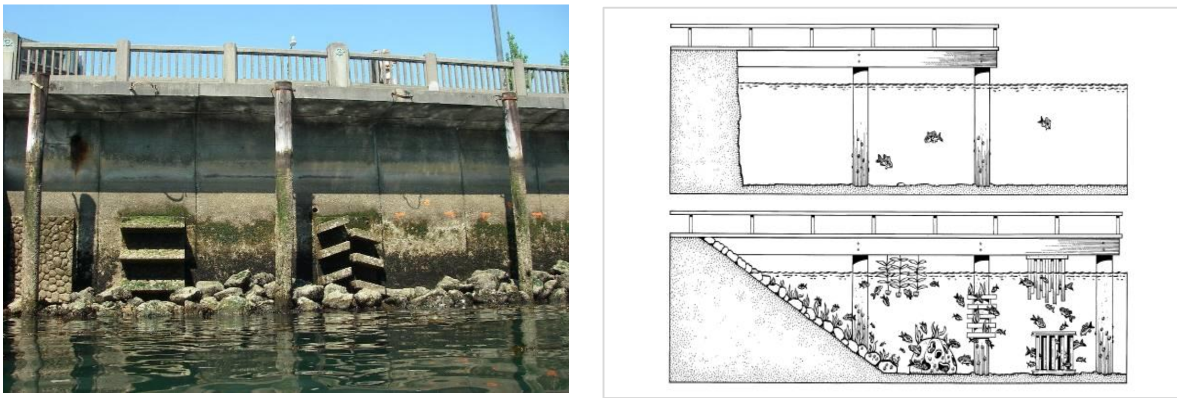


Figure 5.4: Fish friendly structures

5.6.2 Environment Friendly Construction Materials

Good quality habitat will encourage more productive biological communities on a structure. Materials used should be as compatible with the natural environment as possible. Materials that encourage settlement and growth of epibiota may provide additional food and natural refuge for fish:

- Natural materials, such as wood (untreated with chemicals) and rocks may generally provide more 'natural' habitat than artificial materials such as concrete, steel, vinyl and plastic;
- Wood may be less robust and long-lasting than desired in many situations. Where natural wood is not appropriate, recycled plastic composite 'timber' may be an option.
- Concrete can provide a relatively good substrate for growth of epibiota, particularly if sloping and textured. It is durable and stable in the marine environment.
- Geotextile fabric can support rapid growth of diverse fresh water epibiota.
- Use of combination of geo-jute and vetiber grass at the structure slopes may support fisheries and other wildlife and sustaining the structure itself.

All of these structures are purposively built to serve agricultural needs, and none have special features to increase their fisheries efficiency, or serve the needs of navigation. There are several options for providing fish pass facilities in FCD/I projects:

- ✓ Relying on existing hydraulic structures to give passage to migrating fish (with perhaps some modification of structure operation to increase its fisheries efficiency);
- ✓ Relying on public cuts to give passage to migrating fish;
- ✓ Installation of appropriate purpose-built structures designed only for fish migration; and
- ✓ Modifying the design of hydraulic structures so that they are also highly efficient in giving passage to migrating fish (i.e. make them multipurpose).

Fish pass/friendly structure needs

The hydraulic conditions at any obstruction are determined by the topography and the velocity and nature of the flows entering and passing through the reach. The high velocity of the water and turbulence at the hydraulic structure are the prime factors preventing fish to migrate (Clay, 1995). Depth is also another prime factor in fish migration.

The merits of fish way or fish pass structure are as follows:

- ✓ Support and maintain the natural longitudinal an lateral migration;
- ✓ Reduce the hatching/fry mortality rate;
- ✓ Maintain connectivity between the river and beels for flushing and to maintain the condition for fish habitat;
- ✓ Reduce the turbulence;
- ✓ Enough flow and depth to attract fish (especially young fish) to use the structure; and
- ✓ Exit and entrance velocity must be within swimming speed of species (which species expected to be used the structure).

In general, the fish way or fish pass may ensure the safe movement of all kinds of aquatic lives through it throughout the year from outside river system to the water bodies and vice versa.

Principal criteria for a fish pass or fish friendly structure selection:

- The fish pass or fish friendly structure should be constructed at a location that has been adversely affected by another project in a significant way. In other words, the site should promise a major benefit in terms of re-establishing the fish migration routes and increasing fish diversity and catch;
- The impact area inside the Project should be of sufficiently large size that would justify the capital investment and minimize potential opposition from farmers;
- The river outside the structure should be perennial;
- Reliable and abundant populations of migratory fish should occur in the river;
- A number of the Beels inside the FCDI project area should be perennial;
- There should be no cross dams in the Khal which connects to the fish pass;
- Avoid sensitive/critical fish habitats;
- Artificial structures should not be considered as surrogates for natural habitats.

Type of fish pass/friendly structure

Several different types of fish passes/fish friendly structures have been considered for facilitating fish migration or hatchling/fry movement are as follows:

- ✓ Pool and weir fish way;
- ✓ Denil or steep fish passes;
- ✓ Vertical slot fish way;
- ✓ Fish locks;

- ✓ Fish lifts; and
- ✓ Double lift gates.

Most of the embankments in the Haor basin are built for controlling flood and facilitating irrigation. These embankments pose high head differences between the river and Haor during pre-monsoon and monsoon and for this reason vertical slot fish pass structure is suitable for the planning area. In case of minimum head difference, pool and weir/spill fish way is suitable. Types of structures may be different based on the characteristics of the locations. For selecting the type and place of the structure following things should be considered:

- ✓ Condition of fisheries resources prior to the implementation of flood control and irrigation projects;
- ✓ Size and nature of the flood control and irrigation projects;
- ✓ Abundance of fish, their behavior, and cruising swimming speed;
- ✓ Location and nature of connecting canals of both sides of the waterbodies at fish pass site;
- ✓ Cropping pattern and crop production season inside the irrigation project;
- ✓ Topography, hydrology and patterns of hydraulics in the irrigation and flood control project.

Following tables attribute the fish species wise length and corresponding cruising and maximum speeds considered/allowable for establishing fish pass/ friendly structures.

Table 5.2: Target carp large species for fish pass/friendly structure

Group	Species	Type	Minimum Size*			Maximum Size**		
			TL	V_c	V_m	TL	V_c	V_m
Native Carp	Rui	P	43	150	300	85	300	600
	Catla	P	43	150	300	90	315	330
	Mrigel	P	38	135	270	80	280	560
	Kalibaush	P	28	100	200	50	175	350
Minor Carp	Gonia	P	22	80	160	40	140	280
	Lachu	P	17	60	120	25	90	180
	Sarputi	P	14	50	100	25	90	180
Exotic Carp	Carpio	P	24	85	170	50	175	350
	Silver Carp	P	38	135	270	80	280	560
	Grass Carp	P	53	185	370	85	300	600

Source: FAP 6

Table 5.3: Target non-carp large species for fish pass/friendly structure

Group	Species	Type	Minimum Size*			Maximum Size**		
			TL	V_c	V_m	TL	V_c	V_m
Large Catfish	Boal	B	48	35	70	115	85	170
	Air	B	43	30	60	85	65	130
	Ghagot	B	43	30	60	80	60	120
	Baghir	B	80	60	120	180	135	270
	Rita	B	33	25	50	55	40	80
Knifefish	Chital	P	43	150	300	100	350	700
Herring	Ilish	P	28	100	200	45	160	320
Spiny Eel	Baim	B	38	30	60	80	60	120

Source: FAP 6

Table 5.4: Target barbs and catfish species for fish pass/friendly structure

Group	Species	Type	Minimum Size*			Maximum Size**		
			TL	V_c	V_m	TL	V_c	V_m
Small Barbs	Puti	P	3.5	10	20	10	35	70
	Mola	P	4.5	15	30	9	30	60
	Chela	P	5.5	20	40	15	55	110
Small Catfish	Kani Pabda	P	11	40	80	18	65	130
	Pabda	P	14	50	100	25	90	180
	Bacha	P	17	60	120	25	90	180
	Garua	P	16	55	110	25	90	180
	Baspata	P	7.5	25	50	10	35	70
	Batashi	P	5.5	20	40	7	25	50
	Tengra	P	9	5	10	15	10	20
	Gulsha	B	11	10	20	18	15	30

Source: FAP 6

Table 5.5: Target other small fish species for fish pass/friendly structure

Group	Species	Type	Minimum Size*			Maximum Size**		
			TL	V_c	V_m	TL	V_c	V_m
Loach	Rani	B	7.5	5	10	12	10	20
Spiny Eel	Cirka Baim	B	14	10	20	25	20	40
	Tara Baim	B	14	10	20	28	20	40
Knifefish	Foli	P	21	75	150	27	95	190
Needlefish	Kaikka	P	18	65	130	25	90	180
Sardine	Chapila	P	11	40	80	15	55	110

Source: FAP 6

P - Pelagic species; B- Benthic species; TL- Total Length (cm);

** Average size at first maturity; ** Average size of largest individuals in stock;*

V_c - Cruising swimming speed (cm/sec), estimated as 3.5 times body length per sec for pelagic species, and 0.75 times body length per sec for benthic species;

V_m - Maximum swimming speed (cm/sec) is estimated as 2 times cruising speed. V_m is assumed to be the maximum water velocity that can be negotiated through the fish pass.

5.7 Ecology Friendly Measures

Compared to other ecosystems, wetlands are fragile and vulnerable ecosystems. Across the country, wetlands are deteriorating at an alarming pace with the progress of development activities and intensive agricultural practice. Haor wetlands are one of the major ecosystems for the country that requires a holistic eco-friendly plan for any development actions to keep a harmonious relationship between humans and nature which is essential for the sustainability of these haor wetlands.

Agricultural extensions and infrastructural developments have changed haor ecosystems day by day. Different livelihood activities and anthropogenic pressures have impacts on biodiversity and ecological setup of haor areas. To meet up food demand, agricultural extension and incretion of cropping intensity is needed must. For this issue, construction of water control structures have been implemented and application of pesticides/herbicides are increased which forcing ecological imbalance. Ecofriendly solutions can be a way of suitability both for meeting human demands as well as keeping ecological components in healthy manner.

As most of the impacts on haor ecosystem are not directly induced from structural interventions, so no hard measures is considering for future plan. However, here proposed some ecofriendly solutions in haor areas those are mainly related with other disciplinary planning.

I. Implementation of Landuse Planning

Different landforms of the haor area support different ecosystems. To protect each of the landform with its ecological components, proper landuse planning is essential. It will also help to protect future illegal encroachment and demolition of natural vegetation on kandas, fallow lands, forests and reedlands. Government should take regulatory reformation to keep wetlands and ecologically important areas and circulate publicly the landuse plan in local level. The plan should be prepared with exclusive zone of agricultural land, forest land, beel area, seasonal wetlands, fishing area, reed beds, restricted core habitats of important wildlife etc.

II. Consideration water depth in wetland

To keep habitat suitability of Beels and khal areas of haor, design levels for water structures and khal beds should be considered for keeping minimum (required) water level whole of the year after utilized for irrigation purpose. Connectivity between river and beel should be ensured throughout the year.

III. Fixing up the fishing season

To avoid aquatic animals' population loss, damage of aquatic vegetation and ensure nutrient recycling of the haor, fishing seasons should be fixed. First quarter of the monsoon is time for germinating for most of the aquatic vegetation and breeding of aquatic wild fauna. So, it is need to consider fixing fishing season of haor floodplains as well as avoid fishing in 1.5 month (Mid May to last of June).

IV. Use green slope protection against erosion

Slope and bank erosion can be minimized through plantation of Dhol Kolmi (Ipomoea fistulosa) plant which have also economic value for using as fuel wood. This plant is fast propagating and regenerate each year. Embankment, road and settlement toe area can be taken under Kolmi plantation for protect erosion from wave action. Chailla Gaash (Hemarthria protensa) is another grass species suitable for settlement protection from wave action. Submergible embankment can be planted with Hizol (Pongamia pinnata), Koroach (Crataeva nurvala), and Indian willow (Salix tetrasperma) for its stability. These plants will also help as a resting and nesting habitats for avifauna. So, using of native plants can be long term and low-cost measures for soil erosion in lieu of concrete protection.

V. People awareness for application IPM and wildlife conservation

To conserve existing wildlife habitat and avoid hunting of migratory birds and other wild animals, people awareness is essential. In addition, introduction of Integrated Pest Management (IPM) will greatly beneficial for reduction of wild faunal extinction. The programme can be initiated through union level under supervision of DAE and Forest Department and other NGOs.

VI. Create opportunity for commercial snail culture

Duck rearing is emerging important livelihood in haor areas which creates threats on freshwater snails. Snails have important contribution to keep continuation of food chain in wetland ecosystem, providence of fish feeds and soil nutrients. Commercial snail culture can be a well alternative to sustain snail population in haor basin.

References

FAP (1993), Northeast Regional Water Management Plan, Bangladesh Flood Action Plan 6(IEE NERP FAP 6), Government of the People's Republic of Bangladesh, Dhaka 1212

MPHA (2012), Master Plan of Haor Area, Annex-I (Water Resources Sectoral Report), Department of Bangladesh Haor and Wetlands Development, Ministry of Water Resources, Government of the People's Republic of Bangladesh, Dhaka 1215.

Report on

Strategic Environmental Assessment Report for the Haor Region

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Abbreviations and Acronyms

BADC	Bangladesh Agricultural Development Corporation
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BWDB	Bangladesh Water Development Board
CAD	Command Area Development
CBD	Convention on Biological Diversity
CE	Chief Engineer
DAE	Department of Agriculture Extension
DBHWD	Department of Bangladesh Haor and Wetlands Development
DoE	Department of Environment
DoF	Department of Fisheries
DTW	Deep Tube Well
ECA	Environmental Conservation Act
ECA	Ecologically Critical Area
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
EIP	Early Implementation Programme
EMP	Environmental Management Plan
ESCU	Environment, Social, and Communication Unit
FAP	Flood Action Plan
FCD	Flood Control and Drainage
FCDI	Flood Control, Drainage and Irrigation
FMD	Flood Management and Drainage
FY	Financial Year
GAP	Good Agricultural Practices
GC	Growth Center
GDP	Gross Domestic Production
GoB	Government of Bangladesh
HQ	Head Quarter
HYV	High Yielding Varity
ICM	Integrated Crop Management
IPM	Integrated Pest Management
IWRM	Inland Water Resource Management
LGD	Local Government Division
LGED	Local Government Engineering Department

LGI	Local Government Institutions
LLP	Low Lift Pump
MLGRD&C	Ministry of Local Government, Rural Development & Co-operatives
MoEF	Ministry of Environment and Forest
NBSAP	National Biodiversity Strategy and Action Plan
NCA	Net Cultivable Area
NEMAP	National Environment Management Action Plan
NEP	National Environmental Policy
NFP	National Fisheries Policy
NWMP	National Water Management Plan
NWP	National Water Policy
O&M	Operation and Maintenance
PD	Project Director
PIO	Project Implementation Office
PMU	Project Management Unit
PPP	Policy, Plan and Program
RHD	Roads and Highways Department
RoW	Right of the Way
SEA	Strategic Environmental Assessment
SMO	Supervision and Monitoring Office
SRP	System Rehabilitation Project
STW	Shallow Tube well
TSP	Triple Super Phosphate
UNEP	United Nations Environment Programme
UNO	Upazilla Nirbahi Officer
UZHQ	Upazilla Head Quarter
WARPO	Water Resources Planning Organization
WQS	Water Quality Standards

Executive Summary

Bangladesh possesses enormous area of wetlands including rivers and streams, haors, baors, beels, etc. with extensive mangrove swamps. The haors are of fluvial origin and are commonly identified as freshwater wetlands. Haor basin in Bangladesh comprised of large areas of seven districts, namely Sylhet, Sunamganj, Habiganj, Moulvibazar, Kishoreganj, Brahmanbaria and Netrokona Districts covering an area of 20,022 square kilometers. There are 373 haors which cut across 164 unions and 29 sub -districts of seven districts. The haors are the source of livelihoods of millions of rural people who depend on haor for fishing, rice farming, boating, hunting, wage laboring in sand and stone mines, etc. However, like many other wetlands, haor areas are also under threat mainly due to human intervention. The people of these localities whose livelihood depend on wetland based earnings suffer due to these interventions which enhanced the loss of fish production and biodiversity in floodplain ecosystems. Precisely the natural characteristics of haors and other wetlands are gradually disappearing. Though to minimize such loss, Environmental Impact Assessment (EIA) are being conducted prior to start of any project. However, EIA is a reactive approach whereas to conserve the haor areas certain proactive approach is required which will work from the very beginning prior to design any project. Therefore, Strategic Environmental Assessment (SEA) is a pro-active management instrument that will ensure environmental issues are addressed from an early stage in the process of formulating policies, plans and programs, and incorporated throughout this process. It is anticipated that conducting SEA for Haor Region will conserve its environmental and social value as well as its natural characteristics.

The SEA study has been carried out in accordance with the OECD Guidelines, 2006 through a multi-tiered approach involving four stages that include: i) Conceptualization of the overall study including identification of all relevant plans and policies that might impact alternatives involving screening; ii) Articulation of study bounds and concerns of the study with identification of strategic issues to be addressed; iii) Detailed SEA study involving review of key plans/ policies and studies, identification of pertinent stakeholders and subsequent site visits for assessing baseline situation; and iv) Development of detailed plan addressing all identified strategic sustainability objectives through specific criterion based analyses and application of indicator wise alternative approaches in developing a concise decision making tool.

In the conceptualization phase i.e. first stage of conducting the SEA, interventions were identified in water sector and infrastructure sectors in haor areas through literature review (Haor Master Plan) and consultation with different concerned organizations (such as LGED, RHD, Haor Development Board). The selected Policy, Plan and Programs (PPPs) went through screening process to conclude which PPP requires SEA. The screening process included pre-screening and environmental significance screening. Pre-screening was performed to determine whether the proposed plan/program would require SEA. Later the above selected PPPs went through the environmental significance criteria. After completing the screening process the selected PPPs went through the further steps of SEA process. After screening of the projects; Haor Flood Management and Livelihood Improvement Project, Village Protection against Wave Action of Haor Area, 15 roads of LGED and 5 roads of RHD under different plans and programs for Improvement of road communication system of the haor area have been selected for conducting the SEA.

In the second stage, identification and evaluation potential impacts due to the above mentioned selected plans, programs and projects have been conducted. This stage was the beginning of the SEA process in earnest. It developed an understanding of the key environmental and social issues that may be affected and the key measures to be proposed. Precisely, this step identified which aspects of environment might be affected by their implementation and which of these affects were likely to be significant and therefore required investigation. The study team members identified and addressed the likely environmental impacts of the identified interventions. The key environmental aspects that were considered in this SEA are Water resources and navigation, fish, agriculture, ecology and social. Probable impacts on these key environmental aspects were identified accordingly. The evaluation of the identified impacts has been done using 'Impact Matrix' by relevant experts through assessing their magnitude and sensitivity. Scores from -3 to +3 against each of the applicable indicators of the five key environmental aspects reflecting the negative and positive impacts along with their magnitude and sensitivity. Subsequent to the impact assessment discussed above, appropriate mitigation measures have been proposed to avoid, offset, mitigate/reduce, or compensate for the identified impacts.

The third stage involved identifying the preferred alternatives based upon environmental ground and public consultation.

By definition alternative strategy means the strategies those substitute the proposed ones to attain the same objectives. However, here it is tried to suggest options/ strategies that trigger/ strengthen the proposed programs instead of conventional alternative strategies which will reduce the environmental affect and contribute to socio economic development.

To be specific one case study has been designed to show the strategic option for 'Improvement of Taherpur UZHQ Maddanagar via Solmanpur Road'.

The proposed road will go through three haors; Matian Haor, Lubar Haor and Shanir Haor. Two alternative option/strategies have been proposed where the road alignment will be changed slightly and go along the haor boundary of Lubar Baor to avoid the crossing of Baidar Beel. The proposed road length will be 13.9km. Another strategy can be shifting of road alignment along the Shanir and Lubar Haor to avoid interruption of agricultural land and Baidar Beel.

Beside, for proposed roads in deeply flooded area, the strategies are, roads should be submergible and alignment should be along submersible embankment and elevated if anticipated to interrupt important haor eco system. Any further new road should not be constructed in deeply flooded area.

Strategic options/condition for Flood management and wave protection related infrastructure are stated below:

a. All the embankments should be submersible with attention to the improvement of standard of living of the community as emphasized in National Water Policy.
b. To prevent wave attack, CC blocks revetment over geo textile can be used which is the most economical solution in the haor areas. The technique is both environment friendly as well as socially acceptable.
c. Embankments can be constructed using reinforced earth technique using coal ash as primary fill material. This material is eco-friendly as it conserves agricultural land.
d. Geo-synthetics can be used as embankment materials as they possess wide range of physical properties and are akin to an extensive assortment of practical applications.
e. CC blocks revetment over geo textile are the most economical solution in the haor areas for wave protection. These techniques are both environment friendly as well as socially acceptable in their structure.

Chapter 1: Introduction

1.1 Introduction

Strategic Environmental Assessment (SEA) is emerging as a new form of environmental assessment and has already been in practice around the world. It aims to integrate environmental considerations into policies, plans and programmes and evaluate their inter-linkages with economic and social considerations. A growing number of countries at all levels of development have legislation or regulations prescribing the application of Strategic Environmental Assessment (SEA) and many more are introducing it as part of their policy tools.

In Bangladesh, SEA is practicing but not as a legal binding like EIA. However, initiative has been taken to mainstream it and include it in national policies/strategies. Being a part of current practice, a SEA study has been accomplished for Haor region as a preliminary initiatives in Bangladesh for plans related to water management related infrastructure.

Bangladesh possesses enormous area of wetlands including rivers and streams, haors, baors, beels, etc. with extensive mangrove swamps. The haors are of fluvial origin and are commonly identified as freshwater wetlands. Haor basin in Bangladesh comprised of large areas of seven districts, namely Sylhet, Sunamganj, Habiganj, Moulvibazar, Kishoreganj, Brahmanbaria and Netrokona districts covering an area of 20,022 square kilometers (MPHA, 2012). There are 373 haors which cut across 164 unions and 29 sub -districts of seven districts. The haors are the source of livelihoods of millions of rural people who depend on haor for fishing, rice farming, boating, hunting, wage laboring in sand and stone mines, etc.

Like many other wetlands, haor areas are also under threat mainly due to human intervention. The people of these localities whose livelihood depend on wetland based earnings suffer due to these interventions which enhanced the loss of fish production and biodiversity in floodplain ecosystems. Precisely the natural characteristics of haors and other wetlands are gradually disappearing. Though to minimize such loss, environmental impact assessment are conducting prior to start any project. However, EIA is a reactive approach whereas to conserve the haor areas certain proactive approach is required which will work from the very beginning prior to design any project. Therefore, strategic environmental assessment is a pro-active management instrument. It is anticipated that conducting SEA for Haor region will conserve its environmental and social value as well as its natural characteristics.

1.2 Study Objective

Generally the key objective of SEA is to provide early warning of cumulative environmental and social effects that would fall under thresholds for triggering a project EIA. The following specific objectives have been formulated for carrying out the SEA study:

- Identify relative policies, plans, programs related to water resources and infrastructures of haor region and their environmental consequences to ensure appropriate development with economic and social consideration for conservation of Haor Areas;
- Assessment of the impacts exerted by development programs on existing bio-physical and socio-economic conditions of Haor region
- Identify viable alternatives to minimize overall impacts to ensure eco-friendly development

- Prepare comprehensive strategic measures for conservation of environment encompassing the Haor region in accordance with future socio-economic development activities; and
- Development of a comprehensive SEA statement framework to support decision aiding.

1.3 Description of Major Intervention Sectors of Haor area

The haor area of Bangladesh has a unique biodiversity with a large number of flora and fauna all across the wetland. The wetland ecosystem in the northeast of the country is critically important as it plays a vital role in ensuring the food security of the country and conserving the environmental balance.

People living in the haor area mostly depend on agriculture and fisheries. About 0.71 million ha of net cultivable land is available in this area, which produces more than 5.25 million tons of paddy each year. However, sudden intrusion of flash flood may destroy agricultural production of about 0.33 million ha, worth Tk. 3,486 million or 3% of the national agricultural contribution to the Gross Domestic Product (GDP). Haors are rich in aquatic biodiversity, particularly in diverse fish species. There are 140 species of fish in the haor region, which is also home to thousands of migratory birds. Though haor area provides a lot of opportunities both economically and environmentally, it is still a very much under developed area

The haor basin is surrounded by the hill ranges of Meghalaya (India) on the north, the hills of Tripura and Mizoram (India) on the south, and the highlands of Manipur (India) on the east. The bowl shaped large tectonic depression receives surface runoff water from the surrounding rivers and khals and consequently become very comprehensive water body in the monsoon. On the other hand, they dry up mostly in the post-monsoon period. Over the past years this area has experienced some of the most severe hydrological events due to its situation just below the hilly regions of the States of Assam, Meghalaya and Tripura of India.

The most extensive seasonally flooded area of haor is located in between the natural levees of rivers subjected to overflow during the monsoon. The major rivers of this area are Surma and Kushiara alongside some other tributaries Manu, Khowai, Jadukhata, Piyain, Kangsha, Mahadao, Mogra etc. These rivers have created the dense drainage network of the haor region and are the key sources of sedimentation. The physical setting and hydrology of the haor region produce a unique hydrological regime, which creates innumerable opportunities as well as constraints for the inhabitants. Annual rainfall ranges from 2200 mm along the western boundary to 5800 mm in its north east corner and is as high as 12000 mm in the headwaters of some catchments extending to India. Flash flood is the main disaster here which engulfs the primary production sector (e.g., agriculture) and thus threatens the lives and livelihoods of the inhabitants of the haor region. Excess rainfall in the upstream hilly areas and subsequent runoff, river sedimentation, unplanned road and water management infrastructure, deforestation and hill cuts, landslide, improper drainage and the effect of climate change and variability can be viewed as the main reasons for the devastation caused by flash floods.

Water Resources

The vast haor area of Bangladesh mainly faces flash flood, river bank and wave erosion, drainage congestion, poor navigability and sedimentation. Among them flash flood in the pre-monsoon season inundates a large area and nearly ripen crops which is the only source of livelihood for a lot of people living in there. Flooding is also seen to take place in the monsoon, but the damage caused by this is not as severe as the flash flood. In the beginning of dry season drainage problem is causing inconvenience to the cultivator as they cannot make the agriculture bed ready for ploughing. Sedimentation in the canals, connecting the haor with rivers is squeezing the path of water regulation and is causing the problem of water congestion. The beds of the canals and rivers are risen up to 10 feet in particular cases which has resulted in the decrease of water conveyance capacity. The villages and the rural roads inside a haor often face erosion due to wave of *Afal.* The embankment around the villages and the base and sub base courses of the roads are deteriorated in this phenomenon.

Infrastructure

The villages inside the haor area are subjected to various types of natural calamities. The banks of the villages are deteriorated in a large scale due to waves. In some places embankment has been constructed along the bank of the villages and where the threat is bigger retaining walls are constructed. The roads in the haor are also seen to degrade due to wave action. The elevation of the roads is increased in many places to prevent this. After the drainage of flood water many roads become unusable due to the saturation of water inside the road surface. The low-lying settlements inside the haor frequently confront water logging. Narrow passage of water drainage is responsible for this.

Transportation system

The people living in the haor area are mostly dependent on the surrounding rivers and water bodies for the transportation facilities. Different government organizations have constructed some rural and local roads across the haor. The natural causes for the degradation of the transportation system are flash floods, *Afal* or wave erosion, annual inundation, water logging, siltation and sedimentation. Apart from this, Transportation facilities face problems such as lower land elevation, weak infrastructure, and vulnerability due to seasonal variation, scarce facilities, unplanned development and lack of suitable modes of transportation. Boats are the only mode of communication in pre-monsoon (March-May) and monsoon (June-August) season. For the last couple of years, the transportation system has been obstructed in few places due to the accumulation of sediment on river and haor bed. The rise of river bed has decreased the water conveyance capacity of river and canal, resulting in the downfall of navigability of the water vessels. The roadway network connecting the Upzila HQ is somehow satisfactory, but the union level roads have been constantly degrading due to lack of maintenance and wave action. In the beginning of dry season (mid-October) the suffering of the people in haor area increases as they can neither use the waterway as it starts to decrease or the roadway which remains under little water and makes it unusable.

1.4 Study Approach

The SEA study has been carried out in accordance with the OECD Guidelines, 2006 through a multi-tiered approach involving four stages that include:

- Conceptualization of the overall study including identification of all relevant plans and policies that might impact alternatives involving screening;

- Articulation of study bounds and concerns of the study with identification of strategic issues to be addressed;
- Detailed SEA study involving review of key plans/ policies and studies, identification of pertinent stakeholders and subsequent site visits for assessing baseline situation; and
- Development of detailed plan addressing all identified strategic sustainability objectives through specific criterion based analyses and application of indicator wise alternative approaches in developing a concise decision making tool.

The methods have applied extensive review of literature on relevant policies, legislations, regulations and institutional frameworks. Other local and global SEA studies have also been reviewed. The team has used a rigorous participatory approach involving consultations with both the client and key stakeholders such as statutory officers, industrial investors and political leaders. Local communities have also participated through a stakeholder consultation and a public forum. The multidisciplinary SEA team has generated most of their decisions through structured continuous brainstorming sessions. Potential bio-physical and socio-economic impacts have been identified for all the alternatives using a matrix that recorded the estimated intensity and duration of each possible impact. Mitigation measures have also been identified for each negative impact, and implementation and monitoring plans proposed.

Stage 1: Conceptualization (Literature review/ Screening)

Initially, interventions were identified in water sector and infrastructure sectors in Haor areas through literature review (Master Plan of Haor Area, 2012) and consultation with different concerned organizations (such as LGED, RHD, Haor Development Board). The selected PPPs went through screening process to conclude which PPP requires SEA. The screening process includes pre-screening and environmental significance screening.

The first step was pre-screening to determine whether the proposed plan/programme would require SEA. It allowed rapid screening out of PPPs that were clearly not going to have any environmental impact and screening- in those that definitely do require SEA. The criteria/ question that the selected PPPs went through were,

- Is the PPP prepared for water management, transport, agriculture, waste management or any land use?
- Is it a fully flood control related PPP?
- Does it provide any development consent for any project?

For those PPPs, the answer was ‘yes’, might require SEA and went through the environmental significance screening process.

Later the above selected PPPs went through the environmental significance criteria. Criteria for determining the likely significance of environmental effects which have been discussed in chapter 3.

After completing the screening process the selected PPPs went through the further steps of SEA process.

Stage 2: Identification, evaluation and mitigation of potential impacts

This stage was the beginning of the SEA process in earnest. It developed an understanding of the key environmental and social issues that may be affected and the key measures to be proposed. Precisely, this step identified which aspects of environment might be affected by their implementation and which of these affects were likely to be significant and therefore required investigation.

The study team members identified and addressed the likely environmental impacts of the identified interventions. The key environmental aspects that were considered in this SEA are Water resources and navigation, fish, agriculture, ecology and social. Probable impacts on these key environmental aspects were identified accordingly.

The evaluation of the identified impacts has been done using 'Impact Matrix' by relevant experts through assessing their magnitude and sensitivity. Scores from -3 to +3 against each of the applicable indicators of the five key environmental aspects reflecting the negative and positive impacts along with their magnitude and sensitivity.

Subsequent to the impact assessment discussed above, appropriate mitigation measures have been proposed to avoid, offset, mitigate/reduce, or compensate for the identified impacts. Mitigation options were ranged from

- Fundamental change to PPP that is to identify alternatives with a lower impact over all
- Fine tune elements within PPP to ensure that their impacts were reduced

Stage 3: Development of Alternative strategies

This stage involves identifying which are the preferred alternatives based upon environmental ground and public consultation. It may be the case that the preferred alternative is not the best in terms of environmental impacts. This has been clearly stated in the report.

Chapter 2: Review of Plans and Existing Environmental Policy Directives

2.1 Introduction

This chapter will give a concise shot over Haor master pan, future plans of BWDB, roadmap of RHD and LGED to identify the plans to conduct SEA. Along with this, existing environmental policies were also reviewed and precisely discussed in this chapter which will complement/ support SEA process.

2.2 Plans and Programs for SEA

2.2.1 Master Plan of Haor Area

The ***Master Plan of Haor Area*** was prepared in 2012, the first planning document prepared for Haor region. It was a framework plan consisting of 17 Development areas. The Plan will be implemented in three phases and implementation will begin conceptually in the financial year 2012-2013 and will be completed at the end of the financial year 2031-2032. The three phases of the Plan are: Short Term: 1-5 years (from FY 2012-13 to FY 2016-17); Medium Term: 6-10 years (from FY 2017-18 to FY 2021-22) ; and Long Term: 11-20 years (from FY 2022-23 to FY 2031-32) The major plans for water sectors which are directly related to Haor are as below:

- Pre-Monsoon Flood Protection and Drainage Improvement in Haor Area
- Flood Management of Haor Area
- River Dredging and Development of Settlement
- Development of Early Warning System for Flash Flood prone area in Haor and dissemination to Community Level
- Village Protection against Wave Action of Haor Area
- The major plans for water sectors which are directly related to Haor are as below:
- Up gradation of Rural Roads;
- Submersible rural road construction
- Submersible District road construction (Sulla to Ajmiriganj)
- Submersible District road construction (Khaliajuri to Ajmiriganj)
- Submersible District road construction (Itna to Ajmiriganj)
- Submersible District road construction (Austagram to Lakhai)
- Submersible District road construction (Derai to Jagannathpur)
- Construction of Regional Highway
- Construction of Surma Bridge at Chhatak
- Development of 150 landing facilities in the rural area
- Construction of terminal buildings at 15 major passenger stations

2.2.2 Plan and program of BWDB Projects

BWDB has implemented about 118 schemes in the haor area since 1975-76 to till date with a view to mainly protect Boro crop with some other functions like, drainage, irrigation; full flood protection etc by the program of Early Implementation Programme (EIP), System Rehabilitation Project (SRP), Flood Action Plan (FAP), Haor Rehabilitation Schemes. In addition there are some projects only for flood protection, some are for irrigation, and some are for drainage only whereas some are of mix-function. These interventions in haor are maintained every year by BWDB to the required extent to facilitate food production with the allocated budget by GoB.

2.2.3 Plan and Program of LGED

LGED has constructed 184 sub-projects in the haor areas that relate to partial flood management, drainage and water management. Among those projects, 111 subprojects are identified as FMD/ drainage type sub-projects and the rest are for water management, irrigation/CAD subproject in the periphery of Haor area. LGED has also constructed 2 rubber dams for flood management purposes by replacing an existing an old regulator, and in other case by providing a Rubber Dam at an existing opening in the embankment in connection with Karehar Haor project. There are other two rubber dams for water retention by LGED. The projects for transportation sector which are directly and indirectly related to Haor are as below:

- Madanpur-Dirai-Sullah Road
- Taherpur-Mohjampur-Chatapati-Madhanagar Road (Moheshkhali)
- Dharmpasha GC - Joysree GC Road.
- Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road.
- Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha
- Joysree GC - Moddhanogar GC via Chamerdani UPC Road.
- Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.
- Madhayanagar UPC - Toker bazar via Shahapur Road.
- Paykurati UPC - Toker bazar via Jamalpur Madrasha Road.
- Chamerdani UPC - Shararkona Ghat Road.
- Lankapathria-Banarasshipur via Razapur Rd.
- Rasulpur-Azabpur Road
- Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd
- Itna-Azmiriganj GC Road
- Austagram- Lakhai road via Ekurdia Dalarkandi Road
- Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part);
- Banichang-Azmiriganj-Jalsuka; and
- Itna-Mithamoin-Austogram

2.2.4 Plan and Program of Roads and Highway Department

The Roads and Highways Department (RHD) has finalized the road master plan for next 20 years considering maintenance and development objectives. This plan has been developed in response to the direction provided by the National Land Transport Policy, which committed the Government to 'develop a long term (20 year) Road Master Plan. The following projects have been identified in the Haor area as necessary and feasible to cope with traffic growth during the Master Plan period.

- Baniachoong-Azmmeriganj-Hobiganj-Shibpasha Road;
- Baniachoong-Azmmeriganj-Jalshuka Road Road; and
- Itna-Mithamain-Austagram Road

2.3 Existing policy directives related to Water Resources Development

The Department of Environment, the Ministry of Environment and Forest (MoEF) is the main responsible agency to control and abatement of water pollution in Bangladesh. Broadly, DoE are mandated to set and enforce environmental regulations for all forms of pollution and media (air, water and soil). Specifically in relation to water pollution, DoE are responsible for: pollution control; setting water quality standards (WQS) for water use and discharge; defining environmental impact assessment (EIA) procedures; issuing environmental clearance permits; and declaring and protecting degraded ecosystems.

The Ministry of Water Resources through several of its agencies, particularly the Water Resources Planning Organization (WARPO) and the Bangladesh Water Development Board (BWDB), are responsible for all other forms of water management in Bangladesh. The BWDB is principally responsible for implementation, operation and maintenance of water related projects, whilst WARPO is mandated to provide advice on policy, planning and regulation of water resources. The policies and laws through which the BWDB, WARPO and DoE operate include: the National Water Policy; the National Environment Policy and Rules; and the Environmental Conservation Act. There are more than 200 laws aimed at addressing environmental issues in the country (Final Research Report Section 2, Alexandra Clemett).

In 1992 the ***National Environmental Policy (NEP)*** was drawn up with the aim of providing protection and sustainable management of the environment considering four (4) objectives. The relevant objective of the Policy which are pertinent for this study are: i) maintaining the ecological balance and overall development through protection and Improvement of the environment out of four objectives. The present SEA study is the main endeavour, Is the infrastructural development works in the Haor area to comply with the above objectives? and all the controls mentioned in the Water Development, Flood Control and Irrigations sector under the Policy.

In 1999 the ***National Water Policy (NWP)*** was drawn up with the goal improved water resources management and protection of the environment. Every public agency, every community, village and each individual has an important role to play in ensuring that the water and associated natural resources of Bangladesh are used judiciously so that the future generations can be assured of at least the same.

Water bodies like haors, are precious assets of Bangladesh with unique regional characteristics. Apart from their scenic beauty, they have great economical and environmental value. Even during extremely dry seasons, when the smaller beels in the Haor area turn into swamps, the haors retain considerable amount of water. These water bodies account for a large share of the natural capture fisheries and provide a habitat for a wide variety of aquatic vegetation and birds. They also provide sanctuary to migratory birds during winter.

The haors and the beels usually connect to some adjoining river through khals. In the past, many beels have been drained through engineering interventions and turned into cropland for immediate gains. The adverse effects of such interventions have been deleterious to the environment. They have destroyed the fish and aquatic vegetables that thrive in these wetlands and are important in the diet of the rural poor. They have also blocked the flow of wastes, discharged from the flood plains and domestic sources, which naturally move out of the beels through the khals into the river's drainage system. Only submersible dikes have provided tangible benefits in certain haor areas by enabling cultivation of high yielding variety boro rice.

The Government believes that in order to assist the natural processes of groundwater recharge, maintenance of aquatic life and ecological balance, disposal of wastes through the dynamic river system, and for turning the huge water bodies into recreational areas, their planned development is essential. It is, therefore, the policy of the Government that: Natural water bodies such as beels, haors, and baors will be preserved for maintaining the aquatic environment and facilitating drainage; Only those water related projects will be taken up for execution that will not interfere with the aquatic characteristics of those water bodies; Haors that naturally dry up during the winter will be developed for dry season agriculture; Take up integrated projects in those water bodies for increasing fish production; and Natural water bodies will be developed, where possible, for recreational use in support of tourism.

In 1998 ***the National Fisheries Policy (NFP)*** was drawn up with achievement of five objectives. The relevant objective of the Policy which are pertinent for this study. These are enhancement of fish production, poverty alleviation, fulfil the demand of animal protein, achieve economic growth, maintain ecological balance, and conserve biodiversity.

In 1992the ***National Environmental Policy (NEP)*** was drawn up with the aim of providing protection and sustainable management of the environment considering four (4) objectives. The major objective of the Policy which are relevant for this study is: i) maintain ecological balance and conserve biodiversity. The present SEA study is the main endeavour, Is the infrastructural development works in the Haor area to comply with the above objective? Other relevant enhancement measures also mentioned in the fisheries policies under the section 6.2 are:

a) To conserve fish habitats from damage, appropriate care should be taken during the implementation of all developmental activities such as flood control, irrigation and drainage (FCD/1) projects, agriculture, industries, road and urban development projects;

b) A new integrated model for fish/ shrimp cum HYV rice culture will be initiated in the beets, haors and other flood affected areas, especially in the regions encircled by dams in flood control and irrigation projects.

c) Water bodies like haor, baor and beef would be renovated for fish culture and these water bodies would not be reduced in sizes.

2.4 Polices Related to Infrastructure Development

The main objective of the ***Land Use Policy 2001*** are preventing excessive land use due to the ever increasing demand for crop production, maximum utilization of lands, preservation of ‘Khas Lands’ and helping in reducing the number of landless people in Bangladesh. Some statements are made in the land use policy as below which could be related to haor: i) Government will be responsible for reservation of large water bodies like haor, baors, beels, rivers etc. Also, water bodies should be used in a way that does not contradict the Fisheries Policy and still contributes in agricultural irrigation; ii) for ensuring proper use of land and water cultivation of crops need to be done according to soil characteristics. Also, fish production should not be hampered in rivers, haor, baors, khals etc. due to crop production; iii) Regulation should be imposed over the wetlands with regular maintenance and rehabilitation so that they are not filled up but kept available for fish culture. Re-excavation is to be done in filled-up wetlands. The Policy includes a prohibition against encroachment of existing wetlands; iv) To avoid drainage congestion regular maintenance of the embankments need to be done. Also, consistent maintenance of the existing water bodies need to be established; v) The Policy calls for plantation of trees along embankments and provision of drainage facility for embanked areas.

The ***National Agricultural Policy 2013*** was enacted for the overall development of Bangladesh agriculture and farmers focusing on different development strategies, especially the Sustainable Development Goals. The objectives and strategies are set in this act considering different problematic and convenient scenarios of Bangladesh. The act has mentioned several directives which is relevant to agriculture development in haor area are given below: i) Advanced agro-technologies should be introduced to tackle adverse climate condition like flooding, drought, storm, salinity, erosion, disease, insect onslaught etc; Different varieties of crop should be invented and popularized which are high yielding, tolerant to adversity and suitable for different agricultural climate, spatially for the mountainous, drought-prone, Barind, char area, haor region, water logged and coastal area; iii) Sustainable land-water management and integrated crop management activities should be expanded and encouraged to protect agriculture related biodiversity.

The objective of the ***National Forest Policy declared in 1994***, which is appropriate to present study is 'to strengthen agriculture by extending assistance to those sectors related with forest development, especially by conserving land and water resources'. The major directives that can be related to the haor area are: i) Decrease forest degradation and halt deforestation, restore degraded forests and conserve environmental services, biodiversity and wildlife, promote food and water security and enhance community livelihoods to mitigate the impacts of climate change; ii) Strengthen biodiversity conservation by mitigating threats and drivers of forest degradation and the loss of biodiversity and expanding and sustainably managing protected area landscapes and wildlife, including forest corridors; iii) Land-based public development initiatives, including infrastructure planning and implementation, will be required to incorporate appropriate initial environmental investigations and environmental impact assessments to avoid the fragmentation of wildlife and biodiversity habitats and minimize environmental damage; and iv) To provide for and implement afforestation programmes on both public and private lands. Therefore as per the Policy, conservation value of forests and wetlands will be identified and developed for ecotourism.

The ***National Land Transport Policy 2004,*** a Land Transport Policy is essential to ensure the proper physical and institutional infrastructure transport in order to achieve national development. Roads and transport are inseparable part of man's livelihood. The people of Bangladesh spend a significant part of their time and money on transport, in search of a livelihood. The Land Transport Policy has been formulated in the light of the Government pledge to establish a transport system which is a safe, cheap, modern, technologically dependable, environment friendly and acceptable in the light of globalisation. The major directives under the Policy that can be related to the haor area are: i) To maintain an economic and environmental balance: Roads will be constructed with appropriate designs, and the operation of vehicles will be controlled to minimise adverse effects on the environment. Compared to rail and water transport, the pressure on road transport is gradually increasing, but there is a need for intervention in the policy to encourage the use of rail and water transport, as they are comparatively more environment friendly.

2.5 Relevant Plan/ Programs on Water and Infrastructure

2.5.1 National Plans

National Environment Management Action Plan, 1995 identified the key environmental issues, and the actions required to halt or reduce the rate of environmental degradation, improve the natural and manmade environment, conserve habitats and bio-diversity, promote sustainable development and improve quality indicators of human life. In the "Wetland Issues" section the NEMAP emphatically pointed out that "the reduction of wetlands is one of the marked features of environment degradation in Bangladesh". Strategies and associated action plan directly or indirectly related to study are as below:

Water Sector

- Flood proofing, Flood Protection measures
- Re-designing the projects for creating infrastructure for facilitating fish migration to and from floodplains.
- Research development activities on the fish migration and natural recruitment in the FAP area

Wetland

- Implementation of wetland conservation laws and creation of sanctuaries.
- Bio-diversity conservation
- Development of a comprehensive wetland management policy

The National Water Management Plan (NWMP) was prepared in 2001 and approved in 2004, the first planning document prepared following the principle of IWRM. It was a framework plan consisting of 84 programmes grouped into eight sub-sectoral clusters and spatially distributed across eight planning regions of the country. The strategies and plans for water sectors which are directly and indirectly related to Haor are as below:

- Development and management of river system and embankments;
- Integrated development and management of haors and wetland;
- Flood proofing rather than flood control of the rural population living in haor basin;
- Reduction of encroachment and exploitation of ecologically sensitive haor basin;
- Improved water management program for the hoar basin for both waterfowl conservation under Ramsar Conservation and the conservation of mother fish stocks for both commercial and subsistence fishing;
- Identification of cost effective designs for erosion control on medium and small rivers in the short term to medium term; and
- Integrated river management plan covering erosion control, dredging and other elements of river maintenance such as pollution control, abstraction, navigation

and environmental needs.

The ***Bangladesh Climate Change Strategy and Action Plan, 2009*** was adopted as a 10-year programme (2009-2018) to build the capacity and resilience of the country to meet the challenges of climate change in different sectors. The BCCSAP established programmes of action on six main pillars for the first five year period (2009-2013). Programmes relevant to haor under these six pillars are stated below:

- Adaptation in fisheries and livestock systems to ensure local and national food security;
- Livelihood protection in ecologically fragile areas;
- Improvement of flood forecasting and warning system;
- Repair and maintenance of existing flood embankments and ensuring continued flood protection by repairing and rehabilitating existing flood embankments and ancillary infrastructure;
- Adaptation against floods to make flood prone areas more resilient by flood zoning and management;
- Planning, design and implementation of resuscitation of the network of rivers and khals through dredging and de-siltation work;
- Raising productivity of agricultural land and lowering emissions of methane by efficient use of water;
- Increase water efficiency in built environments with further mention to groundwater lowering in major cities including Sylhet; and
- Improving energy consumption pattern in the transport sector, which is related to the navigational facilities in the Haor area without much use of fuel.

The ***National Biodiversity Strategy and Action Plan of Bangladesh, 2016-21*** is a guiding framework for biodiversity conservation, ensuring sustainable use of its components along with fair and equitable sharing of benefits arising out of utilization of genetic resources. The updated NBSAP has been prepared in the line with Convention on Biological Diversity (CBD) strategic planning 2011-2020 (Aichi Biodiversity Targets). Twenty national targets have been proposed to be taken into action during the fiscal year 2015-2016 to 2020-2021. Among 20 national targets 14 are found relevant to this study, which area detailed out in the Environmental Auditing report of the study.

The ***North East Regional Water Management Project (FAP 6)*****,** prepared under the auspices of the Flood Action Plan to assist the GoB in planning and guiding the development of the haor region with particular emphasis on water management. A portfolio of 44 initiatives was developed from the eight regional strategy thrusts divided into four priority groups. Major objectives of this plan were to increase the amount of flood free land to accommodate the rising population and minimize flood damage. Tanguar haor, Pashua beel and Gurmar haor, Hakaluki haor, Hail haor, Kawadighi haor, Balai haor were identified as of international importance by this plan.

2.6 Legal Framework

Environmental Conservation Act (ECA), 1995 is currently the main legislative document in Bangladesh relating to conservation of the environment, improvement of environmental standards and control and mitigation of environmental pollution. It is relevant to haor ecosystem in many aspects. Some directives of this act which directly or indirectly reflects conservation or management of haor ecosystem. These directives are: i) Safety measures or remedial measures should be undertaken to prevent portable accident which may cause degradation and pollution of environment; ii) Research and capacity development are emphasized for conservation, improvement and pollution of the environment; iii) Collection and publication of information regarding environmental pollution should be performed; iv)Inter-agency co-ordination should be established; v) Ecologically Critical Area should be declared if any ecosystem is in the state of critical situation and no interventions should be undertaken in this designated area; vi) Industrial development on any kind of environment or ecosystem is matter of approval of authority

Therefore, this act portrays some strict features regarding conservation of environment as well as ecosystem preventing pollution. This act also states to formulate environmental guideline to conserve the environment.

Bangladesh Environmental Conservation Rules (ECR), 1997 promulgated to implement the Environment Conservation Act, 1995 which is particularly relevant for controlling pollution in Environment. This ECR mainly focused on enforcement of laws for clearance of different categories of industry (i.e. Green, Orange-A, Orange-B and Red) on different location of environment. Necessity of Environmental Impact Assessment (EIA) followed by Environmental Management Plan (EMP) before any kind of development was prescribed to be done.

However, declaration Ecologically Critical Area considering 12 important components of environment is mentioned in this rules, where human habitat, forests, wetland and biodiversity of the relevant area are specifically enunciated to take under consideration.

Bangladesh Water Act, 2013 is the latest and most important legal document which was prepared to make provision of integrated development, management, abstraction, distribution, use, protection and conservation of water resources. In relevant to haor area, this act specifically stated legal bindings on conservation of haor, baor or any other water source and management thereof for conservation of biodiversity dependent on it, in section 22 (b). Other directives of this act are: i) Delineation of water stress area and preferential use of water from sources for different purposes like for agriculture, fisheries, drinking water, industry etc; ii) Ensuring normal flow in water course prohibiting any kind of diversion through construction of structures without feasibility study; iii) Protection of flood control embankment, especially which protects property, life and crops by restricting construction any house, establishment or any other structure on or on the slope of such embankment; iv) Demarcation of flood control zone in wetlands to ensure smooth passage of flood water. This act also emphasized preparation of National Water Resources Plan which will provide guideline to assess impact of different development on water resources.

The government has enacted ***Ecologically Critical Area Management Rules, 2016*** following the Bangladesh Environment Conservation Act, 1995 which provided the concept of “Ecologically Critical Area (ECA)" means such an area which is rich in unique biodiversity or due to the importance of environmental perspective necessary to protect or conserve from destructive activities under section 5 of the Act. Hakaluki Haor and Tanguar Haor were declared as ECAs in 1999 by the government under the legislation of Environmental Conservation Act, 1995.

The ***Ecologically Critical Area Management Rules, 2016*** therefore specifically emphasized on following issues which are related to haor ecosystem: i) National committee and co-management team to ensure engagement from root level like village protection team should be formed for designating an Ecologically Critical Area; ii) Some indicators should be taken under consideration before designating an ECA like degradation of natural condition of river, khal, haor, baor, wetlands, biodiversity related to them, sanctuary etc; iii) The Rules prohibits some activities or processes, which cannot be initiated or continued in an ECA like polluting water by discharging waste or any other activities that could destroy or change the natural characteristics like biodiversity or other habitats of an ECA.

Bangladesh Water Rule, 2017 (draft) is prepared by Water Resources Planning Organization (WARPO) with a view to implement Bangladesh Water Act, 2013. The main purpose of this rule is to ensure the water right of every citizen of Bangladesh. The rule has described the laws regarding the extraction and proper use of surface and ground water.

This rule has given WARPO the authority to give clearance to any agency or owner for development projects in or near a water body under the condition that it would not cause any adverse impact to it, specifically for: i) flood control and management project; ii) water supply and sanitation project; iii) surface water irrigation project; iii) hydraulic intervention project; iv) water extraction or storage project; v) floodplain or haor development project; vi) Project on surface water use for industry; vi) river training works or river bank protection project; vii) river or canal dredging project; and viii) fishery development project in surface water

Increasing public awareness thus in terms of water consumption and usage is another priority of this rule. Emphasis has been given on delineation of water stress area in a scientific way and considering socio-economic perspective. Participatory approach is given priority in this rule to overcome such water stressed situation.

Wildlife (conservation and security) Act, 2012 aims to provide some legal directives for conservation and safety of biodiversity, forest and wildlife of the country. This act summarizes obligations for declaration of sanctuary, special biodiversity conservation area and community conservation area. Some prohibitions have been outlined to protect and conserve bio-diversity of all species or sub-species of flora and fauna living in aquatic, terrestrial and marine ecosystems and for proper utilization, conservation and management of natural resources of the sanctuary. Emphasis has been given on determination of vulnerable, endangered and critically endangered species. Promotion of public participation in managing bio-diversity or co-management system is encouraged in this act. This act has several implications on haor ecosystem because of its rich biodiversity which need to manage or conserve sustainably through safety measures under legal bindings.

Chapter 3: Screening of Plans/Programs and Scoping the SEA

3.1 Introduction

The process for determining whether or not an SEA is required is called screening. The SEA screening is a two stage process. First is pre-screening and second step is environmental significance criteria based screening. Both processes will be discussed in this chapter.

3.2 Pre screening

To assess whether an SEA is required a screening process is followed based on a standard set of criteria. Initially total twenty three plans were identified considering Haor Master Plan, road map of RHD and LGED (table 3.1). Then all these projects went through the following process stated in figure 3.1.

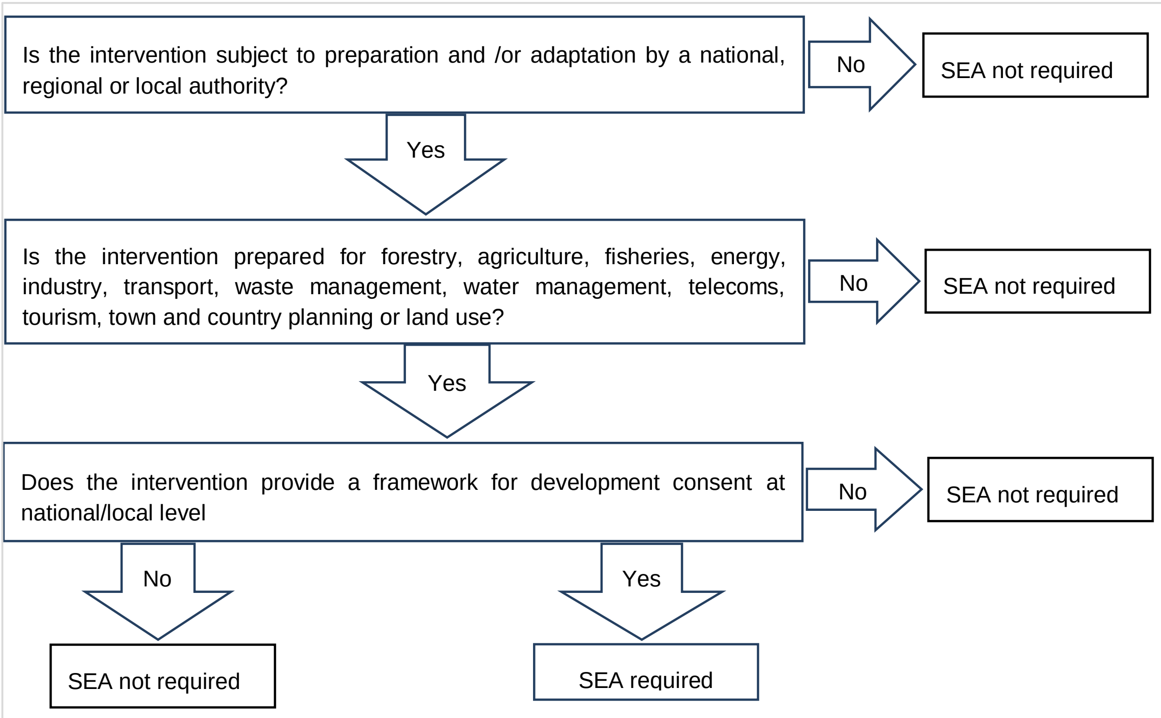

Figure 3.1: Screening Process of Future Plans

Precisely all the selected interventions are prepared by national authority (LGED/RHD/ BWDB) and intended for water management and transport sector development of Haor area. After that all these interventions were screened based on environmental significance criteria.

3.3 Environmental Significance criteria based screening

In applying these criteria, the listed interventions were went through the following criteria/result in;

a. Significant changes in action/decision of government that could lead to

- Development of infrastructure or other change in urban or rural land use.
- A negative or beneficial impact on water/ agricultural/fish/ ecological resources
- Impact on people and communities

- Change in the amount or type of waste or pollutants released to water, land or air.

b. Does the intervention promote sustainable development?

The interventions those would have the related with the above stated issue/ criteria will need SEA to conduct. The entire matrix is shown in table 3.1. It is to be mentioned here the entire screening process is based on judgement of SEA team. The screening process is qualitative. Later this will be discussed with different stakeholder for verification and modification.

Table 3.1: Screening process of future plans and programs for SEA

Interventions	Environmental Significance Criteria				
	Development of infrastructure or change land use	Impact on natural resources	Impact on society	Change in waste, pollutant generation	Contribute to sustainable development
Haor Flood Management and Livelihood Improvement Project	yes	yes	yes	yes	yes
Village protection against Wave action of haor area	yes	yes	yes	no	yes
Madanpur-Dirai-Sullah Road	yes	yes	yes	yes	yes
Taherpur-Mohjampur-Chatapati-Madhanagar Road (Moheshkhali)	yes	yes	yes	yes	yes
Dharmpasha GC - Joysree GC Road.	yes	yes	yes	yes	yes
Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	yes	yes	yes	yes	yes
Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha road, Culverts, bridges, embankment protection work	yes	yes	yes	yes	yes
Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	yes	yes	yes	yes	yes
Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	yes	yes	yes	yes	yes
Madhayanagar UPC - Toker bazar via Shahapur Road.	yes	yes	yes	yes	yes
Paykurati UPC - Toker bazar via Jamalpur Madrasha Road.	yes	yes	yes	yes	yes
Chamerdani UPC - Shararkona Ghat Road.	yes	yes	yes	yes	yes
Lankapathria-Banarasshipur via Razapur Rd.	yes	yes	yes	yes	yes
Rasulpur-Azabpur Road	yes	yes	yes	yes	yes
Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	yes	yes	yes	yes	yes
Itna-Azmiriganj GC Road	yes	yes	yes	yes	yes
Austagram- Lakhai road via Ekurdia Dalarkandi Road	yes	yes	yes	yes	yes
Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	yes	yes	yes	yes	yes
Banichang-Azmiriganj-Jalsuka	yes	yes	yes	yes	yes
Itns-Mithamoin-Austogram	yes	yes	yes	yes	yes
R260(Regional highway)Sylhet-Sunamganj	yes	yes	yes	yes	yes
N2 Bhairab-Moulvibazar 4lane	yes	yes	yes	yes	yes
N2 Habiganj-Sylhet 4lane	yes	yes	yes	yes	yes

3.4 Description of the projects

Different projects in the Haor Region on flood management, livelihood improvement, village protection, improvement and/or construction of roads for improving the road communication system etc. have been planned to be implemented by different agencies like BWDB, LGED, RHD etc. Description of these projects based on available information is given in the following sections.

3.4.1 Haor Flood Management and Livelihood Improvement Project

The overall objective of the "Haor Flood Management and Livelihood Improvement Project" is to reduce the damages from flood, improve access to basic infrastructure and increase agriculture and fishery productivity in the hoar areas of the upper Meghna River basin through rehabilitation and construction of the flood management facilities; rehabilitation and construction of the rural infrastructures; and implementation of agriculture and fishery promotion activities, and thereby contributing to the improvement of living standard and activation of economic activities in the target area. In order to fulfil the project objectives, BWDB has taken initiative for implementation of flood management and rehabilitation work in 29 haors as per their scope of work which has been detailed out in Annex G. BWDB has already started implementing the interventions in 7 haors and would initiate the implementation work in remaining 22 haors of which 7 projects are aiming at flood management and 15 projects are targeting rehabilitation work. Therefore, this study has focused on identifying the potential impact of these 22 projects and developing alternative strategies based on the findings of the impact analysis. Components of these 22 projects are given in the following tables:

Table 3.2: Main Interventions in Seven Sub-projects

SL No	Sub-Project No.	Name of Subproject	District	Upazila	Submergible Embankment Length	Khal & River Length (km) (Khal/River)	No. of Regulators	No. of Bridge	No. of Cause way	No. of Pipe Sluice/ Box	No. of Irrigation Inlet	Reb. of existing Regulators	Gross Area (Ha)
1	N-6	Badla Haor Sub- Project	Kishoreganj	Itna & Tarail	21	10	2 (1-1V& 1-2V)		1	3	6	5	2087
2	N-7	Chatal Haor Sub- Project	Kishoreganj	Itna & Tarail	4.51	2	2 (2-2V)			1	4		1116.62
3	N-9	Suniar Haor Sub-Project	Kishoreganj & Netrokona	Tarail, Kendua	0.54	22	4 (3-lV& l -6V)		2				4427.8
4	N-10	Mokhar Haor Sub-Project	Habiganj	Baniachong, Nabiganj	23.82	55.70 (25.20+30.50)t	7 (5-lV, l-2V &l-4V)		4	9	15	1	16821.2
5	N-11	Ganesh Haor Sub-Project	Netrokona	Atpara & Madan	2.8	12	4 (3-lV &l-4V)			2	2	1	3367
6	N-13	Jaliar Haor Sub- Project	Sunamganj	Chhatak	7.22	6.1	3 (l-lV,l- 2V&l -3V)		7	6	4	1	2047.87
7	N-14	Dhakua Haor Sub-Project	Sunamganj	Sadar & Jamalganj	23.17	26.04 (4.56+2l .48)t	6 (4-lV &2-2V)		3	7	9		6374.44
	Total				**261.682**	**354.216**	**57**	**1**	**35**	**44**	**131**	**9**	**87,706.71**

Table 3.3: Rehabilitation Work of 15 nos. Rehabilitation Sub-Project

Sl No	Sub-Project	Name of Subproject	District	Upazila	Rehabilitation Embankment Length (Km)		Khal Length (km)	Repair of Regulator Gates & Others	Installation of Regulator/ Causeway	Gross Area (Ha)
					Embankment	Submerge				
1	R-1	Alalia-Bahadia Sub-Project	Kishoreganj	Katiadi, Pakundia	0	0	3	2	0	2464
2	R-2	Modkhola-Bairagir Cha Sub- Project	Kishoreganj	Katiadi, Pakundia	3	0	3	3	0	2060
3	R-3	Ganakkhali Sub-Project	Kishoreganj	Kuliarchar	2	0	4	2	0	2652
4	R-4	Boraikhali Khal Sub-Project	Kishoreganj, Mymansingh	Sadar, Hosainpur & Nandail	0	0	7	6	0	8667
5	R-5	Koirdahla Ratna Sub-Project	Habiganj	Ajmiriganj, Baniachong	0	11	6	9	0	11900
6	R-6	Guingajuri Sub-Project	Habiganj	Sadar, Baniachong & Bahubal	18	16.9	21.5	17	2	8450
7	R-7	Aralia Khal Sub-Project	Habiganj	Baniachong	0	25.33	6	5	2	1501
8	R-8	Bashira River Re-excavation Sub-Project	Habiganj	Ajmiriganj, Baniachoong	0	14.2	19.5	0	2	4521
9	R-9	Dampara Water Management Scheme	Netrokona	Purbadhola	37	0	10	10	1	15000
10	R-10	Kangsha River Scheme	Netrokona	Sadar, Purbadhola	15	0	16	16	0	11337
11	R-11	Singer Bell Sub-Project	Netrokona	Barhatta	5.5	5.2	5	6	0	7200
12	R-12	Khaliajuri FCD Polder-2	Netrokona	Khaliajuri	0	6	20	14	0	6611
13	R-13	Khaliajuri FCD Polder-4	Netrokona	Khaliajuri	0	10	22	10	0	7201
14	R-14	Chandal Beel Sub-Project	Brahmanbaria	Banchharampur	0	0	0	2	0	1012
15	R-15	Satdona Beel Scheme	Brahmanbaria	Banchharampur	0	0	0	2	0	5079
				Total	**80.6**	**88.63**	**143**	**104**	**7**	**95625**

3.4.2 Village Protection against Wave Action of Haor Area

The Haor Master Plan (HMP) 2012 is a framework plan which will be implemented on the short, medium and long term basis. This ‘integrated development plan’ spells out the means for optimizing available resources of the area for future development of potentials by incorporating all relevant social and environmental considerations. The Haor Master Plan has proposed several projects of which “Village Protection against Wave Action of Haor Area” is a significant one. The main objective of this project is to protect villages of the haor areas from erosion. This project will protect social facilities and immovable property of haor villages and ensure sustainable livelihood of haor. It will enhance the wetland trees of the Haor area. The main components of this projects are: construction of 74 km (202 nos.) revetment work, construction of 180 nos. of stair and ramp work, development of 37 km green belt and development of 19 nos nurseries.

3.4.3 Plans and Programs of LGED for Improvement of Road Communication

The Local Government Engineering Department hasundertaken to improve the different existing roads including the following roads. Information available about the existing condition of the roads are described below:

Austagram- Lakhai Road via Ekurdia Dalarkandi Road

Austagram- Lakhai Road has started from Austagram Upazila of Kishoreganj and has ended at Lakhai, Habiganj. The total length of this road is 11.92 km, of which 1.5 km is earthen and rest 10.42 km is rigid. The crest width of this road is 5.55 m. There are 15 structures in this road.

Itna-Azmiriganj GC Road

Itna-Azmiriganj GC Road runs from Itna Upazila of Kishoreganj District to Azmiriganj of Habiganj. This road has a total length of 15.5 km of which 3.5 km is earthen and rest 12 km has rigid pavement. The crest width of this road is 7.32 m. There are 46 structures in this road having a total span length of 51.6 m.

Rasulpur-Azabpur Road

The total length of Rasulpur-Azabpur Road is 3.8 km, of which 2.8 km is earthen and rest 1 km is brick pavement. The crest width of this road is 3 m. There are 3 structures in this road having a total span length of 21 m.

Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)

This road runs from Derai Upazila to Jagannathpur Upazila of Sunamganj District after crossing through Jagdol, Hossainpur, Pailkapon and Telikona. The total length of this road is 14.94 km, of which 8.75 km is earthen and rest 6.19 km is rigid. The crest width of this road is 3.66 m. There are 8 structures in this road having a total span length of 231.0 m. 14 existing gap in this road has a total span length of 315 m. There are no structures without approaches.

Habigonj-Baniachong R&H Road (Chilapanja)-Azmiriganj GC Road

This road is located between Habiganj and Brahmanbaria Districts. The total length of this road is 6.39 km, of which 5.87 km is flexible and rest 0.52 km is rigid pavement. The crest width of this road is 3.66 m. There are 8 structures in this road having a total span length of 231 m.

Dharmpasha GC-Joysree GC Road

The Dharmapasha- Joysree Road is located in Dharmapasha Upazila of Sunamganj District. This is an Upazila Road. The total length of this road is 10.95 km, of which 5.64 km has flexible pavement and rest 5.32 km has brick pavement. The crest width of this road is 5.0 m. There are 18 structures in this road having a total span length of 475.5 m.

Dharmapasha GC-Golakpur GC via Mohodipur Bazar Road

This an Upazila Road is situated in Dharmapasha Upazila of Sunamganj District. The total length of this road is 20.02 km, of which 9.12 km is earthen, 2.18 km is flexible and rest 8.72 km is rigid pavement. The crest width of this road is 3.15 m. There are 26 structures in this road having a total span length of 118.5 m.

Joysree GC - Moddhanogar GC via Chamerdani UPC Road

Joysree-Moddhanogar UPC Road is located in Dharmapasha Upazila of Sunamganj District. It is an upazila road. The total length of this road is 17.21 km, of which 15.67 km is earthen and rest 1.55 km is rigid pavement. The crest width of this road is 3.60 m. There are 9 structures in this road having a total span length of 49.65 m. 23 existing gaps in this road have a total span length of 119 m.

Dharmapasha UPC - Badshagonj Bazar via Mohishakanda Bazar Road

This road runs across the Dharmapasha Upazila of Sunamganj District. This is a Union road. The total length of this road is 8.25 km, of which 3.75 km is earthen and rest 4.5km is rigid pavement. The crest width of this road is 3 m. There are 7 structures in this road having a total span length of 171.8 m.

Chamerdani UPC - Shararkona Ghat Road

Chamerdani UPC - Shararkona Ghat Road is located in Dharmapasha Upazila of Sunamganj District. This is a Union road. The total length of this road is 6.31 km and all of it is earthen. The crest width of this road is 2 m. There are no structures in this road. 4 existing gaps in this road have a total span length of 45 m.

Madhayanagar UPC - Toker bazar via Shahapur Road

The road is situated in Dharmapasha Upazila of Sunamganj District. This road is a Union road. The total length of this road is 7.5 km. This entire road is earthen. The crest width of this road is 3 m. There are no structures in this road. 6 existing gaps in this road have a total span length of 29.5 m.

Paykurati UPC - Toker bazar via Jamalpur Madrasha Road

The location of Paykurati UPC - Toker Bazar via Jamalpur Madrasha Road is in between Dharmapasha Upazila of Sunamganj District. It is a Union road. The total length of this road is 6.5 km, of which 4.5 km is earthen and rest 2 km is rigid pavement. The crest width of this road is 3.0 m. There are 4 structures in this road having a total span length of 31 m. One single existing gap in this road has a span length of 30 m.

Lankapathria-Banarasshipur via Razapur Road

The location of Lankapathria-Banarasshipur Road is in Dharmapasha Upazila of Sunamganj District. This is a village road. The total length of this road is 11.25 km, of which 8.25 km is earthen and rest 3 km is rigid pavement. The crest width of this road is 3 m. There are no structures in this road. 11 existing gaps in this road have a total span length of 46 m.

Sulla HQ-Paharpur GC (Azmirigong) via Protappur Bazar Road

This road has started from Sulla Upazila in Sunamganj District and ended in Badalpur, Sunamganj. This is a submersible upazila road. The total length of this road is 6.4 km, of which 0.05 km is earthen and rest 6.35 km is rigid pavement. The crest width of this road is 3.5 m. There are 5 structures in this road having a total span length of 27 m.

Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road

The location of Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road is in between Tahirpur and Dharmapasha Upazila of Sunamganj District. This is an Upazila road. The total length of this road is 12.72 km and all of it is rigid pavement. The crest width of this road is 3.30 m. There are 10 structures in this road having a total span length of 42.45 m. 16 existing gaps in this road have a total span length of 302.2 m.

3.4.4 Plans and Programs of RHD for Improvement of Road Communication

Three roads of the Roads and Highways Division (RHD) (i.e. Sylhet-Sunamganj Road (R262), N2 Bhairab-Moulvibazar 4Lane and N2 Habiganj-Sylhet 4 Lane),which are in pipeline for improvement work (as given in the Road Master Plan-2009 of RHD, have been selected for assessing the impact for the improvement work. Moreover, two roads (Habiganj-Baniyachang-Ajmiriganj-Sultan Road and Madanpur-Dirai-Sullah Road) which have been proposed for construction as per the Haor Master Plan 2012 have also been considered in this study. Description of these roads are given below:

Sylhet Sunamganj road (R260) is intended to improve by the year 2026/27. Bishwambarpur, Jamalganj, Sulla, Tahirpur, Dwarabazar upazilas of Sunamganj are not currently connected to the RHD network according to Table 3-12 of Road Master Plan (Volume-01). Project Bhairab-Mouvlibazar 4 lane’s and Habiganj-Sylhet 4 lane’s (96km) would be improved by the year 2026/27. Level Crossings requiring grade separation is needed in Habiganj Sadar according to Table 13-3 of Road Master Plan (Volume-01).

Based on national priority Habiganj-Baniyachang-Ajmiriganj-Sullah Road would be constructed as a regional highway. If the project can be implemented, the people of Azmiriganj will have fast and easy road communication with district and divisional HQ and the capital city Dhaka. Presently there is an 18km long zilla road from Habiganj-Baniyachang but it has been planned to construct 21km long road from Habiganj-Baniyachang zilla road to connect Ajmiriganj. Another objective of this project is to construct disconnected portion of Sulla Bazar (Shahgonj Bazar) to connect Sunamganj District. This road is actually started from Modonpur point of Sylhet-Sunamganj regional highway. The proposed DPP road is actually started from Sulla to Sulla Bazar (Shahganj Bazar) near Kushiara River. The target of this project is to establish a road connection between Sunamganj and Habiganj by constructing 15.80km new road.

Chapter 4: Identification and Prediction of Potential Impact

4.1 Introduction

Identification of the potential impact of the plans or programs is an integral part of conducting SEA. This chapter presents the potential impacts of the future development plans and programs on the associated sectors (i.e. Water Resources and Navigation; Land, Agriculture and Livestock Resources; Fisheries Resources; Ecological Resources and Socio-economic Resources).

4.2 Approach of Predicting Impact

A rigorous participatory approach involving qualitative judgment by the experts based on the available information, public consultation as well as consultations with relevant agencies (e.g. like Local Government Engineering Division (LGED), Department of Bangladesh Haor and Wetlands Development (DBHWD) etc.) has been adopted to predict the potential impacts of the plans and programs to be implemented in the haor region. Potential impacts predicted in this manner laid the basis of formulating alternative strategies which have been given in Chapter 6.

The multidisciplinary SEA team has provided their expert judgment based on the information of the interventions of the development plan. While providing the judgement, the experts have utilized different tools like ArcGIS, Google Map etc. and also consulted with other relevant experts. Based on their judgment, they have assigned scores from -3 to +3 against each of the applicable indicators of the five sectors and the scores reflected the negative and positive impacts along with their magnitude. In case of having no impacts on an indicator, “zero” has been scored by the experts. Moreover, the impact of the future interventions has also been predicted through public consultation as well as from the consultation with the relevant agencies.

4.3 Potential Impact

Sector wise impacts of the interventions to be implemented as per the development plans and programs of Local Government Engineering Division (LGED), Department of Bangladesh Haor and Wetlands Development (DBHWD), Roads and Highways Department (RHD) as identified through the scoring of the respective experts and consultation with the public as well as with the relevant agencies have been discussed in the following section. Potential (both positive and negative) impacts of different development plan and program as identified through the scoring of the respective experts have been given in Annex A while summary of the impacts on different sectors, as identified through the above mentioned scoring process and consultation with the stakeholders, have been discussed in the following section.

4.3.1 Water Resources and Navigation

Analysis of five identified programmes i.e. Flood Management and Livelihood Improvement Project, Village protection against Wave Action, Improvement of Road and Communication System by LGED and RHD depicts that flooding and drainage situation might be improved due to various interventions like construction or rehabilitation of submersible embankment, re-excavation of internal khals and rivers, construction of water regulation structures etc. Some supplementary enhancement measures may be needed to improve the flooding and drainage situation more. Navigation would also be facilitated due to implementation of these programmes. But, sedimentation problem inside the haor, rivers and khals might be increased in some areas of haor region because of construction of different water regulation structures, delaying smooth recession of flood, delayed and poor operation and maintenance works etc. Erosion of khals or rivers banks may also be expedited due to these programmes.

The impacts of the future interventions on water resources due to implementation of different projects, following the different plans of programs of different agencies, as identified through the scoring of the respective experts have been given in Annex A.

4.3.2 Land, Agriculture and Livestock Resources

People living in the haor area mostly depend on agriculture. About 0.71 million ha of net cultivable land is available in this area, which produces more than 5.25 million tons of paddy each year. However, any kind of development work may have impact on the agricultural sector. Crop production as a whole will increase due to reduction of crop damage and reduce flood vulnerability due to village protection against wave action. However, agro-chemical use may increase. Moreover, components of this program like excavation and re-excavation of khals will increase surface water availability during dry season that reduce drought vulnerability, hence crop production will be increased. The Flood Management and Livelihood Improvement Program will increase the crop production by reducing the crop damage. However, there is a possibility of increased use of agro-chemical.

Two different programs on improvement of road and communication System undertaken by Roads and Highways Department and Local Government and Engineering Division may reduce the crop area may if the proposed roads are constructed on agriculture land. Crop damage may occur if flooding and drainage situations are deteriorated by the construction work. Irrigation and water supply may also be disrupted if the roadsare constructed on irrigation canal.

The impacts of the future interventions on land, agriculture and livestock resources due to implementation of different projects, following the different plans of programs of different agencies, as identified through the scoring of the respective experts have been given in Annex B.

4.3.3 Fisheries

Major impacts on fisheries resources due to different components of Flood Management and Livelihood Improvement Project, Village protection against Wave Action are given below:

Table 4.1: Impacts on fisheries resources due to different components of "Flood Management and Livelihood Improvement Project" and project on "Village protection against Wave Action"

Sl No.	Components	Potential Environmental Impacts
1	Construction/Reconstruction/Re-sectioning of Submersible Embankments	Use of more agro-chemicals may degrade water quality and habitat condition and hence decrease fish productivity. Moreover, it may also impede pre-monsoon migration of small indigenous species of fish; hamper breeding; increase mortality rate; etc.
2	Construction of Compartmental Dykes	Imbalance in fish species composition may occur; fish migration would be impeded; fish productivity may decrease, etc.
3	Construction of Cross Dams	Longitudinal fish migration along the river would be shuttered during the operation of cross dam; indiscriminate fishing would be promoted and crisis of species diversity might arise; etc.
4	Construction of Drainage Regulators	Lateral fish migration from river to Beel/haor would be limited during the operation of regulators; indiscriminate fishing would be

Sl No.	Components	Potential Environmental Impacts
		promoted and crisis of species diversity might arise; fish productivity may be reduced; etc.
5	Drainage Outlets	Drying up of Beel area would be expedited and hence habitat area would be decreased gradually.
6	Causeways/Fuses	Retaining of water in the canal might facilitate canal fishery and recruitment to Beel.
7	Irrigation Inlets	Baseflow coming from irrigated area may facilitate Beel fishery.
8	Repair and Rehabilitation of existing regulators	Fish migration may be facilitated by the proper operation of regulators.
9	Re-excavation of Internal Khals	Increase of water room and retention period would facilitate canal and Beel fishery; recruitment potential would be enhanced; condition of species diversity would be improved; etc.
10	Dredging of Surma-Baulai River System	Creation of more water room would facilitate dry season refuge areas of bigger fishes; increase recruitment potential; longitudinal migration would be facilitated; species diversity might be facilitated; etc.
11	O&M during Construction	Facilitate fish migration

The impact of a single road construction on fisheries in the Haor area may be in lower magnitude but the combined effect of all roads may be magnified largely. The impact on fisheries sector due to construction and improvement of road network by LGED and RHD is given below:

- Changes will be occurred to fish habitat area due to excavation of floodplain to raise the road;
- Floodplain to some extent would be turned into borrow pit having longer water retention period;
- Fish migration and movement may be impeded due to narrow down of migratory route;
- Species diversity may get confined and imbalance may arise;
- Since borrow pits are expected to be managed by the respective land owners, thus fishers' livelihood may be adversely affected;
- Connectivity may be affected by the road construction and may merit restoration;
- Fisheries management may be facilitated in terms of rapid accessibility.

The impacts of the interventions on fisheries resources as identified through the scoring of the respective experts have been given in Annex C.

4.3.4 Ecology Resources

The Haor Basin in the north eastern part of Bangladesh is a wetland ecosystem considered to be of international ecological importance due to enriched with different flora and fauna communities including the extensive waterfowl population that uses the basin as its habitat. Any kind of development work has impacts on existing ecological settings as well as its vegetation and wildlife communities. Hence, identifying potential environmental impacts for the project implementation, anticipating possible measures or alternatives and coordinate those with planning process are required. Project component wise major impacts on biodiversity and ecological habitats are as follows:

Table 4.2: Impacts on ecology resources due to different components of different interventions

Sl. No.	Components	Potential Environmental Impacts
1	Construction of Road	• Damages of vegetation along the Right of the Way (RoW) and at the earth collection site • Loss and fragmentation of aquatic wildlife habitat since road will act as barriers to wildlife movement • Filling wetland at the RoW • Increase noise, water and air pollution that will create disturbance to wildlife those are dwelling in surrounding vegetation.
2	Re-construction/repairmen of Road	• Damages of vegetation along the road slopes and at the earth collection site
3	Construction of road structures	• Damages of aquatic vegetation and relocation or even death of aquatic fauna due to dewatering and site clearing at the structure site
4	Filling the existing Gap of the road	• Damages of vegetation at the earth collection site
5	Approach Less Structure	• No significant impact
6	Topographic Survey	• No impact
7	Pre and Post Dredging Survey	• No impact
8	Construction of Submersible Embankments	• Damages of vegetation along the RoW and at the earth collection site • Perennial wetland might be squeezed for expansion of agricultural practice (indirect impact) • Reduce supporting and regulating ecosystem services from wetlands (indirect impact)
9	Reconstruction/Re-sectioning of submergible embankment	• Damages of vegetation along the embankment slopes and at the earth collection site • Squeeze perennial wetland for expansion of agricultural practice (indirect impact) • Reduce supporting and regulating ecosystem services from wetlands (indirect impact)
10	Construction of Compartmental Dykes	• Damages of vegetation along the RoW and at the earth collection site (For newly constructed dyke) • Loss connectivity of seasonal wetland and ultimately reduce aquatic faunal population
11	Construction of Cross Dams	• Fragmentation of aquatic habitat/Damages of vegetation at the earth collection site • May reduce provisional and regulating ecosystem services
12	Construction of 39 Drainage Regulators	• Temporary interruption of connectivity between river and canals or beels during construction • May reduce natural vegetation coverage for boosting up crop production (indirect impact) • May reduce amphibians and arthropods population for using insecticides in agricultural fields (indirect impact) • May reduce supporting and regulating ecosystem services from wetlands (indirect impact)
13	Drainage Outlets	• No impact
14	Causeways/Fuses	• No impact
15	Irrigation Inlets	• Reduce natural vegetation coverage for boosting up crop production

Sl. No.	Components	Potential Environmental Impacts
		• May reduce amphibians and arthropods population for using insecticides in agricultural fields (indirect impact)
16	Repair and Rehabilitation of existing regulators	• No significant impact
17	Re-excavation of Internal Khals	• Increase perennial water area and foster aquatic fauna for year round • Enhance all kind of ecosystem services from the khals
18	Dredging of Surma-Baulai River System	• Increase perennial water area and foster aquatic fauna for year round • Enhance all kind of ecosystem services from the river
19	O&M during Construction	• No impact
20	Revetments	• Damages of undergrowth vegetation along the embankment and at the earth collection site
21	Stairs and Ramps	• No impact
22	Greenbelt	• Increase terrestrial vegetation coverage, support wide species of terrestrial wildlife • Support aquatic avifauna as well as migratory birds for their nesting habitat • Create possibility of swamp forest • Protect existing terrestrial vegetation on settlements by protecting from wave action during monsoon • Enhance ecosystem goods and services both human, wildlife and environment
23	Nurseries	• Ensure saplings supply for establishing the greenbelt as well as create swamp forest

The impacts of the interventions on ecology resources as identified through the scoring of the respective experts have been given in Annex D.

4.3.5 Socio-economic Resources

Major impacts on socio-economic resources due to different components of Flood Management and Livelihood Improvement Project, Village protection against Wave Action are given below:

Table 4.3: Impacts on Socio-economic Resources due to different components of “Flood Management and Livelihood Improvement Project” and project on “Village protection against Wave Action”

Sl No.	Project Component	Potential Impact
1	Construction/Reconstruction /Re-sectioning of Submersible Embankments	Agricultural production based income will be increased. The embankments will also serve as road for which transportation and communication system will be improved during the dry period. Moreover, land value will increase due to better connectivity and production as well. People of the community will have more employment opportunity.
	Construction of Compartmental Dykes	Agricultural production based income will be increased. The dykes will also serve as road for getting easy access to the schools and clinics as well as other places during the dry period. On the other hand, land value will increase due to better connectivity and production as well. People of the community will have more employment opportunity.

Sl No.	Project Component	Potential Impact
2	Construction of Cross Dams	Agricultural production based income will be increased but income opportunity based on open- water fishing could be reduced. They may also serve as road for getting easy access to schools and clinics during the dry period. Moreover, land value will increase due to better connectivity and production as well. People of the community will have more employment opportunity.
3	Construction of 39 Drainage Regulators	Agricultural production based income and land value will be increased.
4	Drainage Outlets	Agricultural production based income and land value will be increased.
5	Causeways/Fuses	Agricultural production based income will be increased. Transportation and communication system will be improved. Moreover, land value will increase due to better connectivity and production as well. People of the community will have more employment opportunity.
6	Irrigation Inlets	Agricultural production based income and land value will be increased.
7	Repair and Rehabilitation of existing regulators	Agricultural production based income and land value will be increased.
8	Re-excavation of Internal Khals	Re-excavation of khal will increase the income opportunity of the fisher community as well as the agricultural production based income. At the same time the spoils that will come from re-excavation of the khals can be dumped into the fallow lands which will help to increase the land price. Internal communication system using non-mechanized boats will be benefited.
9	Dredging of Surma-Baulai River System	Dredging of river will increase the income opportunity of the fisher community as well as increase the agricultural production based income. At the same time, the spoils that will come from dredging can be dump into the fallow lands which will help to increase the land price. The transportation and communication system will also improve in terms of navigation.
10	O&M during post Construction	Regular O&M will create some temporary employment opportunity for the local labors every year. Agriculture production based income will also be secured.
11	Revetments/ Stairs and Ramps/ Greenbelt/ Nurseries	The settlement area will be more protected and the vulnerability of settlement erosion will be reduced. Land price of the settlement area will be highly increased.

Potential impacts of two different programs on Improvement of road and communication System undertaken by Roads and Highways Department and Local Government and Engineering Division has been identified for socio-economic resources of the haor region. For haor ecosystem all season road is harmful for its environmental aspects. Agricultural production based income may reduce if the proposed road will construct on agriculture land and the marginalized farmers. But due to the construction of road the communication system will highly improved. The land value will also be highly appreciated. More employment opportunities will be created in the area. The primary producers will get direct access to the whole sale market. At the same time the modern products and technologies will marginalized the local products.

The impacts of the interventions on as identified through the scoring of the respective experts have been given in Annex E.

4.4 Limitation

Predicting the impact of the future interventions in the haor region required detailed information about these interventions which includes specific objective of the plans, specific location of the interventions (exact alignment in case of roads), type and components of the interventions, timeline of the projects etc. However, in most of the cases, the abovementioned information was not available. Difficulties were faced in identifying the actual alignment and reach of the roads which would be either developed or improved. Lack of such details about the components including their specific location created difficulty for the experts to identify location specific impacts on the selected sectors which forced the experts in predicting the impacts in a generalized manner rather than being precise.

Chapter 5: Stakeholder Consultations

5.1 Introduction

Strategic Environmental Assessment (SEA) is emerging as a new tool to incorporate environmental concerns into the highest levels of decision-making. Public participation in strategic environmental assessment (SEA) is important as it aims to increase the transparency and credibility of decision-making and include relevant issues during the plan- or programme-making process. In addition, it allows incorporating public's opinions in the plan- or programme-making process as well as in the implementation phase. With this perspective, 14 consultation workshops were held at different upazillas of Sunamganj, Sylhet, Moulavibazar, Habiganj, Netrokona, Mymensingh and Kishoreganj District from 03 December, 2017 to 07 December, 2017. Based on the prepared checklist, all concern stakeholders from respective Upazilla administrations, LGI representatives, and community representative delivered their feedbacks on the probable impacts of future intervention in the Haor region.

5.2 Objective

The broad objective of the consultation workshopwas to take views of all concerned stakeholders (primary and secondary stakeholder) about the impact of future development plan and probable interventions in the haor region and find out possible measures to mitigate the negative impact for such development.

5.3 Consultation Workshops

Primary and secondary stakeholders were present in the consultation workshops which were organized at different upazillas of Sunamganj, Sylhet, Moulavibazar, Habiganj, Netrokona, Mymensingh and Kishoreganj District from 03 December, 2017 to 07 December, 2017. Farmers, fisherman, boatman, small businessman, entrepreneurs, local LGI representatives were present as the primary stakeholders and Upazilla Chairman, Upazilla Nirbahi Officer (UNO), other officers from upazilla administration, local government representative from different unions, journalists, and local representative were present as the secondary stakeholders in these workshops. A checklist on water resources, agriculture, fisheries, haor ecosystem and socio economic condition were used to get the insight from attended stakeholders based on the triggered problems and suggestions for future concern. The participation of both primary and secondary stakeholders was remarkable and they provided insights on probable impact of future intervention in the haor region. The future impacts as identified under five different sectors and the measures suggested against them are presented in the following sections.

5.4 Water Resources

Future Impacts and problems

a) Possibility of severe damage of embankments and agricultural production due to regular flooding;
b) Possibility of siltation of River, Beel and Haor bed due to washing off the top soil;
c) The Sluice gates, regulators may not function in the long run due to lack of regular monitoring and maintenance; and

Suggested measures

a) Regular Dredging is important for ensuring connectivity of rivers, internal *khals/canals* and Beels;
b) Regular operation and maintenance of the structures; and
c) Flooding condition of the Haor areas needs to be assessed before implementing any plans and programs.

5.5 Fisheries

Future Impacts and problems

a) Structural Interventions may pose a threat to indigenous fish; and
b) Possibility of increased use of insecticides which may pose a threat to fishes and their habitats;

Suggested measures

a) Open river shouldn't be considered for leasing arrangements;
b) The lease of Jalmahal should be provided to the actual fishermen;
c) The use and sale of Current Jal /Tona Jal should be prohibited fully;
d) Natural vegetation which is required for Fishes should be cared properly;
e) The plantation of Hijol and Koroch trees should be increased for the survival of endangered fish;
f) The use of insecticides needs to be decreased, especially for those areas where the Jalmahal or Fish Habitat is located; and
g) Construction of future intervention like culvert, sluice gates, embankments, closers should assess the existing fish habitat condition, migration route, other impacts of existing fisheries.

5.6 Agriculture

Future Impacts and problems

a) Siltation problem and water logging may increase due to construction and non-maintenance of structural interventions and cause problems for agricultural production; and
b) The cultivation and production may get hampered if there is insufficient irrigation facilities.

Suggested measures

a) Early flash flood resilient rice varieties or seeds should be used;
b) Deep tube wells should be installed for facilitating the irrigation facilities; and
c) Intervention for flood management should be undertaken in the Haors where such interventions have not yet been implemented by BWDB and other agencies.

5.7 Ecosystem

Future Impacts and problems

a) Reduced natural vegetation coverage due to conversion of fallow land for roads, crop cultivation and human habitation;

b) Over extractions of swamp trees, herbs and shrubs for meeting the demand of fuel wood;
c) The number of *Hijol Koroch* trees may decrease;
d) Migratory birds may decrease with the period of time;
e) Increased use of pesticides may create a detrimental effect to aquatic flora and fauna; and
f) Possibility of damages to floating and submerged plants by random use of fishing nets inside floodplains and perennial wetlands.

Suggested measures

a) Demarcation of perennial boundaries of the beels and enforce law and order to ban agricultural extension in such beels, and ban fully drying of wetland for fish catch;
b) Raising awareness among the people for wildlife conservation and optimum use of pesticides and fertilizers;
c) Tree Plantation program along the river levees, embankment slopes, *kandas* and other *khas* lands involving local people for nursery raising; and
d) Involvement of Forest Department for conserving important swamp forest.

5.8 Socio economic

Future Impacts and problems

a) Absence of participatory management for flood control and repairing of existing structure; and
b) The accountability and transparency of institutional governance.

Suggested measures

a) A functional PIC and monitoring should be formed considering the concerns of all stakeholders for O&M in the haor region;
b) Local People's feedback should be acknowledged and incorporated before the implementation of any policy, plan and program in the haor regions;
c) Alternative training and soft loan would be provided to enhance resilience for the development of entrepreneurship; and
d) Bottom-up approach should be followed during design, operation and maintenance of the project.

Chapter 6: Alternative Strategies

The alternative strategies have been formulated based on a blend of structural and non-structural measures to make optimal use of available natural resources with minimal/ no disturbance to the haor ecosystem. The basis of the strategy development is the impact analysis of the future programmes for haor area as discussed in previous chapters.

By definition alternative strategy means the strategies those substitute the proposed ones to attain the same objectives. However, here it is tried to suggest options/ strategies that trigger/ strengthen the proposed programmes instead of conventional alternative strategies which will reduce the environmental affect and contribute to socio economic development.

6.1 Alternative Strategies for Proposed Roads by LGED and RHD

i. For the roads to be located in deeply flooded area:

- All the proposed roads should be submergible;
- The roads should be elevated if anticipated to affect any important haor ecosystem.
- For the submersible road the alignment should be along the submersible embankment;
- For all weather road, road should be constructed with sufficient drainage provision.
- Any further road should not constructed in deeply flooded area.

ii. General condition to be followed for proposed roads and any further plans/programs:

- The Government in the Gazette notification (2009) prohibited some activities or processes, which cannot be initiated or continued in an ECA, those are harmful for aquatic life; polluting water by disposing waste; and any other activity that could destroy or change the natural characteristics of soil and water. Under this circumstance, further investigation is required to study whether the proposed interventions will affect the haor ecosystem. If so, then such intervention should be either avoided or the road alignment should be revised/changed.
- All the proposed roads should be constructed avoiding agriculture land. Adequate cross drainage, culvert or inverted siphon should be ensured for passing flood, drainage and irrigation conveyance.
- Transportation planners and natural-resource planners should collaborate to promote integrated planning at comparable scope and scale so that the efforts can support mutual objectives.
- LGED has development road design standard where guideline for submersible road pavement in haor areas has been mentioned. It proposed RCC pavement for upazilla and union road. Road geometry of this RCC Pavement Road is comprised of 3.70m or 3.00m RCC pavement with 1.8m earthen shoulder on each side totaling 7.30m or 5.50m in crest for upazila or union road respectively. These measurements should be followed for the proposed roads.

Case study on 'Improvement of Taherpur UZHQ Maddanagar via Solmanpur Road'

The proposed 'Improvement of Taherpur UZHQ Maddanagar via Solmanpur Road' (13.44 km) will go through three haors; Matian Haor, Lubar Haor and Shanir Haor where Shanir Haor, having more than 20,000 water birds is an ecologically important haor (Figure 6.1). In addition the proposed road is assumed to cross Baidar Beel which is a source of income for haor people. Under this circumstance, two alternative option/strategies have been proposed here which is shown in Figure 6.1. In option 1 the road alignment is proposed to be changed slightly and go along the haor boundary of Lubar Haor to avoid the crossing of Baidar Beel. The proposed road length will be 13.9km. Another strategy can be shifting of road alignment along the Shonir and Lubar Haor to avoid interruption of agricultural land and Bbaidar Beel.

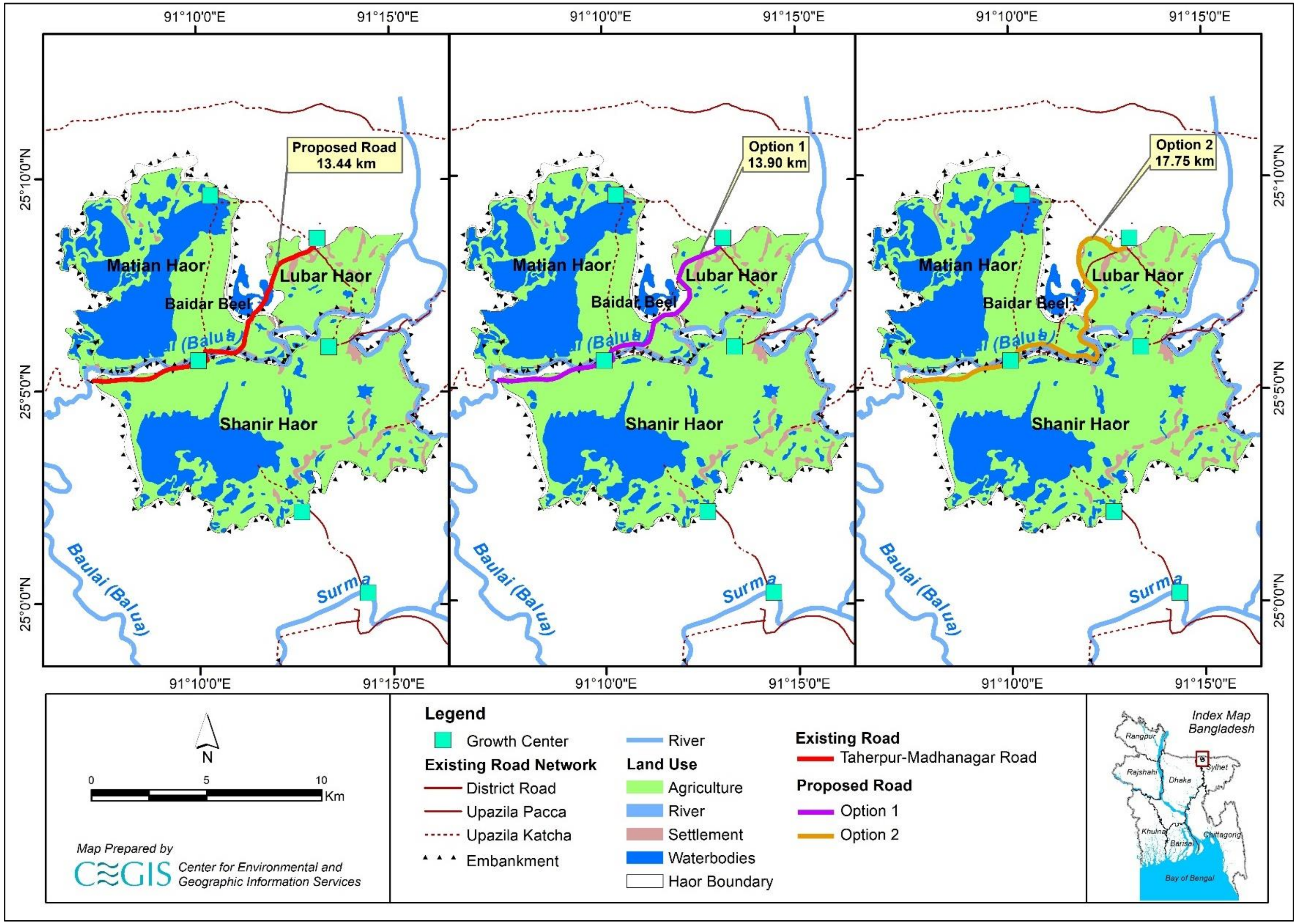

Figure 6.1: Existing Condition and Strategic Options for the proposed Improvement of Taherpur UZHQ Maddanagar via Solmanpur Road

6.2 Strategic options/condition for Flood management and wave protection related infrastructure

a. All the embankments should be submersible with attention to the improvement of standard of living of the community as emphasized in National Water Policy. A study can be under taken to investigate how to integrate food security, ecological and livelihood criteria in the planning of the flood management project in the haor region.

b. The provision of reinforced flood passages in appropriate places instead of bridges and culverts could reduce impedance of flood flow as well as capital and maintenance costs.

c. To prevent wave attack, CC blocks revetment over geo textile can be used which is the most economical solution in the haor areas. The technique is both environment friendly as well as socially acceptable. It has expected to serve the purpose of saving lives and property of residents because of the resistant property of geotextile.

d. Embankments can be constructed using reinforced earth technique using coal ash as primary fill material. Coal ash has high shear strength and has a high consolidation rate and thus can be compacted over a wide range of moisture content. This material is eco-friendly as it conserves agricultural land.

e. Geo-synthetics can be used as embankment materials as they possess wide range of physical properties and are akin to an extensive assortment of practical applications. Geo-synthetics are also environmentally friendly as the drastically reduce the CO2 emission associated from construction work. Geo-synthetic can be used in term of reinforcement and drainage in embankments, soil reinforcement in dam embankments, separation of materials and filtration, and internal drains or internal water barriers.

f. Multimodal use of embankments can be done through construction of submersible roads over the embankments. This will on one hand provide more accessibility in terms of transportation of both people and goods, and also it will provide protection against erosion and subsequent damage to crops and aquatic habitat.

g. CC blocks revetment over geo textile are the most economical solution in the haor areas for wave protection. These techniques are both environment friendly as well as socially acceptable in their structure.

6.3 Implementation strategy

The major implementing agencies will implement the alternative strategies with assistance of other local government bodies. The major implementing organizations are required to involve local government and the private sector wherever necessary. In implementation, government agencies will ensure that they are designed with specific provision for O&M activities.

Here the proposed interventions are under the responsibility of LGED, RHD and BWDB and thus the implementation of strategies require the coordination of these three authorities through Bangladesh Haor and Wetlands Development Board. These three authorities will have their own implementation strategies like other project they are implementing which has been discussed below.

6.3.1 Institutional arrangement of Bangladesh Water Development Board (BWDB)

The BWDB is responsible for controlling as well as for developing standards and guidelines for water management structures. In addition they will ensure the implementation of the proposed alternative strategies. The BWDB will set up the Project Management Unit (PMU) to manage the implementation. The PMU will be led by the Project Director (PD). To manage and oversee the environmental and social aspects of the Project, the PMU will have an Environment, Social, and Communication Unit (ESCU). The Unit will supervise compliance with and implementation of the EMP. The Unit will include a Senior Environmental Specialist. One environment specialist will be posted at the field level to support all three divisions. The ESCU will maintain liaison with the regulatory agencies, and other stakeholders during the Project implementation.

6.3.2 Institutional arrangement Local Government and Engineering Department (LGED)

The executing agency is headed by the Chief Engineer (CE), under the supervision of Local Government Division (LGD) of MLGRD&C. Under the CE, the Project Management Office (PMO) headed by a Project Director (PD) is established at LGED headquarters. Different Organizational Units are engaged in the implementation process of the project.

A Project Director along with supporting staff will be held responsible for implementation of the projects with the alternative strategies. The Executive Engineer, Assistant Engineers & Sub-assistant Engineers will assist the Project Director in supervising, monitoring & physically visiting the implementation activities also preparing yearly work plan. The Executive Engineer and Assistant Engineer of LGED at district level will implement Construction/development of all the infrastructure of the project including rural road, bridge/culverts. At upazila level, the Upazila Engineer and his technical staff will provide support to the Executive Engineer in implementing the activities of the respective upazila. The Chief Engineer LGED will co-ordinate project activities to ensure proper and smooth implementation of the project. The Supervision and Monitoring Offices (SMOs), Project Implementation Offices (PIOs) and LGED Upazila Engineer Offices are responsible for the implementation of the rural components.

6.3.3 Institutional arrangement Roads and Highways Department (RHD)

The implementing agency of the proposed strategies will be the Roads and Highways Department. In some cases, within major cities, implementation may be assisted by the relevant City Corporation. RHD should monitor the physical implementation and report on this annually. The institutional arrangement for implementing any project as well as incorporating the alternative strategies is shown in figure 6.2.

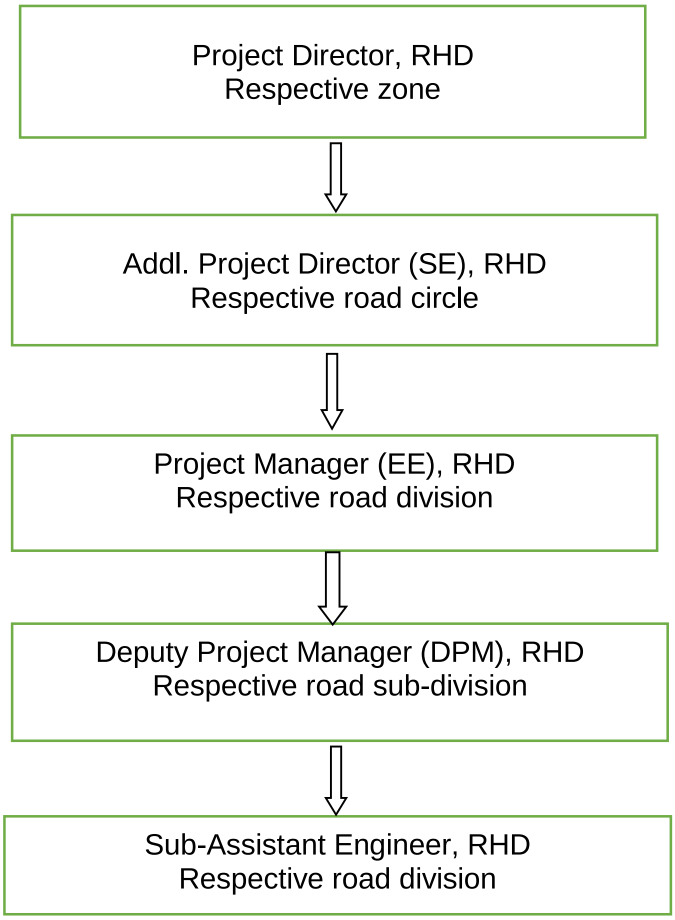

Figure 6.2: Institutional Arrangement of RHD for Alternative Strategy Implementation

References

MPHA (2012), Master Plan of Haor Area (Vol II), Department of Bangladesh Haor and Wetlands Development, Ministry of Water Resources, Government of the People's Republic of Bangladesh, Dhaka 1215. 260 pp.

Annex A: Scoring Matrix for Water Resources and Navigation

Table A-1: Impact on the Water Resources and Navigation due to Flood Management and Livelihood Improvement Project

Project Component			Flooding	Drainage	Sedimentation	Navigation	Erosion	Cumulative Consequence of Intervention
SL No	**Sub-Project No.**	**Name of Subproject**						
1	N-6	Badla Haor Sub- Project	1.6	2.1	-0.9	0.7	-0.3	0.7
2	N-7	Chatal Haor Sub- Project	1.4	2.0	-0.6	0.4	-0.4	0.6
3	N-9	Suniar Haor Sub-Project	2.0	1.8	-0.5	1.3	-0.5	0.8
4	N-10	Mokhar Haor Sub-Project	1.6	2.1	-0.9	0.7	-0.3	0.7
5	N-11	Ganesh Haor Sub-Project	1.6	2.1	-0.9	0.7	-0.3	0.7
6	N-13	Jaliar Haor Sub- Project	1.6	2.1	-0.9	0.7	-0.3	0.7
7	N-14	Dhakua Haor Sub-Project	1.5	2.0	-0.7	0.8	-0.3	0.7
8	R-1	Alalia-Bahadia Sub-Project	2.0	3.0	0.0	1.5	-0.5	1.2
9	R-2	Modkhola-Bairagir Cha Sub- Project	2.3	1.3	-0.3	0.3	-0.7	0.6
10	R-3	Ganakkhali Sub-Project	2.3	1.3	-0.3	0.3	-0.7	0.6
11	R-4	Boraikhali Khal Sub-Project	2.0	3.0	0.0	1.5	-0.5	1.2
12	R-5	Koirdahla Ratna Sub-Project	2.0	1.7	-0.3	0.7	-0.7	0.7
13	R-6	Guingajuri Sub-Project	2.2	1.2	-0.8	0.0	-0.6	0.4
14	R-7	Aralia Khal Sub-Project	2.0	2.0	-0.8	0.5	-0.5	0.5
15	R-8	Bashira River Re-excavation Sub-Project	2.0	1.7	-0.3	0.7	-0.7	0.7
16	R-9	Dampara Water Management Scheme	2.3	1.8	-0.8	0.3	-0.5	0.6
17	R-10	Kangsha River Scheme	2.3	1.3	-0.3	0.3	-0.7	0.6
18	R-11	Singer Bell Sub-Project	2.3	0.8	-0.5	0.0	-0.8	0.4
19	R-12	Khaliajuri FCD Polder-2	2.0	1.7	-0.3	0.7	-0.7	0.7
20	R-13	Khaliajuri FCD Polder-4	2.0	1.7	-0.3	0.7	-0.7	0.7
21	R-14	Chandal Beel Sub-Project	2.0	3.0	-2.0	0.0	0.0	0.6
22	R-15	Satdona Beel Scheme	2.0	3.0	-2.0	0.0	0.0	0.6
Overall Impact on Haor Region								**0.7**

Table A-2: Impact on the Water Resources and Navigation due to Village Protection against Wave Action in Haor Area

Sl No	Project Name	Flooding	Drainage	Sedimentation	Navigation	Erosion	Cumulative Consequence of Intervention
1	Village Protection against Wave Action in Haor Area	1	1	0.5	0	2.75	1.1
Overall Impact on Haor Region							**1.1**

Table A-3: Impact on the Water Resources and Navigation due to Improvement of Road Communication by LGED

Sl No.	Project Name	Flooding	Drainage	Sedimentation	Navigation	Erosion	Cumulative Consequence of Intervention
1	Austagram- Lakhai road via Ekurdia Dalarkandi Road	-2	-1	-1	-1	-1	-1.2
2	Itna-Azmiriganj GC Road	-2	-1	-1	-1	-1	-1.2
3	Rasulpur-Azabpur Road	-2	-1	-1	-1	-1	-1.2
4	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj GC Road	-2	-1	-1	-1	-1	-1.2
5	Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	-2	-1	-1	-1	-1	-1.2
6	Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	-2	-1	-1	-1	-1	-1.2
7	Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	-2	-1	-1	-1	-1	-1.2
8	Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	-2	-1	-1	-1	-1	-1.2
9	Chamerdani UPC - Shararkona Ghat Road	-2	-1	-1	-1	-1	-1.2
10	Madhayanagar UPC - Toker bazar via Shahapur Road	-2	-1	-1	-1	-1	-1.2
11	Paykurati UPC - Toker bazar via Jamalpur Madrasha Road	-2	-1	-1	-1	-1	-1.2
12	Lankapathria-Banarasshipur via Razapur Rd	-2	-1	-1	-1	-1	-1.2
13	Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	-2	-1	-1	-1	-1	-1.2

Sl No.	Project Name	Flooding	Drainage	Sedimentation	Navigation	Erosion	Cumulative Consequence of Intervention
14	Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road	-2	-1	-1	-1	-1	-1.2
15	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha	-2	-1	-1	-1	-1	-1.2
Overall Impact on Haor Region							**-1.2**

Table A-4: Impact on the Water Resources and Navigation due to Improvement of Road Communication by RHD

Sl No.	Project Name	Flooding	Drainage	Sedimentation	Navigation	Erosion	Cumulative Consequence of Intervention
1	Madanpur-Dirai-Sullah Road	-2	-1	-1	-1	-1	-1.2
2	Habiganj-Baniyachang-Ajmiriganj-Sullah Road	-2	-1	-1	-1	-1	-1.2
3	R260 Sylhet-Sunamganj	-2	-1	-1	-1	-1	-1.2
4	N2 Bhairab – Moulvibazar 4 lane	-2	-1	-1	-1	-1	-1.2
5	N2 Habiganj – Sylhet 4 lane	-2	-1	-1	-1	-1	-1.2
Overall Impact on Haor Region							**-1.2**

Annex B: Scoring Matrix for Land, Agriculture and Livestock

Table B-1: Impact on the Land, Agriculture and Livestock due to Flood Management and Livelihood Improvement Project

Sl No	Sub-Project No.	Name of Subproject	Cropping intensity	Cropped area	Crop production	Crop damage	Irrigated area	Agro-chemicals use	Cumulative Consequence of elements	Cumulative Consequence of Intervention
1	N-6	Badla Haor Sub-Project			1.3	2.1	1.5	-1.0	1.6	1.6
2	N-7	Chatal Haor Sub-Project			1.0	2.0	1.0	-1.0	1.2	1.2
3	N-9	Suniar Haor Sub-Project			1.3	1.8	3.0		1.7	1.7
4	N-10	Mokhar Haor Sub-Project			1.3	2.0	2.5	-1.0	1.5	1.5
5	N-11	Ganesh Haor Sub-Project			1.0	1.2	1.5		1.1	1.1
6	N-13	Jaliar Haor Sub-Project			1.1	1.8	1.5	-1.0	1.3	1.3
7	N-14	Dhakua Haor Sub-Project			1.1	1.7	2.0	-1.0	1.3	1.3
8	R-1	Alalia-Bahadia Sub-Project			1	2	2		1.5	1.5
9	R-2	Modkhola-Bairagir Cha Sub- Project			1	2	2		1.5	1.5
10	R-3	Ganakkhali Sub-Project			1	2	2		1.5	1.5
11	R-4	Boraikhali Khal Sub-Project			1	2	2		1.5	1.5
12	R-5	Koirdahla Ratna Sub-Project			1	2	2		1.5	1.5
13	R-6	Guingajuri Sub-Project			1.4	2.5	3		2.0	2.0
14	R-7	Aralia Khal Sub-Project			1.3	2	2		1.6	1.6

Sl No	Sub-Project No.	Name of Subproject	Cropping intensity	Cropped area	Crop production	Crop damage	Irrigated area	Agro-chemicals use	Cumulative Consequence of elements	Cumulative Consequence of Intervention
15	R-8	Bashira River Re-excavation Sub-Project			1	1.5	2		1.3	1.3
16	R-9	Dampara Water Management Scheme			1	2	2		1.5	1.5
17	R-10	Kangsha River Scheme			1	2	2		1.5	1.5
18	R-11	Singer Bell Sub-Project			1	1.7	2		1.4	1.4
19	R-12				1	2	2		1.5	1.5
20	R-13	Khaliajuri FCD Polder-4			1	1.5	2		1.3	1.3
21	R-14	Chandal Beel Sub-Project			1	1			1.0	1.0
22	R-15	Satdona Beel Scheme			1	1			1.0	1.0
Overall Impact on Haor Region										1.43

Table B-2: Impact on the Land, Agriculture and Livestock due to Village Protection against Wave Action in Haor Area

Sl No	Project Name	Cropping intensity	Cropped area	Crop production	Crop damage	Irrigated area	Agro-chemicals use	Cumulative Consequence of Intervention
1	Village Protection against Wave Action in Haor Area			1	2.2	1.75	-1.5	1.4
Overall Impact on Haor Region								**1.4**

Table B-3: Impact on the Land, Agriculture and Livestock due to Improvement of Road Communication by LGED

Sl No.	Project Name	Cropping intensity	Cropped area	Crop production	Crop damage	Irrigated area	Agro-chemicals use	Cumulative Consequence of Intervention
1	Austagram- Lakhai road via Ekurdia Dalarkandi Road	N/A	-1	-1	-2	-1		-1.25
2	Itna-Azmiriganj GC Road	N/A	-1	-1	-2	-1		-1.25
3	Rasulpur-Azabpur Road	N/A	-1	-1	-2	-1		-1.25
4	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj GC Road	N/A	-1	-1	-2	-1		-1.25
5	Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	N/A	-1	-1	-2	-1		-1.25
6	Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	N/A	-1	-1	-2	-1		-1.25
7	Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	N/A	-1	-1	-2	-1		-1.25
8	Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	N/A	-1	-1	-2	-1		-1.25
9	Chamerdani UPC - Shararkona Ghat Road	N/A	-1	-1	-2	-1		-1.25
10	Madhayanagar UPC - Toker bazar via Shahapur Road	N/A	-1	-1	-2	-1		-1.25
11	Paykurati UPC - Toker bazar via Jamalpur Madrasha Road	N/A	-1	-1	-2	-1		-1.25
12	Lankapathria-Banarasshipur via Razapur Rd	N/A	-1	-1	-2	-1		-1.25
13	Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	N/A	-1	-1	-2	-1		-1.25
14	Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road	N/A	-1	-1	-2	-1		-1.25
15	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha	N/A	-1	-1	-2	-1		-1.25
Overall Impact on Haor Region								**-1.25**

Table B-4: Impact on the Land, Agriculture and Livestock due to Improvement of Road Communication by RHD

Sl No.	Project Name	Cropping intensity	Cropped area	Crop production	Crop damage	Irrigated area	Agro-chemicals use	Cumulative Consequence of Intervention
1	Madanpur-Dirai-Sullah Road		-1	-1	-2	-1		-1.25
2	Habiganj-Baniyachang-Ajmiriganj-Sullah Road		-1	-1	-2	-1		-1.25
3	R260 Sylhet-Sunamganj		-1	-1	-2	-1		-1.25
4	N2 Bhairab – Moulvibazar 4 lane		-1	-1	-2	-1		-1.25
5	N2 Habiganj – Sylhet 4 lane		-1	-1	-2	-1		-1.25
Overall Impact on Haor Region								**-1.25**

Annex C: Scoring Matrix for Fisheries Resources

Table C-1: Impact on the Fisheries Resources due to Flood Management and Livelihood Improvement Project

SL.No.	Sub-Project No.	Name of Sub-project	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of intervention
1	N-6	Badla Haor Sub- Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
2	N-7	Chatal Haor Sub- Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
3	N-9	Suniar Haor Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
4	N-10	Mokhar Haor Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
5	N-11	Ganesh Haor Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
6	N-13	Jaliar Haor Sub- Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
7	N-14	Dhakua Haor Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
8	R-1	Alalia-Bahadia Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
9	R-2	Modkhola-Bairagir Cha Sub- Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
10	R-3	Ganakkhali Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
11	R-4	Boraikhali Khal Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
12	R-5	Koirdahla Ratna Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
13	R-6	Guingajuri Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
14	R-7	Aralia Khal Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
15	R-8	Bashira River Re-excavation Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
16	R-9	Dampara Water Management Scheme	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8

SL.No.	Sub-Project No.	Name of Sub-project	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of intervention
17	R-10	Kangsha River Scheme	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
18	R-11	Singer Bell Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
19	R-12	Khaliajuri FCD Polder-2	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
20	R-13	Khaliajuri FCD Polder-4	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
21	R-14	Chandal Beel Sub-Project	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
22	R-15	Satdona Beel Scheme	-1	-2	-1	-2	-1	1	-1	1	-1	-0.8
Overall Impact on Haor Region												**-0.8**

Table C-2: Impact on the Fisheries Resources due to Village Protection against Wave Action in Haor Area

Sl No	Project Name	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of intervention
1	Village Protection against Wave Action in Haor Area						1				1
Overall Impact on Haor Region											1.0

Table C-3: Impact on the Fisheries Resources due to Improvement of Road Communication by LGED

Sl No.	Project Name	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of Intervention
1	Austagram- Lakhai road via Ekurdia Dalarkandi Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
2	Itna-Azmiriganj GC Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
3	Rasulpur-Azabpur Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
4	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj GC Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
5	Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	-1	-1	-1	-2	0	0	-1	1	-1	-1
6	Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
7	Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	-1	-1	-1	-2	0	0	-1	1	-1	-1
8	Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	-1	-1	-1	-2	0	0	-1	1	-1	-1
9	Chamerdani UPC - Shararkona Ghat Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
10	Madhayanagar UPC - Toker bazar via Shahapur Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
11	Paykurati UPC - Toker bazar via Jamalpur Madrasha Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
12	Lankapathria-Banarasshipur via Razapur Rd	-1	-1	-1	-2	0	0	-1	1	-1	-1
13	Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	-1	-1	-1	-2	0	0	-1	1	-1	-1

Sl No.	Project Name	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of Intervention
14	Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road	-1	-1	-1	-2	0	0	-1	1	-1	-1
15	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha	-1	-1	-1	-2	0	0	-1	1	-1	-1
Overall Impact on Haor Region											**-1**

Table C-4: Impact on the Fisheries Resources due to Improvement of Road Communication by RHD

Sl No.	Project Name	Fish Habitat Area	Fish Habitat Condition	Fish Species Diversity	Fish Migration/ Movement	Fish Production	Fishing Appliances	Fisher's Livelihood	Fisheries Management	Other (Habitat Connectivity Restoration)	Cumulative Consequence of Intervention
1	Madanpur-Dirai-Sullah Road	-1	-1	-1	-2	0	0	-1	1	-1	**-1**
2	Habiganj-Baniyachang-Ajmiriganj-Sullah Road	-1	-1	-1	-2	0	0	-1	1	-1	**-1**
3	R260 Sylhet-Sunamganj	-1	-1	-1	-2	0	0	-1	1	-1	**-1**
4	N2 Bhairab – Moulvibazar 4 lane	-1	-1	-1	-2	0	0	-1	1	-1	**-1**
5	N2 Habiganj – Sylhet 4 lane	-1	-1	-1	-2	0	0	-1	1	-1	**-1**
Overall Impact on Haor Region											**-1**

Annex D: Scoring Matrix for Ecology

Table D-1: Impact on the Ecology Resources due to Flood Management and Livelihood Improvement Project

SL No	Sub-Project No.	Name of Sub-project	Terrestrial flora and Fauna	Aquatic Flora and Fauna	Forest (Swamp Forest, Reedland)	Environmental Pollution	Ecosystem goods and services	Cumulative Consequence of Intervention
1	N-6	Badla Haor Sub- Project	-0.1	0.0	-0.1	0.0	0.4	0.0
2	N-7	Chatal Haor Sub- Project	-0.1	0.0	-0.1	0.0	0.4	0.0
3	N-9	Suniar Haor Sub-Project	0.0	-0.4	0.0	0.0	0.3	0.0
4	N-10	Mokhar Haor Sub-Project	-0.4	0.3	0.0	-0.1	0.3	0.0
5	N-11	Ganesh Haor Sub-Project	-0.1	-0.1	0.0	0.0	0.1	0.0
6	N-13	Jaliar Haor Sub- Project	0.0	-0.3	0.0	0.0	0.0	-0.1
7	N-14	Dhakua Haor Sub-Project	-0.3	-0.1	0.0	0.0	0.1	-0.1
8	R-1	Alalia-Bahadia Sub-Project	0.0	0.0	0.0	0.0	0.2	0.0
9	R-2	Modkhola-Bairagir Cha Sub- Project	-0.4	0.4	0.0	-0.2	0.2	0.0
10	R-3	Ganakkhali Sub-Project	-0.4	0.4	0.0	-0.2	0.2	0.0
11	R-4	Boraikhali Khal Sub-Project	-0.2	0.2	0.0	-0.2	0.0	0.0
12	R-5	Koirdahla Ratna Sub-Project	-0.2	0.0	0.0	0.0	0.2	0.0
13	R-6	Guingajuri Sub-Project	-0.2	0.4	0.0	0.0	0.2	0.1
14	R-7	Aralia Khal Sub-Project	0.0	0.2	0.0	0.0	0.0	0.0
15	R-8	Bashira River Re-excavation Sub-Project	0.0	0.2	0.0	0.0	0.0	0.0
16	R-9	Dampara Water Management Scheme	-0.4	0.4	0.0	0.0	0.0	0.0
17	R-10	Kangsha River Scheme	-0.2	0.4	0.0	0.0	0.0	0.0
18	R-11	Singer Bell Sub-Project	0.0	0.2	0.0	0.0	0.0	0.0
19	R-12	Khaliajuri FCD Polder-2	0.0	0.4	0.0	0.0	0.4	0.2
20	R-13	Khaliajuri FCD Polder-4	0.0	0.2	0.0	0.0	0.0	0.0
21	R-14	Chandal Beel Sub-Project	0.0	0.0	0.0	0.0	0.0	0.0
22	R-15	Satdona Beel Scheme	0.0	0.0	0.0	0.0	0.0	0.0
Overall Impact on Haor Region								**0.0**

Table D-2: Impact on the Ecology Resources due to Village Protection against Wave Action in Haor Area

Sl No	Project Name	Terrestrial flora and Fauna	Aquatic Flora and Fauna	Forest (Swamp Forest, Reedland)	Environmental Pollution	Ecosystem goods and services	Cumulative Consequence of Intervention
1	Village Protection against Wave Action in Haor Area	0.4	0.1	0.3	0	0.2	0.2
Overall Impact on Haor Region							**0.2**

Table D-3: Impact on the Ecology Resources due to Improvement of Road Communication by LGED

Sl No.	Project Name	Terrestrial flora and Fauna	Aquatic Flora and Fauna	Forest (Swamp Forest, Reedland)	Environmental Pollution	Ecosystem goods and services	Cumulative Consequence of Intervention
1	Austagram- Lakhai road via Ekurdia Dalarkandi Road	-0.7	-0.7	0.0	0.0	0.0	-0.3
2	Itna-Azmiriganj GC Road	-0.7	-0.3	0.0	0.0	0.0	-0.2
3	Rasulpur-Azabpur Road	-0.7	-0.3	0.0	0.0	0.0	-0.2
4	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj GC Road	0.0	-0.5	0.0	0.0	0.0	-0.1
5	Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	-0.7	-0.3	0.0	0.0	0.0	-0.2
6	Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	-0.7	-0.3	0.0	0.0	0.0	-0.2
7	Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	-0.7	-0.3	0.0	0.0	0.0	-0.2
8	Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	-0.3	-0.3	0.0	0.0	0.0	-0.1
9	Chamerdani UPC - Shararkona Ghat Road	-0.7	0.0	0.0	0.0	0.0	-0.1
10	Madhayanagar UPC - Toker bazar via Shahapur Road	-0.7	0.0	0.0	0.0	0.0	-0.1

Sl No.	Project Name	Terrestrial flora and Fauna	Aquatic Flora and Fauna	Forest (Swamp Forest, Reedland)	Environmental Pollution	Ecosystem goods and services	Cumulative Consequence of Intervention
11	Paykurati UPC - Toker bazar via Jamalpur Madrasha Road	-0.3	-0.3	0.0	0.0	0.0	-0.1
12	Lankapathria-Banarasshipur via Razapur Rd	-0.7	0.0	0.0	0.0	0.0	-0.1
13	Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	0.0	-0.3	0.0	0.0	0.0	-0.1
14	Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road	-0.3	-0.3	0.0	0.0	0.0	-0.1
15	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha	0.0	-0.3	0.0	0.0	0.0	-0.1
Overall Impact on Haor Region							**-0.15**

Table D-4: Impact on the Ecology Resources due to Improvement of Road Communication by RHD

Sl No.	Project Name	Terrestrial flora and Fauna	Aquatic Flora and Fauna	Forest (Swamp Forest, Reedland)	Environmental Pollution	Ecosystem goods and services	Cumulative Consequence of Intervention
1	Madanpur-Dirai-Sullah Road	-1	-1	0	-1	0	-0.6
2	Habiganj-Baniyachang-Ajmiriganj-Sullah Road	-1	-1	0	-1	0	-0.6
3	R260 Sylhet-Sunamganj	-1	-1	0	-1	0	-0.6
4	N2 Bhairab – Moulvibazar 4 lane	-1	-1	0	-1	0	-0.6
5	N2 Habiganj – Sylhet 4 lane	-1	-1	0	-1	0	-0.6
Overall Impact on Haor Region							**-0.6**

Annex E: Scoring Matrix for Socio-economic Resources

Table E-1: Impact on the Socio-economic Resources due to Flood Management and Livelihood Improvement Project

SL No	Sub-Project No.	Name of Subproject	Agricultural Production and Income	Income from Fisheries	Employment Opportunity	Housing Condition	Transportation and communication	Land Value	Navigation Route	Cumulative Consequence of Intervention
1	N-6	Badla Haor Sub-Project	1.4	0.1	0.5	0.4	0.5	0.5	0.3	0.5
2	N-7	Chatal Haor Sub-Project	1.3	0.1	0.5	0.4	0.5	0.5	0.3	0.5
3	N-9	Suniar Haor Sub-Project	1.3	0.1	0.5	0.4	0.5	0.5	0.3	0.5
4	N-10	Mokhar Haor Sub-Project	1.4	0.3	0.6	0.4	0.5	0.5	0.4	0.6
5	N-11	Ganesh Haor Sub-Project	1.3	0.0	0.5	0.4	0.5	0.5	0.3	0.5
6	N-13	Jaliar Haor Sub-Project	1.3	0.1	0.5	0.4	0.5	0.5	0.3	0.5
7	N-14	Dhakua Haor Sub-Project	1.4	0.3	0.6	0.4	0.6	0.5	0.4	0.6
8	R-1	Alalia-Bahadia Sub-Project	0.4	0.2	0.2	0.0	0.0	0.0	0.2	0.1
9	R-2	Modkhola-Bairagir Cha Sub- Project	0.6	0.2	0.4	0.2	0.2	0.2	0.2	0.3
10	R-3	Ganakkhali Sub-Project	0.6	0.2	0.4	0.2	0.2	0.2	0.2	0.3
11	R-4	Boraikhali Khal Sub-Project	0.6	0.2	0.2	0.0	0.0	0.0	0.2	0.2
12	R-5	Koirdahla Ratna Sub-Project	0.8	0.2	0.4	0.0	0.2	0.2	0.2	0.3
13	R-6	Guingajuri Sub-Project	2.0	0.6	1.4	1.2	1.0	1.0	0.4	1.1
14	R-7	Aralia Khal Sub-Project	1.2	0.2	0.8	0.4	0.4	0.4	0.2	0.5
15	R-8	Bashira River Re-excavation Sub-Project	1.2	0.6	0.8	0.6	0.4	0.4	0.4	0.6

SL No	Sub-Project No.	Name of Subproject	Agricultural Production and Income	Income from Fisheries	Employment Opportunity	Housing Condition	Transportation and communication	Land Value	Navigation Route	Cumulative Consequence of Intervention
16	R-9	Dampara Water Management Scheme	1.6	0.4	0.8	0.6	0.6	0.6	0.4	0.7
17	R-10	Kangsha River Scheme	1.2	0.4	0.8	0.6	0.6	0.6	0.4	0.7
18	R-11	Singer Bell Sub-Project	1.6	0.4	0.6	0.4	0.4	0.4	0.4	0.6
19	R-12	Khaliajuri FCD Polder-2	1.2	0.6	0.6	0.4	0.2	0.2	0.6	0.5
20	R-13	Khaliajuri FCD Polder-4	1.4	0.6	0.8	0.4	0.4	0.4	0.6	0.7
21	R-14	Chandal Beel Sub-Project	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	R-15	Satdona Beel Scheme	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Overall Impact on Haor Region										0.47

Table E-2: Impact on the Socio-economic Resources due to Village Protection against Wave Action in Haor Area

Sl No	Project Name	Agricultural Production based Income	Income from fisheries	Employment opportunities	Housing Condition	Transportation and Communication	Land Value	Cumulative Consequence of Intervention
1	Village Protection against Wave Action in Haor Area	0.3	1.0	0.8	1.8	0.0	2.5	1.1
Overall Impact on Haor Region								1.1

Table E-3: Impact on the Socio-economic Resources due to Improvement of Road Communication by LGED

Sl No.	Project Name	Agricultural Production based Income	Income from fisheries	Employment opportunities	Housing Condition	Transportation and Communication	Land Value	Cumulative Consequence of Intervention
1	Austagram- Lakhai road via Ekurdia Dalarkandi Road	-1	-1	1	1	3	2	0.83
2	Itna-Azmiriganj GC Road	-1	-1	1	1	3	2	0.83
3	Rasulpur-Azabpur Road	-1	-1	1	1	3	2	0.83
4	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj GC Road	-1	-1	1	1	3	2	0.83
5	Derai-Kolkolia RHD (Jagannathpur) via Jagdol, Hossainpur, Pailkapon, Telikona Road (Derai part)	-1	-1	1	1	3	2	0.83
6	Dharmapasha GC - Golakpur GC via Mohodipur Bazar Road	-1	-1	1	1	3	2	0.83
7	Joysree GC - Moddhanogar GC via Chamerdani UPC Road.	-1	-1	1	1	3	2	0.83
8	Dharmapasha UPC - Badshagonj bazar via Mohishakanda bazar Rd.	-1	-1	1	1	3	2	0.83
9	Chamerdani UPC - Shararkona Ghat Road	-1	-1	1	1	3	2	0.83
10	Madhayanagar UPC - Toker bazar via Shahapur Road	-1	-1	1	1	3	2	0.83
11	Paykurati UPC - Toker bazar via Jamalpur Madrasha Road	-1	-1	1	1	3	2	0.83
12	Lankapathria-Banarasshipur via Razapur Rd	-1	-1	1	1	3	2	0.83
13	Sulla HQ-Paharpur GC (Azmirigong)via Protappur Bazar Rd	-1	-1	1	1	3	2	0.83
14	Tahirpur UZ HQ- Madhaynagar GC Via Chatapati Road	-1	-1	1	1	3	2	0.83
15	Hobigonj-Baniachong R&H Road (Chilapanja)-Azmiregonj gc Road via Shibpasha	-1	-1	1	1	3	2	0.83
Overall Impact on Haor Region								**0.83**

Table E-4: Impact on the Socio-economic Resources due to Improvement of Road Communication by RHD

Sl No.	Project Name	Agricultural Production based Income	Income from fisheries	Employment opportunities	Housing Condition	Transportation and Communication	Land Value	Cumulative Consequence of Intervention
1	Madanpur-Dirai-Sullah Road	-1	-1	1	1	3	2	0.83
2	Habiganj-Baniyachang-Ajmiriganj-Sullah Road	-1	-1	1	1	3	2	0.83
3	R260 Sylhet-Sunamganj	-1	-1	1	1	3	2	0.83
4	N2 Bhairab – Moulvibazar 4 lane	-1	-1	1	1	3	2	0.83
5	N2 Habiganj – Sylhet 4 lane	-1	-1	1	1	3	2	0.83
Overall Impact on Haor Region								**0.83**

Annex F: Photographs of Consultation Workshop


Photo 1: Consultation Workshop at Tahirpur, Sunamganj


Photo 2: Consulation Workshop at Jamaganj Upazilla, Sunamganj


Photo 3: Consultation Workshop At Derai, Sunamganj

Photo 4: Consulation Workshop at Ajimiriganj Upazilla, Habiganj

Photo 5: Consulatation Workshop at Mohonganj Upazilla, Netrokona

Photo 6: The Directorate-General of Haor and Wetland Department delivered his speech, At Mohonganj Upazilla, Netrokona

Photo 7: Consultation Workshop At Mohonganj, Netrokona

Photo 8: Consultation Workshop At Kalmakanda, Netrokona

Photo 9: Consultation Workshop At Kishoreganj Sadar, Kishoreganj

Photo 10: Consultation Workshop at Bajitpur, Kishoreganj


Photo 11: Consultation Workshop at Goainghat, Sylhet


Photo 12: Consultation Workshop at Kanaighat, Sylhet


Photo 13: Consultation Workshop at Rajnagar upazilla, Maulvibazar

Photo 14: Consultation Workshop at Sreemangal upazilla, Maulvibazar

Photo 15: Consultation Workshop at Bahubal upazilla, Habiganj

Annex G: Scope of Work for BWDB in Haor Flood Management and Livelihood Improvement Program

The Scope of each project components of the BWDB Part are presented in TableG-1.

TableG-1: BWDB Portion of Project Components

Component	Item
Component1 (Flood Management Infrastructure)	Component1-1:Flood management infrastructure development 1. Rehabilitation of existing flood control facilities 2. Construction of new flood control facilities Full Flood Embankment Rehabilitation 1.55km Submergible Embankment - Rehabilitation 8.09km - New construction 286.51km Regulators - Replacement of gates 98nos. - Reinstallation of regulator 5nos. - New installation 59nos. Causeway (New) 16nos. Re-excavation of canals - Rehabilitation 75.4km - New 305.62km Pipe Sluice 15nos. Pipe inlet 25nos. River dredging(2Places)– 11.8km Component1-2:Capacitydevelopment 1) Training for O&M manual preparation (for BWDB officials) 2) Training for water management organization(WMO)(formulation of WMO, management training O&M technical training)
Component 3-1 (Agriculture)	Component3-1:Agriculture 1) Field program (adaptive trial of new varieties, field demonstration improved agricultural practices etc.) 2) Farmer training program (farming skills, organization strengthening etc.) 3) Field staff empowerment 4) Small-scale farmer support 5) Farm machinery support 6) Technology development 7) Small-scale income generation (Vegetable, micro-poultry, fruit production etc.)
Consulting Services (for BWDB)	1) Detailed design 2) Baseline survey 3) Tender assistance 4) Construction supervision 5) Capacity development support for WMO 6) Agricultural activities support

Annex H: Terms of References

Terms of References

i. Identify relevant development policies, plans and programs through screening for related to water resources and infrastructures of haor region and their environmental consequences to ensure appropriate development with economic and social consideration for conservation of Haor Areas;

ii. Conduct pre-screening beforehand to rapidly narrow down list of PPPs to determine whether the PPP will be taken to the next level of screening.

iii. Review of selected existing policies, laws and institutions relevant to the associated sectors as well as past national and international SEA studies for deeper understanding of the process and possible type of outcomes;

iv. Assessment of the impacts exerted by development programs on existing bio-physical and socio-economic conditions of Haor region

v. Identify the impacts exerted by development programs on existing bio-physical and socio-economic conditions of Haor region through consultation with primary and secondary stakeholder, relevant agencies and expert judgment;

vi. Identify viable alternatives to minimize overall impacts to ensure eco-friendly development

vii. Prepare comprehensive strategic measures for conservation of environment encompassing the Haor region in accordance with future socio-economic development activities; and

viii. Development of a comprehensive SEA statement framework to support decision aiding.