

Bangladesh Regional Waterway Transport Project 1

Environmental Impact Assessment



Revised Final Report

April 2019



Volume I (Main Report)

Bangladesh Inland Water Transport Authority

Government of People's Republic of Bangladesh

Ministry of Shipping

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ACRONYMS AND ABBREVIATIONS

AAQ	Ambient Air Quality
ADB	Annual Development Budget
AIS	Alien Invasive Species
AR	Assessment Report
ARC	Accidents Research Centre
AUC	Asian Waterbird Census
AWC	Asian Waterfowl Census
Baor	Oxbow Lake
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDM	Biodiversity Management Consultant
BDT	Bangladeshi Taka
BECA	Bangladesh Environment Conservation Act
BETS	Bangladesh Engineering and Technological Services
BFRI	Bangladesh Fisheries Research Institute
BIPIWTT	Bangladesh India Protocol on Inland Water Transit and Trade
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BIWTMAS	Bangladesh Inland Water Transport MASTERPLAN
BLI	Birdlife International
BMD	Bangladesh Meteorological Department
BOBLME	Bay of Bengal Large Marine Ecosystem
BOD	Biochemical Oxygen Demand
BOQ	Bill of Quantities
BRE	Brahmaputra Right Embankment
BUET	Bangladesh University of Engineering and Technology
BWA	Bangladesh Wildlife (Conservation and Security) Act 2012
BWDB	Bangladesh Water Development Board
CARINAM	Center for Advance Research in Natural Resources and Management
CBD	Conservation on Biological Diversity
CC	Climate Change
CE	Cumilitive Effect
CEAP	Construction Environmental Action Plan
CEGIS	Center for Environmental and Geographic Information Services
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
CMS	Convention on Migratory Species
COD	Chemical Oxygen Demand
CPA	Chittagong Port Authority
CPD	Conservancy and Pilotage Department
CR	Critically Endangered
CSC	Construction Supervision Consultants

DAE	Department of Agriculture Extension
DC	Deputy Commissioner
D-C corridor	Dhaka-Chittagong corridor
DO	Dissolved Oxygen
DoE	Department of Environment
DoF	Department of Fisheries
DoS	Department of Shipping
DPHE	Department of Public Health and Engineering
DSC	Dredging Supervision Consultant
Duars	Deepest hole in the river
EC	Electric Conductivity
ECA	Environmental Conservation Act
ECC	Environmental Clearance Certificate
ECDS	Electronic Chart Display Information System
EcIA	Ecological Impact Assessment
ECOPs	Environmental Codes of Practice
ECR	Environment Conservation Rules
EGIS	Environmental and Geographic Information Services
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMF	Environmental Management Framework
EMP	Environmental Management Plan
EMS	Environmental Monitoring System
EN	Endangered
ENRAC	Environment and Resource Analysis Center Limited
ES	Environment Specialist
E&S	Environment and Social
EIA	Environmental Impact Assessment
ESW	Economic and Sector Work
EU	European Union
FCDI	Flood Control Drainage and Irrigation
FD	Forest Department
FGD	Focus Group Discussion
FY	Fiscal Year
GDP	Gross Domestic Product
GIIP	Good International Industry Practice
GoB	Government of Bangladesh
GPS	Global Positioning System
GW	Ground Water
HIV	Human Immunodeficiency Virus
HSE	Health, Safety & Environment
IBA	Important Bird Area
ICM	Information and Consultation Meeting
IECs	Important Environmental Components
IEE	Initial Environmental Examination

IFC	International Finance Corporation
IMO	International Maritime Organisation
IMTP	Integrated Multimodal Transport Policy
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control
IUCN	International Union for Conservation of Nature
IWC	International Waterbird Census
IWM	Institute of Water Modelling
IWT	Inland Water Transport
KMC	Knowledge Management Consultants
LAD	Least Available Depth
LCC	Location Clearance Certificate
LGI	Local Government Institute
LRP	Land Reclamation Project
MARPOL 73/78	Marine Pollution 73/78
MCCI	Metropolitan Chamber of Commerce Industries
M&E	Monitoring & Evaluation
MES	Meghna Estuary Study
MOS	Ministry of Shipping
MPA	Mongla Port Authority
MSDS	Material Safety Data Sheets
NBSAP	National Biodiversity Strategy and Action Plan
NEDCO	The Netherlands Engineering Consultants
NGOs	Non-Governmental Organization
NLUP	National Land Use Policy
NOAA	National Oceanographic and Atmospheric Administration
NOCs	No Objection Certificates
NSPAR	National Strategy for Accelerated Poverty Reduction
NWA	National Water Act
NWMP	National Water Management Plan
NWP	National Water Policy
OHS	Occupational Health and Safety
O&M	Operations & Maintenance
OP	Operational Policy
OPRC	Oil Pollution Preparedness Response and Cooperation
OSPAR	The Conservation for the Protection of Marine Environment of the North-East Atlantic (The OSPAR Convention) was adopted in Paris, France in September 1992 and entered into force in March 1998
PBC	Performance Based Contracting
PCBs	Polychlorinated Biphenyl
PD	Project Director
PIA	Project Influenced Area
PIs	Performance Indicators
PIU	Project Implementation Unit
PMU	Project Management Unit

PMBP	The Padma Multipurpose Bridge Project
POPs	Persistent Organic Pollutant
PPE	Personnel Protective Equipment
ppt	parts per thousand
PRA	Participatory Rural Appraisal
PRRA	Participatory Rapid Rural Appraisal
PRSP	Poverty Reduction Strategy Paper
PWD	Public Works Department
Ramsar	Convention on Wetlands of International Significance
RAP	Rapid Action Plan
RDB	Red Data Book
RETF	Recipient-Executed Trust-Funded
RMIP	The River Management Improvement Program
RPF	Resettlement Policy Framework
RRA	Rapid Rural Appraisal
RTW	River Training Works
SCC	Site Clearance Certificate
SES	Socio-Ecological System
SIA	Social Impact Assessment
SMPs	Social Management Plans
SRDI	Soil Research and Development institute
SSC	Species Survival Commission
SSC	Suspended Sediment Concentration
STD	Sexually Transmitted Disease
STI	Sexually Transmitted Infections
SWOT	Strengths, Weaknesses, Opportunities and Threats
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
ToC	Table of Contents
TOR	Terms of Reference
TSS	Total Suspended Solids
UNEP	United Nations Environment Program
VECs	Valued Environmental Components
VESCs	Valued Environmental and Social Components
VU	Vulnerable
WB	World Bank
WBG	World Bank Group
WI	Wetland International
WPE	Waterbird Population Estimate
WWF	World Wide Fund for Nature

1 INTRODUCTION

1.1 Background

There are hundreds of rivers in Bangladesh with a large network of navigation routes. Transportation through waterways has always been a natural, environment friendly and relatively cheap mode of transport. Inland waterways have become the very important mode not only for maintaining transport link between various remote parts of the country; it is a means of transporting export-import cargo as well. Over the decades the navigability during dry season in many rivers of the country has been deteriorating because of morphological processes and for withdrawal of water from the rivers beyond the border and within the country. The navigability has been further aggravated by poor or no maintenance of inland waterways. Navigability of inland waterways is intensely influenced by river morphology and hydraulics. River systems in Bangladesh exhibits high seasonality over a year i.e. abundant of water during monsoon and scarcity of water during dry season from December to May. Navigability becomes very critical during dry season in many river routes and ferry crossing. A total length of 12,000 km. of waterways during monsoon was estimated by NEDCO, The Netherlands Engineering Consultants Year not mentioned. Currently the total length of navigable waterways during monsoon is about 4,000km and 2,000-2,500 km is navigable during the low water period (IUCN, 2012). The Government of Bangladesh has recently formulated sound IWT related policies which recognized to meet the poverty alleviation and to attain the millennium development goals a well-developed sustainable and accessible multimodal transport network with special focus on inland navigation is of fundamental requirement for movement of people and goods. It is worthy to mention that the transport system of Bangladesh has changed substantially over the last four decades. Prior to independence in 1971 there were no national or regional highways, but only a few roads connecting Dhaka with rest of the country. And Inland Water Transport is now playing an increasingly important role in the social and economic development of the country by maintaining communication between various remote parts of the country which are inaccessible by other modes of transport; particularly during the periods of peak monsoon. Over the decades transport demand in Bangladesh has grown faster than the GDP growth of the country. However, the shares of different transport modes particularly IWT and railway did not increase in the same proportion. The road sector carried the majority of the increase in passenger traffic, with a share of 73% by 1996. In the freight sector where IWT had been playing a dominant role, its share also eroded from 37% in 1974 to 30% in 1996 and 16% in 2005. A World Bank study on Revival of inland Water Transport conducted in 2006 estimated that 102 million passengers and 30 million metric tons of freight were transported by inland waterways in 2005. This is quite an achievement when compared with other modes, particularly in view of the fact that IWT suffered persistently from short-term policy decisions and low budgetary allocations. It is also an indication of its prospects and potentialities that can be exploited in future.

The vision for the inland water transport (which includes coastal waterways) is to develop and operate the system safely and efficiently and in accordance with the IWT sector policy and integrated multimodal transport policy (IMTP) to ensure economic development within the framework of the Poverty Reduction Strategy Paper (PRSP). Bangladesh Inland Water Transport Authority (BIWTA) under the ministry of Shipping is responsible for operation and

maintenance navigation routes. Navigation routes in Bangladesh are categorized as Classes I through IV depending on their advertised depths, the navigation depth for each class is presented in Table 1.1. The Government has identified 65 main river navigation routes that are essential to passenger and freight transport within Bangladesh. Of these, 12 have been clearly identified as high priority Is it possible to show route in map or mention the name?. A study to prioritize the remaining 53 routes is underway under the World Bank-supported Bangladesh Trade and Transport Studies Recipient-Executed Trust-Funded (RETF) project.

Table 1-1: Classes of navigation routes and the draught/ depth of each class

<u>Class</u>	<u>Draught in m /(In Feet)</u>
Class- I	3.66-3.96 and above (12-13 and above)
Class- II	2.13-2.44 & less than 3.66 (7-8 & less than 12)
Class- III	1.52-1.83 & less than 2.13 (5-6 & less than 7)
Class- IV	Less than 1.52 (Less than 5)

Source: BIWTA

The Government of Bangladesh has prioritized the improved development and maintenance of the Class I routes and linked Class II and III routes along the Dhaka-Chittagong corridor. For this purposes “Bangladesh Regional Waterway Transport Project 1” has been undertaken with the support of World Bank. The proposed project requires carrying out an Environmental and Social Assessment in accordance with the Environment Conservation Act 1995 (subsequent amendment), the Environment Conservation Rules 1997, and the World Bank Safeguard Policies. The implementing agency Bangladesh Inland Water Transport Authority (BIWTA) has engaged Institute of Water Modelling (IWM) to carry out the Environmental Impact Assessment (EIA) for the Bangladesh Regional Waterway Transport Project 1.

According to Environmental Conservation Rule 1997 of Department of Environment (DoE), and Word Bank Operation Policy (OP) 4.01 the project is categorized as ‘Red’ and Category ‘A’ respectively. For Red Category project, DoE requires apporoval of ToR for EIA before commencement of the study. Therefore, IWM prepared a ToR for EIA study and got approval of the same with comments from DoE. This EIA is prepared following the guidelines of both OP 4.01 and the approval letter of DoE (**Annex-A**) on Exemption of IEE and Approval of Terms of Reference dated February 29, 2003 for EIA study of the project.

1.2 Rationale of the Project

Need for Improvement of Navigability of Rivers in Bangladesh: Bangladesh lies predominately within the Bengal basin, the world’s largest delta formed by the Ganges, Brahmaputra and Meghna river systems. Navigation is complicated by the braided nature of the rivers, which are characterized by high sediment delivery and - due to extremely low gradients - very low sediment throughput. This makes the rivers extremely sensitive to flooding with rapid geometry (boundary and channel) changes. Further, river systems in Bangladesh exhibits high seasonality over a year i.e. abundant of water during monsoon and scarcity of water during dry season from December to May. Navigability becomes very critical during dry season in many river routes and ferry crossing. Problems of navigation are compounded by the growth of inland water vessel size and the IWT fleet now comprises dry and liquid bulk ships of up-to 3,000 deadweight tons, mainly trading on the class 1 river routes. Moreover, the size of the IWT fleet is growing and currently there are over 22,300

registered vessels which carry over 50% of all freight traffic and one quarter of all passenger traffic. In addition, there are some 750,000 country (traditional) boats, a substantial part of which have been mechanized. Approximately 65% of these are passenger boats, where demand is predominantly generated by rural communities, a substantial proportion of which only have access to river transport.

Need for Improvement of Dhaka – Chittagong – Ashuganj IWT Corridor: The GoB has identified 65 main river navigation routes that are essential to passenger and freight transport within Bangladesh. Of these, river corridors between Dhaka and Chittagong; and between Dhaka and Ashuganj (with extensions to Narayanganj and Barisal) are identified as high priority routes for domestic trade and bilateral trade with India. About 80% of country's IWT transport is routed through these corridors and daily about 200,000 passengers use these routes. Inland river terminals at Dhaka, Narayanganj, Chandpur and Barisal along these routes play very important role in transporting and handling passenger and cargo. Food grains, fertilizers and consumer goods are the main commodities which are transported by cargo vessels and cargo-cum-passenger launches. The cargo terminal at Ashuganj is a key terminal for Bangladesh – India trade and it is connected by road to the north eastern states of India.

Cargo transport is heavily orientated towards imports and in volume terms, most is trafficked on the Class 1 river routes, primarily between Chittagong, Narayanganj and Dhaka. Cargo is mainly: dry bulks (including clinker, fertilizers, food grains, coal, salt, gypsum and fly ash); liquid bulks (petroleum products); and, general dry cargo (bagged cargo, machinery and steel). The main dry and liquid bulks are typically offloaded at private jetties or terminals, most of which are equipped with dedicated bulk handling equipment. Some break bulks and other smaller general cargoes are handled at limited number common user facilities or directly over the riverbanks by manual labour. There is some cross-border traffic on protocol routes between Bangladesh and India, however bilateral trade volumes are very small, accounting for just 3% of total IWT freight traffic in Bangladesh. Most of this consists of fly ash (and some wheat), mostly collected from India on Bangladesh registered vessels. Improved maintenance of advertised depths along the protocol route waterways will ideally spur increased trade.

Need for Improvement of Inland River Ports and Landing Stations: Inland river terminals at Dhaka, Narayanganj, Chandpur and Barisal along the Project routes play very important role in transporting and handling passenger and cargo. These four river ports together transport annually about 53 million tonnes of cargo and 22 million passengers (in 2013-2014). The facilities built at these terminals are not sufficient to meet the growing demand of IWT as they lack in adequate facilities for berthing, parking and storage areas, and passenger comfort. The port facilities at Sadharghat terminal at Dhaka and surrounding areas are highly congested with commercial and residential development leading to traffic congestion and inefficient use of port facilities, and also there is no space around the current terminal for further expansion. The GoB would like to augment the facilities at Sadarghat terminal in Dhaka by building a new passenger terminal at Shasanghat (2.5 km downstream), develop a cargo terminal at Pangaon, and augment and modernize the existing facilities at Ashuganj, Narayanganj, Chandpur and Barisal river terminals.

In addition to river terminals, there are a number of landing stations along the Project corridor which are very important for people living in the rural and remote areas. The landing stations (also known as launch ghats) are berthing points of high importance for the local communities that they serve, yet lack proper infrastructure and other essential facilities such as toilets and drinking water, as well as basic safety features for users, and many are in a highly dilapidated state. They usually consist of one pontoon with shore connection for

embark and disembark passenger and cargo. They play an important role in the lives of the rural people, as without them vessels would not berth and they would not receive much needed food, medicines, fuel and other consumer essentials.

1.3 Project Development Objectives

The Dhaka-Chittagong corridor is the main trafficked route for inland water transport and carries approximately 80 percent of all Inland Water Transport (IWT) traffic. Realizing the importance of this corridor and the need to fully utilize all transport modes to reduce demand on roads, the Government has prioritized the improved development and maintenance of the Class I routes and linked Class II and III routes along this corridor. The main trunk route is about 300km, of which it is initially estimated that about 40km currently require dredging and channelization to maintain the advertised depth for the existing traffic. Another 110-130km of linked routes is part of this corridor, of which about 33-50km requires constant maintenance. The proposed Bank financed project aims to pilot a new approach to (i) Dhaka-Munshigonj-Gajaria-Chandpur-Chittagong corridor and two key connecting routes to Barisal, and Ashuganj, (ii) maintenance of three priority ferry crossings along these corridors, and (iii) construction and maintenance of an estimated six vessel shelters along the corridors for use during cyclones/storms. Specifically, the proposed project will utilize a performance based contracting scheme to carry out the above activities. BIWTA is expected to be responsible primarily to verify that performance targets are being met by the contractors including maintenance of specified depths and compliance with related technical, environmental and social requirements, specify dredge spoils disposal, acquire land for spoils disposal where applicable, and manage the onshore dredge spoils deposits including facilitating use of spoils based on demand. The proposed activities might result in significant environmental impacts, if the investment activities are not properly planned, designed, executed, and maintained. Further to that, the project will provide an opportunity to improve the institutional capacity for environmental management, social management, and safety in overall IWT sector. IWT in Bangladesh is the life line of transport system, while Dhaka-Chittagong corridor and adjoining routes under study is the artery of IWT network. Being the main consumption and distribution area, i.e., Dhaka-Narayanganj in an apparent centralized country is connected by rivers with almost two-third area of the country by rivers. Two maritime ports of Chittagong and Mongla and the upcoming third maritime port of Payra are connected with Dhaka-Chittagong completely or mostly by these routes. As many as 200,000 passengers are transported daily by these routes. Transport output of these routes is further augmented by inflow and outflow of traffic from and to other IWT routes. Importance of Dhaka-Chittagong corridor and adjoining routes under study has further been increased by sub regional traffic flow. D-C corridor and adjoining routes are considered to be the common and main routes under Bangladesh-India Protocol on Inland Water Transit and Trade (PIWTT).

Bangladesh is proceeding gradually from lower middle income country to be an upper middle income country by 2021. To this end, facilitation of trade and commerce is inevitable. And for the growth and facilitation of trade an efficient multi-modal transport network is the main pre requisite. Only revival of IWT may ensure such efficient and cost effective network. Being the main artery D-C corridor cannot demonstrate efficiency in terms of efficient navigation. Existing navigational quality does not ensure uninterrupted navigation. Vessels are to wait for high tide or to plan navigation adjusting time of high tide at different hot spots. In both cases, cost and time of transportation increase. Groundings of vessels and subsequent

accident have become more frequent. Users lost confidence on IWT and looking for modal shift.

There are also passenger services operated by BIWTC. Thus around 200,000 passengers use services in these routes daily. Chittagong port alone handles more than 90% sea-borne trade, and distribution of cargo towards main sink-places like Dhaka, Narayanganj, Chandpur and Barisal are done by IWT through D-C corridor and adjoining routes. Annual mean of departures from Chittagong to different destination is almost 18,000. Particularly, transporting petroleum oil and lubricant has to depend on this corridor. Apart from all these above, there has been a protocol since 1972 between Bangladesh and India on Inland Water Transit and Trade for the purpose of commercial transport between the countries using water ways, and providing transit facilities for two places in India. Also, the requirement of container traffic is increasing from time to time. About 70% of the total numbers of containers handled at Chittagong port are destined towards or originating from Dhaka and Narayanganj area. An inland container terminal has been constructed at Pangaon on the right bank of the Buriganga, four others in and around Dhaka and Narayanganj are being constructed. It is anticipated that in the revival of IWT container traffic and their development will play a significant role on economic development of the country. Again, both railway and road suffer capacity constraint, and also road is not fit for transporting trailers. In view of the above, maintenance of waterways is inevitable. Smooth and sustainable navigability in D-C corridor and adjoining routes under study can ensure revival of IWT. Maintenance of waterways will ensure sufficient water at all seasons and more water in rivers will ensure better eco system. The proposed project activities may produce considerable environmental and social impact in the future. The project is to be financed by the World Bank and implemented by BIWTA, government of Bangladesh – both have environmental and social guidelines regarding impacts. This document is an Environmental and Social Impact Assessment for the preparation of the proposed World Bank Dhaka-Chittagong Ashuganj Regional IWT project and this EIA document is a part of a larger Environmental Assessment package of the proposed project. This EIA mainly covers the activities under Component 1 of the proposed World Bank project i.e. performance based navigation maintenance of IWT routes, ferry crossing and vessel shelters.

1.3.1 Project Components

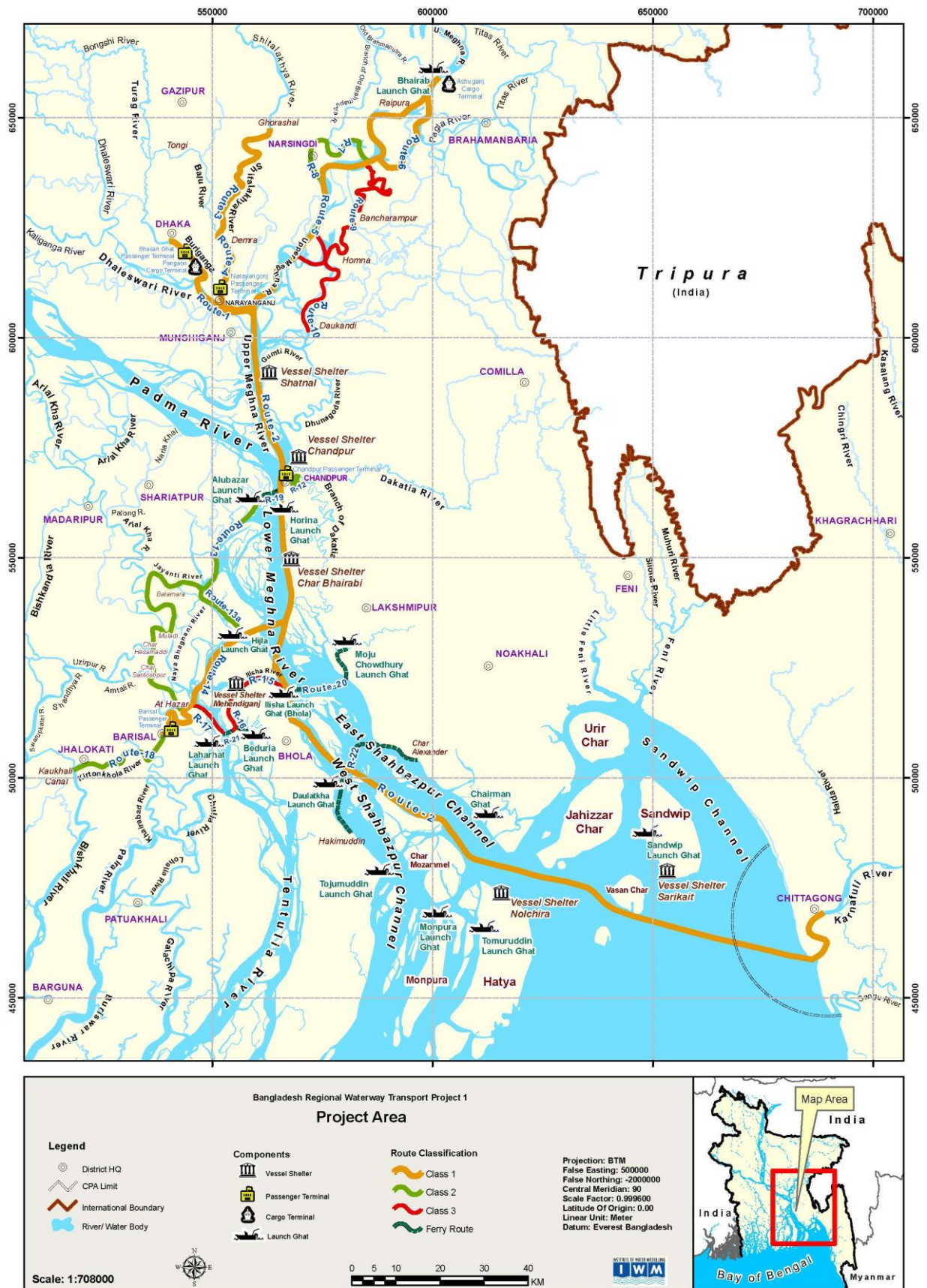
The Project will provide US\$360 million in IDA funds to finance interventions aimed at improving IWT for cargo and passengers along the heavily-trafficked Chittagong-Dhaka-Ashuganj river routes, and in so doing, stimulating traffic growth on the waterways and away from the already heavily congested roads along these routes. These fall under the jurisdiction of the Bangladesh Inland Water Transport Authority, a Government authority mandated to oversee sector development. Main interventions include: navigation channel maintenance and improvement; navigation safety improvements; the construction, rehabilitation, and modernization of select river terminals; development of River Information Systems; institutional capacity development; and, funding for research and development to enable continuing sector improvement and sustainability. This includes work on sector policies and strategies needed to: improve revenue collection and management; incentivize public and private sector investments especially related to container transport; and, mitigate and improve IWT's impact on the social and physical environment. The Project consists of three components as follows:

Component 1: Improved Inland Waterway Navigation (US\$235 million).

Component 2: Improved Services at Priority Inland Waterway Terminals and Landing Ghats/Stations (US\$75 million).

Component 3: Institutional Capacity Development and Sustainability (US\$50 million).

The map showing the project interventions is presented in Figure 1.1.



1.3.2 Brief descriptions of interventions

Dhaka-Chittagong river route is 280 km long in which the length from Dhaka to Munshiganj is 30 km and from Munshiganj to Chittagong is 250 km. According to BIWTA route classification, the entire route is classified as Class I. Ghorashal extension route is 57 km long that contains River Class I and III (Ghorashal-Demra section is of Class III that is, under this project, planned to be upgraded to Class I). Ashugang extension route is 244 km long that contains river routes of Class I, II, III (Narshindi loop and Bancharampur loop). Barisal extension is 222 km long which is under River Class I (approach to Aat Hazar via Illisha in the Meghna river, and Aat Hazar to Jhalokathi in Bishkhali River), Class II (approach to Aat Hazar via Hijla), and Class III (approach to Aat Hazar via Muladi). Not all the paths along the navigation route will undergo dredging works. Only river/channel sections that contain areas of shallow depths, obstacles by bars, constrictions etc. shall be taken into consideration for dredging.

Locations of Vessel Shelter

Six locations were selected by BIWTA for vessel shelters, and they are broadly at, in the sequence from upstream to downstream, Shatnol (Shatnol Nala), Chandpur (upstream of Madrasghat), around Hijla Bazaar/Miar Char, Sarikait in Sandwip, Nolchira in Hatiya. Vessel shelters would not necessarily be of the same type and size but location and need specific (planning and design – type, orientation, size, etc). Also where possible, multiple facilities are to be provisioned so that shelter could be used during idle time.

1.4 Environmental and Social Assessment

This section details the methods applied in the collection and analysis of the primary and secondary data used in this report. Primary and secondary information from government sources, non-government organizations (NGOs) and other Project-related stakeholders has been collected to support the preparation of this report. This section also describes the methods of impact assessment used along with methods for the development of recommended management and mitigation measures.

1.4.1 Purpose of EIA

The Component 1 of Dhaka Chittagong Inland Water Transport Corridor Project intends to maintain the river routes between Dhaka -Chittagong and Dhaka – Ashuganj corridors and three ferry routes through annual maintenance dredging. (Prior to inception of the project, it is important to ensure that socio-economic impacts of the interventions are projected. The key purpose to the EIA study therefore will be to identify any possible adverse impacts of the proposed project in advance and prepare a plan to avoid, minimize and mitigate these impacts to revive the stakeholder population and to improve or at least restore their pre project socio-economic condition.

1.4.2 Project influence area and study areas

Environmental Conservation Rules, 1997 (ECR) requirements, along with the newly-released industry guidelines (ERE Consulting Group, 2009), specify that the size of the overall study area should be determined on a case-by-case basis for individual projects, and that it should be based on an assessment of the likely zone-of-influence of the potential project impacts. As such, the broader Project study area was deemed to comprise entire river width of the proposed IWT route with a buffer of one kilometre on each side of the river bank.

1.4.3 Study Methodology

In order to conduct the required impact assessment for the EIA report, it is necessary to collect relevant data from appropriate primary and secondary sources to fully establish existing baseline conditions for the relevant environmental (biophysical and socio-economic) aspects.

The EIA study has conducted in-depth consultation meetings with stakeholders including socio-economic survey at 31 locations along the proposed IWT routes until December 2015. Respondents were selected from each of the launch/ferry terminals and dredging locations with a range from 15 to 25 while 30 respondents were interviewed from each of the storm vessel shelters. A team of experienced professionals and support staff has conducted surveys and consultation meetings after being briefed about the project in a day-long orientation session at the conference room of the Consultant office in Dhaka on the 15 September 2015. The orientation session was facilitated by social, environmental and technical team members. Techniques of data collection, sampling methods, methods of filling up questionnaire, potential locations of the survey, etc. were discussed in the orientation session using map of the study area. The sampled respondents representing HHs were 585 that consist of 2793 population with average HH size is 4.77. The respondents were selected by random sampling method from each of the locations and also by purposive sampling method in some locations. The questionnaire had modules on demography, socio-economic profile, income and livelihoods, Social infrastructure and river related issues. Each questionnaire was checked once in the field by supervisors and again in office, while processing data. Respondents' contact information was collected for further verification, if and when required. The consultation meeting participants were from project stakeholders on site and the FGD participants were selected from various homogeneous groups particularly occupational groups like farmers, fishermen, female passengers, sand traders, physically disabled transport users, etc. One consultation meeting was held in each location. The consultation meetings were conducted in participatory approach. The stakeholders were briefed about the project and their perception, concern and demands from the project were duly noted and presented in the EIA. In addition, an additional national consultation workshop was carried out on the full draft EIA study on March 31, 2016. Full details of consultation and disclosure meetings held as part of the study, including records of feedback provided, are provided in Chapter 13 and Annex I.

Environmental Data Collection and Analysis

In order to establish the baseline biophysical conditions within the study area, relevant secondary and primary data was collected and reviewed, a comprehensive field visit was undertaken, and a number of specialist studies were carried out. This process also included consultation with various relevant agencies including Government department, BIWTA, locally-active NGOs, and members of the local community.

The data generated allowed the Project team to better understand the complex interplay between the various biotic and abiotic factors within the study area and to establish the baseline conditions. Once this baseline was established it was used as a reference point to identify potential changes to the environment that may occur as a result of the proposed Project activities, as well as to allow development of measures to prevent, mitigate or manage these potential impacts.

Secondary Data Collection

A review was conducted of the biophysical, ecological and legal literature relevant to the Project. The review of secondary sources and informal initial field investigations were undertaken in order to prepare a preliminary assessment of the physical and social environment, biodiversity, and conservation significance of the identified study area. This preliminary literature review also assisted in identifying data gaps which would require collection of additional primary information through physical field survey. The following activities were included in this phase of the Project:

- Data and information was collected from various government departments – including DoE and Department of Public Health and Engineering (DPHE) – relating to site aspects including drainage networks, flooding characteristics, climate (weather), groundwater quality and soils; Secondary ecological data sources were collected and assessed;
- An appraisal was made of all legislation having direct and indirect relevance to environmental management within the Study Area including aspects such as biodiversity conservation, water quality, waste management, natural resource management and spill response;
- Previous environmental site studies, where available, were reviewed as well as relevant scientific journal articles; and

Thereafter, an information gap analysis was undertaken to identify the areas where further primary data collection would be required to complete the EIA.

Further detail regarding the titles of the relevant literature, policies, acts and other regulations and guidelines reviewed and applied during the course of this process can be found in legal section of this report.

Physical Environment Field Survey

To comprehensively evaluate the existing Project area baseline conditions, a field visit and data collection program incorporating a number of biophysical investigations was developed and implemented.

This survey aimed to identify important environmental components and environmental issues within the study area. It included investigation and observation of the local landforms, habitat types, drainage patterns, species abundance and distribution, soil types, water quality (surface water and groundwater), air quality, noise and hydromorphology.

The study area and surrounds were surveyed by foot and by vehicle. Important environmental features were identified and logged. Hand-held geographic positioning systems (GPS) were used to identify specific features for mapping and further analysis in the Project office.

Noise Monitoring and Assessment

Noise monitoring was undertaken to determine the ambient noise levels at six locations encompassing each of the sample sites were recorded using a calibrated SVAN 949 Sound Level Meter set to A-weighting, fast response and statistical analysis settings. This monitoring provided a variety of noise descriptors, including LA10, LA90 and LAeq levels.

Soil and Water Sampling

For the water samples, a number of physical and chemical parameters were tested on-site including pH, temperature, conductivity and turbidity. Visual observations were also recorded including color and the presence/absence of detectable odors.

Ecological Field Survey

Two separate field surveys were undertaken to provide a primary assessment of the biodiversity values of the study area, as well as the potential presence/absence of protected species and ecologically-critical areas. Due to the specialist nature of this study, CARINAM was engaged by IWM to undertake the required work.

Initially, secondary data sources were analyzed in order to compile a potential presence/absence list of significant fauna and flora species. Thereafter two field teams – each comprised of a Wildlife Biologist, a Botanist and Aquatic Biologist – were deployed to undertake the required sampling and assessment. Sampling and survey was undertaken for both aquatic and terrestrial ecosystems, validation checks were made against the earlier-compiled species lists in order to establish a comprehensive baseline. Field surveys to establish the biological baseline were carried out in two phases to cover the monsoon (19 September – 07 October 2015) and dry (18 -25 December 2015) seasons. This assessment was also informed by the results of the mapping exercise described in the Physical Environment Survey above, particularly spatial information regarding vegetation patterns and water bodies.

The following activities were undertaken during the terrestrial and aquatic field surveys:

Direct Observation:

Direct observation on the occurrence and abundance of flora and fauna was made while travelling along creek banks and within water bodies, along road edges, across the agricultural fields and within village groves. As well as direct sightings, identification of animal presence was also based on identification of tracks, foot prints, feeding signs and animal/bird calls. Appropriate field guides and data proformas were used for this activity so that information was accurately recorded. Some plant species which could not be identified in the field were pressed and taken to the Dhaka herbarium for subsequent identification.

Interviews with Local Residents:

Many of the mammalian and reptilian species are cryptic and unlikely to be encountered using standard field sampling methods. As such, experience suggests that interviews with local people are a very useful method for collecting information on local biodiversity. This data is anecdotal and as such should not form the core of any assessment; however it does nonetheless provide useful supplementary information. During the field survey period, extensive interviews with local people were conducted to collect information on animal and plant presence, including occurrences, behavior, breeding, distribution and seasonal appearance.

Inspection of Fishermen's Catches and Fish Market Survey:

Whenever available, the catches of local fishermen were examined to assess species composition and abundances. The local fishermen were also interviewed to collect information on the occurrence and abundance of species, seasonality, etc. As with the terrestrial data collected during interviews with local residents, the data collected from these activities did not comprise the core information of the aquatic assessment, however nonetheless provided a useful supplement. The major fish markets, including the local fish landing centers, were also surveyed to record the local fish species caught as well as other aquatic animals which were collected along with the fish catch (e.g., insect larva collected in cast nets). Sources of the fish were ascertained prior to making any observations to verify that they were from within the local study area.

Geographical Information Systems

Geographical Information Systems (GIS) was used as a specialized analysis and presentation tool. Before commencing field investigations, spatial analysis of satellite imagery identified and present administrative areas and other boundaries/constraints to be considered for both the environmental and social assessments. For example, the sanctuaries, spawning grounds, infrastructures, vessel shelter locations, possible dredge materials disposal areas can be identified

Composition of Study Team

The environmental impact assessment (EIA) has been carried out by Bangladesh Inland Water Transport Authority with the assistance of a multi-disciplinary team of national experts. In addition to the national team, Ministry of Shipping, Bangladesh engaged two (2) expatriate consultants namely Dr. Venkata Nukala (EIA advisor) and BKD Raja (SIA Advisor) to provide guidance and support to the national team to carry out this EIA study in accordance with World Bank Guidelines.

Environmental study team: The EIA team comprised of Zahirul Haque Khan (Team Leader), Dr. Sheikh Muhammad Abdur Rashid (River Ecologist), Mohammed Anisuzzaman Khan (Terrestrial (Plain/Charland) Ecologist), Md. Mehedi Hasan Emon (Environmental Engineer with expertise in pollution management), Rubayat Alam (River Hydrologist), Mohammad Abdus Salam Sikder (Coastal Hydrologist), Mohammad Ziaur Rahman (Modeller Sediment Dispersion), Md. Zahidul Islam (Agriculture Expert), Farhan Md. Zahir (Junior Water Resource Professional), Muhammad Ghulam Rasul (Junior Agriculture professional), Afroza Mahzabeen Anannya (Junior Environmental Expert/Terrestrial Ecologist), Md. Shamsuddin (Junior Environmental Expert/River Ecologist), Md. Zahid Hasan Siddiquee (GIS Expert) and Syed Monowar Hussain (Survey Specialist/Navigation Specialist) of IWM.

Social study team: The social team consisted of Khairul Matin (Sr. Socio-Development Specialist), Md. Rafiqul Islam (Media and Communications Specialist), G.M. Manzurul Mazid (Junior Socio- Development Specialist), Sukhendra Narayan Chowdhury (Junior Socio- Development specialist) Md. Mustafizur Rahman ((Junior Socio-Development Specialist), and M. Hamidul Islam (English-Bangla report translator) of IWM.

1.4.4 Contents of the EIA Report

The report is divided into twelve chapters that follow the activities stipulated in the TOR of the EIA study.

Chapter 1- Introduction: This chapter describes the background of the study, project description, importance of the project and objectives of this EIA study

Chapter 2- Legal and Regulatory Framework: It provides descriptions of Applicable Policies in Bangladesh and EIA approval framework, international treaties and World Bank safeguard policies, overviews of Ops and guidelines, World Bank EHS guidelines.

Chapter 3- Project Description: This chapter contains project objectives, project components, proposed interventions and implementation methodology.

Chapter 4- Analysis of Alternatives: This chapter presents no project alternatives, alternatives to the project, IWT versus road and rail, alternative means of channel maintenance, alternative dredger types, and alternative to dredged materials management.

Chapter 5- Baseline Environment: Explains general climate, river hydrology and morphology, estuarine and coastal hydrology and morphology, flood plain hydrology, environmental quality on surface water, groundwater, riverbed sediment and air quality, riverine ecology, estuarine and coastal ecology, flood plain and char land ecology,

Chapter 6- Socioeconomic Baseline: Demography, livelihood sources, land use, public health, social infrastructure and cultural resources.

Chapter 7- Climate change and Adaptation: This chapter illustrates the new climate change scenarios i.e. Representative Concentration Pathways and projection on South Asia in accordance with the Assessment Report5 of IPCC. Trend analysis of sea level rise, change in temperature and precipitation in Bangladesh has also been presented. Projection of RCP 8.5 on the change in flow in the Brahmaputra, Ganges and Megna River for 2040-2069.

Chapter 8- Potential Significant Environmental Impacts: Methods of assessing significance of impacts, environmental, health and safety of impacts, social impacts and impact of vessel shelters and impacts of inland water transport are described in this chapter.

Chapter 9- Cumulative Impact Assessment: This chapter contains descriptions of Valued Environmental Components (VEC), likely impacts on VEC and cumulative impacts.

Chapter 10- Environmental Management Plan: The chapter focuses the impacts to be mitigated, and activities to implement the mitigation measures, including how, when, and where they will be implemented. The environmental monitoring plan describes the impacts to be monitored, and when and where monitoring activities will be carried out, and who will carry them out. In addition, EMP also provides the cost associated to each mitigation and monitoring measures. It also covers Institutional Arrangements.

Chapter 11- This chapter contains capacity development, existing institutional capacity of BIWTA and grievances.

Chapter 12- Consultation and Disclosure: Covers the process of various national, regional stakeholder consultations, FGDs and views, suggestions of the people from various cross sections attended in the consultations and FGDs

Chapter 13- Conclusion and Recommendation

1.5 Revision of EIA Report

The project (BRWTP-1) authority submitted an application to DoE for Environmental Clearance Certificate on 27 July 2018 along with relevant supporting documents (i.e. EIA reports, duly filled and signed application form and challan for environment clearance fees and VAT). In this connection, DoE arranged so far three meetings in order to have more clarification on some specific issues. As per DoE's comments and suggestions, response matrix has been prepared which is attached herewith as annexure S and T (the annexes are attached in Vol-II of the EIA report).

Moreover, as per DoE comments, the copy of the EIA report was sent to the Dept. of Fisheries (DoF) and Bangladesh Fisheries Research Institute (BFRI) through Ministry of Fisheries and Livestock (MoFL). DoF and BFRI reviewed the EIA report and transmitted their observations directly to the ministry. Based on the DoF and BFRI observations, MoFL arranged a sharing meeting on 23 December 2018 with the participation of concerned ministry, project, IWM, DoF, DoE and BFRI personnel. As per decision of the meeting, MoFL prepared minutes of meeting (MoM) which is attached as annexure T. Summarized response matrix is attached with Volume –II of the EIA report. The title of the annexures contains comments and response matrix are as follows:

Annex S: Comments and Response Matrix Obtained from DoE.

Annex T: Minutes of Discussion meeting held at Secretariat (Ministry of Fisheries and Livestock) on 23rd Dec, 2018 & Comments-Response Matrix of DoF, BFRI and Ministry of Fisheries and Livestock

The report also included the following annexures in the Vol-II by the following headings such as:

Annex N: Terms of Reference for Third Party Monitoring and Evaluation of Environmental Safeguards

Annex L: Terms of Reference (ToR) for Monitoring and Development of Bio diversity Management Plan

Annex E: Terms of Reference (ToR) for Implementation and Conservation of Biodiversity Management Plan

Annex V: Environmental Clearance Certificate application along with challan for fees and VAT

In addition, it is mentioned that the project has already prepared a detail communication strategy which will be followed during dredging period. The communication process will be informed to the concerned authorities like Department of Environment, BIWTA, Department of Forest, Department of Fisheries etc. through writing letter from project office, prior to dredging work, making for informing the different livelihood groups etc. In addition, concerned PIC and PSC member will duly be informed through project internal communication method.

The EIA report has been updated incorporating the above response matrix and ToRs and finalized accordingly.

2 LEGAL AND REGULATORY FRAMEWORK

2.1 Introduction

This Chapter presents a review of the national policy, legal and regulatory framework relevant to the environmental and social aspects of the present study. Also reviewed in the Chapter are the relevant international treaties of which Bangladesh is a signatory. The World Bank environmental and social safeguard policies are also highlighted.

2.1.1 Relevant National Legislations and Policies in Bangladesh

The implementation of the proposed interventions will be governed by the relevant Environmental Acts, Rules, Policies, and Regulations. Table 2-1 presents precise description of the applicable national laws, regulations and policies for the environmental social management of the project interventions.

Table 2-1: Review of Relevant Laws, Regulations and National Policies

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
National Environmental Policy, 1992	Bangladesh National Environmental Policy 1992 sets out the basic framework for environmental action, together with a set of broad sector action guidelines. The policy addresses 15 sectors in all, in addition to providing directives on the legal framework and institutional arrangements. Marine environment is one of the key sectors covered in this policy. The main policy requirements related to the water sector are to ensure environmentally sound utilization of resources, so that developments do not create any significant adverse impacts on the environment; and that all water bodies and water resources are kept free from pollution. Key elements of the policy are: • Maintenance of the ecological balance and overall progress and development of the country through protection and improvement of the environment; • ensure that all steps are taken for flood control, including construction of embankments, dredging of rivers, digging of canals, etc., be environmentally sound at local, zonal and national levels; • keep the rivers, canals, ponds, lakes, haors, baors and all other water bodies and water resources free from pollution;; • Identification and regulation of all types of activities, which pollute and degrade the environment; • Ensuring sustainable utilization of all natural	According to this policy the proposed project needs full environmental assessment. The proposed interventions are required to comply with all the policy directives emphasizing particularly on reducing adverse environmental impacts. The EIA studies are required to address the potential impacts and propose mitigation measures. In compliance to the policy detail EIA is prepared.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	resources, and • Conduct environmental impact assessment before undertaking projects for water resources development and management.	
Environment Conservation Act (ECA) 1995 and subsequent amendments (2000, 2002 and 2010)	ECA '95 is currently the main legislation related to environment protection in Bangladesh. This Act is promulgated for environment conservation, environmental standard development and environment pollution control and abatement. The main strategies of the Act, that are relevant for this project, can be summarized as: • Declaration of ecologically critical areas and restriction on the operation and process, which can or cannot be carried/initiated in the ecologically critical areas; • Environmental clearance requirement for certain projects, which potentially create significant adverse environmental impacts; • Regulation of the industries and other development activities' discharge permit. • Promulgation of standards for quality of air, water, noise and soil for different areas for different purposes. • Promulgation of standard limit for discharging and emitting waste and, • Formulation and declaration of environmental guidelines. This Act has established the Department of Environment (DoE), and empowers its Director General to take measures as he considers necessary which includes conducting inquiries, preventing probable accidents, advising the Government, coordinating with other authorities or agencies, and collecting and publishing information about environmental pollution. According to this act (Section 12), no industrial unit or project shall be established or undertaken without obtaining, in a manner prescribed by the accompanying Rules, an Environmental Clearance Certificate (ECC) from the Director General of DoE. The amendment 2010 provided clarification of defining wetlands as well as Ecologically Critical Areas and included many important environmental concerns such as conservation of wetlands, hill cutting, ship breaking, and hazardous waste disposal.	The EIA study is prepared following guidelines of this Act. In accordance with the Act, the IWT project will need DoE's clearance prior to the commencement of the project. Also the Ecologically Critical Areas, defined by DoE under this act, will be considered while planning and designing of the project interventions. In connection with the project particularly construction of terminals on the bank of Buriganga at Sadarghat and Sasan ghat DoE,s opinion was solicited by the Consultant DoE informed that such development intervention can not be stopped even the river is considered as ECA. However, there shall be detail EMP in place for managing solid and liquid wastes at the terminals.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	This amendment empowered the government to enforce more penalties than before. Moreover, affected persons were given provision for putting objections or taking legal actions against the polluters or any entity creating nuisance to affected person.	
Environment Conservation Rules 1997 and Subsequent amendments (2002 and 2003)	The rule among others categorizes the industries and projects into four categories. As per ECR 1997, the project falls under Red Category needing detail EIA to obtain environmental clearances from DoE prior to commencement of any physical activities. Under the Rules, the following aspects, among others, are covered. • Declaration of ecologically critical areas • Procedures for issuing the Environmental Clearance Certificate (ECC) • Determination of environmental standards. The Rule 3 defines the factors to be considered in declaring an area 'ecologically critical area' (ECA) as per Section 5 of ECA 1995. It empowers the Government to declare an area 'ECA', if it is satisfied that the ecosystem of the area has reached or is threatened to reach a critical state or condition due to environmental degradation. The Government is also empowered to specify which of the operations or processes shall not be carried out or shall not be initiated in the ecologically critical area. The Rule 7 classifies industrial units and projects into four categories depending on environmental impact and location for the purpose of issuance of ECC. These categories are: Green, Orange A, Orange B, and Red. All existing industrial units and projects and proposed industrial units and projects, that are considered to be low polluting are categorized under "Green" and shall be granted Environmental Clearance. For proposed industrial units and projects falling in the Orange-A, Orange-B and Red Categories, firstly a site clearance certificate and thereafter an environmental clearance certificate will be required. A detailed description of these four categories of industries has been given in Schedule-1 of ECR'97. Apart from general requirement, for every Red category proposed industrial unit or project, the application must be accompanied with feasibility report, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) based on approved terms of	The EIA report is prepared in consideration of the procedure set in this rule.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	reference (ToR) by DoE, Environmental Management Plan (EMP). As per ECR'97, water resources development projects fall under 'Red' category project. Therefore the project is 'Red' category project which requires IEE, EIA and EMP for environmental clearance from DoE. The rules however provide the Director General a discretionary authority to grant Environmental Clearance to an applicant exempting the requirement of site/location clearance, provided he considers it appropriate. [Section 7(4), 2nd Paragraph, Page 3105 of the Bangladesh Gazette of 27 August 1997].	
National Water Policy, 1999	The policy aims to provide guidance to the major players in water sector for ensuring optimal development and management of water. The policy emphasizes efficient and equitable management of water resources, proper harnessing and development of surface and ground water, availability of water to all concerned and institutional capacity building for water resource management. It also addresses issues like river basin management, water rights and allocation, public and private investment, water supply and sanitation and water need for agriculture, industry, fisheries, wildlife, navigation, recreation, environment, preservation of wetlands, etc. The policy has several clauses related to the project for ensuring environmental protection. Some of the relevant clauses are: Clause 4.9b: Measures will be taken to minimize disruption to the natural aquatic environment in streams and water channels. Clause 4.12a: Give full consideration to environmental protection, restoration and enhancement measures consistent with National Environmental Management Action Plan (NEMAP) and the National Water Management Plan (NWMP). Clause 4.12b: Adhere to a formal environment impact assessment (EIA) process, as set out in EIA guidelines and manuals for water sector projects, in each water resources development project or rehabilitation program of size and scope specified by the Government from time to time.	A number of clauses of this policy are applicable to the project as the dredging operation will affect water quality including change in aquatic habitats. The proposed interventions are designed and implemented with due consideration of the relevant clauses of the policy.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
National Water Act, 2013	The recently published Water Act 2013 is based on the National Water Policy, and designed for integrated development, management, extraction, distribution, usage, protection and conservation of water resources in Bangladesh. In general, if one takes a critical look at the Act, the new law has provided the right framework for better management of water resources in the country. As per this Act, all forms of water (e.g., surface water, ground water, sea water, rain water and atmospheric water) within the territory of Bangladesh belong to the government on behalf of the people. The private landowners will be able to use the surface water inside their property for all purposes in accordance with the Act. A worthwhile initiative is the requirement for permits/licenses for large scale water withdrawal by individuals and organizations beyond domestic use. Without prior permission issued by the Executive Committee, no individuals or organizations will be allowed to extract, distribute, use, develop, protect, and conserve water resources, nor they will be allowed to build any structure that impede the natural flow of rivers and creeks. However, the maximum amount of surface water or groundwater that can be withdrawn by individuals or organizations is not mentioned in the Act. Setting up a priority order for water usage in an area where the water resources is in critical condition is also a significant step.	The Act is considered relevant as the intervention involves improvement of navigability of the major water ways in the country. The EIA study is conducted in consideration of relevant section of the Act.
The National Environment Management Action Plan (NEMAP, 1995)	NEMAP, 1995 identifies the main national environmental issues, including those related to the water sector. The main water related national concerns include flood damage, riverbank erosion, environmental degradation of water bodies, increased water pollution, shortage of irrigation water and drainage congestion; various specific regional concerns are also identified.	Relevant section of NEMAP is complied with in design and implementation of the project.
Bangladesh Environment Court Act, 2010	Bangladesh Environment Court Act, 2010 has been enacted to resolve the disputes and establishing justice over environmental and social damage raised due to any development activities. This act allows government to take necessary legal action against any parties who creates environmental hazards/ damage to environmentally sensitive areas as well as human	According to this act, government can take legal actions if any environmental problem occurs due to project interventions.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	society.	
The National Land Use Policy (NLUP), enacted in 2001	The National Land Use Policy (NLUP), enacted in 2001, aims at managing land use effectively to support trends in accelerated urbanization, industrialization and diversification of development activities. The NLUP urges that increasing the land area of the country may be not possible through artificial land reclamation process, which is cost-effective only in the long run. Therefore, land use planning should be based on the existing and available land resources. The policy suggests establishing land data banks where, among others, information on accreted riverine and coastal chars will be maintained.	The project intervention is designed adhering to the NLUP so that there is no and/or minimal change.
The National Water Management Plan (NWMP) 2001	The National Water Management Plan (NWMP) 2001, approved by the National Water Resources Council in 2004, envisions establishing an integrated development, management and use of water resources in Bangladesh over a period of 25 years. Water Resources Planning Organization (WARPO) has been assigned to monitor the national water management plan. The major programs in the Plan have been organized under eight sub-sectoral clusters: i) Institutional Development, ii) Enabling Environment, iii) Main River, iv) Towns and Rural Areas, v) Major Cities; vi) Disaster Management; vii) Agriculture and Water Management, and viii) Environment and Aquatic Resources. Each cluster comprises of a number of individual programs, and a total of 84 sub-sectoral programs have been identified and presented in the investment portfolio.	The project EIA study is conducted with due consideration of NWMP sub-sector clusters i), iii) and viii).
Coastal Zone Policy, 2005	Coastal zone policy initiated as a harmonized policy that transcends beyond sectoral perspectives. The policy provides general guidance so that the coastal population can pursue their livelihoods under secured conditions in a sustainable manner without impairing the integrity of the natural environment. The policy framework underscores sustainable management of natural resources like inland fisheries & shrimp, marine fisheries, mangrove and other forests, land, livestock, salt, minerals, sources of renewable energy like tide, wind and solar energy. It also emphasizes conservation and enhancement of critical ecosystems.	In line with this policy the operation is conducted with minimal disturbance to the natural resources (benthic species, inland fisheries & shrimp, marine fisheries, mangrove forest, etc.) in the coastal area with fragile ecosystem. The EIA has been

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
		prepared with due note of this policy.
Dredging and Dredged Material Management Policy, 2013	Government introduced the Policy 2013. Salient instructions, among others, relevant to dredging are: Project has to be formulated after identifying location of dredging and location for disposal of dredged materials. In dry season, dredged material shall not be disposed into flowing water. However, in south and southeast region, where tidal influence is very strong, material can be discharged into the river based upon recommendations from proper study. In rainy season, material may be disposed into river flow based on proper study of hydro-morphological considerations. 6.1.11 the following information will be required before the dredging program implementation related to the navigation: a) The goal of dredging works; b) River section by hydrographic / bathymetric survey; c) The location of dredging area; d) The amount of dredging works highlighting the river section by hydrographic / bathymetric survey; e) The distance between the dredging site and the dredged material disposal; f) The timing / period of conduct of dredging program; g) The information from the study of adverse effects on the environment or ecology due to dredging; h) The mitigation measure on the reduction of the adverse effects on the environment and the ecology. 8.0 Dredged material management: 8.1 Before starting dredging operation, proper planning, implementation technique and methodology are to be determined. 8.2 Provision for maintenance dredging is to be kept with its management. 8.3 For management of dredged materials following factors are to be considered:	The policy is relevant to the study in question. The EIA study is conducted by considering salient contents of relevant sections particularly Sections 6.1.11, 7 and 8 of the policy. A meeting was held with DoE, BIWTA and Consultants on February 3, 2016. Director Natural Resources Management and Research, chaired the meeting. In response to the queries of BIWTA Consultant regarding disposal of dredge materials, the director opined that in stream disposal to scour holes along the Lower Meghna is allowed subject to monitoring of impact on aquatic habitat and river morphology. He also emphasized that dumping of dredged materials shall avoid ponds, wetlands, etc, In case of on land

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	i. Objective of dredging; ii. Type and quality of river bed materials; iii. Size of river; iv). River bank and flood plain Characteristics; v). Demand for use of dredged material; vi) Quality of dredged material According to the policy dredged materials (soil, sand, sediment, etc.) from rivers can be disposed at specified locations for developing lands, urbanization, creating tourist areas, constructing dams and roads, exporting abroad to earn foreign currency, etc. 8.4 Conditions on temporary stockpiling: No agricultural land can be used for disposal of dredged spoils, dredged materials can be dumped in shallow places of river upon technical considerations and connections to link <i>khals</i> cannot be disrupted. 8.5 Conditions on permanent stockpiling: Best way of management of dredged materials is to fill up low land following Conservation Act 2000, ensure use along with dredging, and arranging piling on government <i>khas</i> land.	disposal preference for beneficial use is to be given and nonarable <i>khass</i> land is to be used for piling dredge materials.
Inland Water Transport Policy (IWTP), 2009	The objective of the IWTP is to revive inland waterways traffic. This policy for IWT development has direct bearing on overall improvement of BIWT sector including dredging navigation routes, provision of inland port facilities and navigation aids, conducting hydrographic survey, vessel development, etc. The salient points of IWT Policy are: Inland Waterways Network: For this to be achieved, waterways shall be re-classified. In short term however, a core waterways network shall be identified to keep existing infrastructure and facilities running. Inland River Ports and Launch Landing Stations: More investments shall be made in ports and landing stations to make IWT more attractive and efficient. Proper passenger and cargo infrastructure and facilities shall be developed or augmented; accesses by roads shall be provided so that multi-modal traffic is ensured; waterways access shall be improved to reduce congestion at the berths; mechanical handlings shall be introduced to enhance efficiency and increase turn-round of vessels; and provide secured operational areas by security walls in order to improve passenger	The proposed interventions are in line with the project. Compliance to the policy is addressed properly in the EMP Section of the EIA and proper monitoring arrangement by the project proponent is ensured in the study.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	and cargo handlings. Network Maintenance: Funds shall be required to be committed by the Government only to maintain existing navigational asset. Hydrographic surveys shall be required to be carried out regularly to assess condition of waterways network and identify channels needing dredging works. Safety: Special focus is to be given on accident prevention, largely in the areas of inspection and enforcement. Design of vessels and construction shall be checked stringently. Institutional Issues: Considering transport sector as a whole, adequate government support in decision making and prioritization shall be given to IWT mode not only to maintain its present level of services but also to make improvements.	
Inland Shipping Ordinance 1976 and Inland Shipping (Amendment) Act 1990	Deals with the administration, registration, competency and pollution control, etc., of inland water transport. Primarily addresses pollution in the coastal and national waters and seaports of Bangladesh. The Act provides control for oil or pollutants discharged, spilled or dumped into Bangladesh water from ships, ship transfer to land, land, ports, and exploration of the sea bed, pipelines and offshore installations.	The proposed intervention has close relationship with the ordinance and Act. EMP section of the EIA has addressed relevant issues and BIWTA is committed to ensure proper compliance to these through proper monitoring arrangement.
Draft Rules for Inland Ship Safety 1994	The proposed Rules control impacts from all inland water transport, ports, ship-related facilities, and ship related activities for the protection of inland water in regard to air emissions, handling and storage of harmful materials, solid and liquid waste discharges, dredging, and disposal of dredged sediments.	The major activities of proposed interventions are in line with the rules and are addressed in the EMP.
Bangladesh Labour Act 2006	The Act provides the guidance of employer's extent of responsibility and workmen's extent of right to get compensation in case of injury by accident while working. Provides for safety of work force during	This act is relevant to the project intervention as there will be

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	construction period.	involvement of skilled and unskilled labour in operation and management of dredged spoils. The EMP is prepared to address relevant section of this Act.
Land Acquisition and Requisition Ordinance 1984	This Ordinance governs acquisition and requisition by the government of immovable property for any public purpose or in the public interest.	The project may require land acquisition and requisition for disposal of dredged materials, development of vessel shelters, etc. RAP will be prepared to deal these aspects.
The Bangladesh National Building Code (BNBC)	BNBC clearly sets out the constructional responsibilities according to which the relevant authority of a particular construction site shall adopt some precautionary measures to ensure the safety of the workmen. According to section 1.2.1 of chapter 1 of part 7, “In a construction or demolition work, the terms of contract between the owner and the contractor and between a consultant and the owner shall be clearly defined and put in writing.”	The project will create facilities including construction of vessel shelters. These will involve construction of infrastructures. All civil construction works will be carried out following the BNBC Code.
National Agriculture Policy, 1999	This policy aims to make the nation self-sufficient in food through increasing production of all crops including cereals and ensure a dependable and secure food system for all. The policy particularly stresses on research and development of improved varieties and technologies for cultivation in water-logged and salinity affected areas. The policy also recognizes that adequate measures should be taken to reduce water-logging and salinity and provide irrigation facilities for crop production.	The proposed project is expected to contribute to achieve the objectives of the agriculture policy by avoiding disposal of dredged materials on arable land and creating

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
		arable land by raising land level subject to quality of spoil material.
National Fisheries Policy, 1998	The policy recognizes that fish production has declined due to environmental imbalances, adverse environmental impact and improper implementation of fish culture and management programs. The policy suggests, among others, that biodiversity will be maintained in all natural water bodies and in marine environment and control measures will be taken against activities that have a negative impact on fisheries, resources and vice-versa. National Fisheries Policy focuses on aquaculture and marine fisheries development and includes the following mandates: (i) Maintaining biodiversity in all natural water bodies and in marine environment, (ii) Ensuring that chemicals harmful to the environment will not be used in fish shrimp farms; (iii) Using environment friendly fish shrimp culture technology; (iv) Expanding fisheries areas and integrating rice, fish and shrimp cultivation; (v) Undertaking control measures against activities that have a negative impact on fisheries resources and vice-versa; and (v) Formulating laws will to ban the disposal of any untreated industrial effluents into the water bodies.	This policy is relevant as the dredging activities involve major river system of the country, which are important fish feeding, breeding, and spawning and migration routes. The proposed EIA is conducted in compliance with the relevant directives including maintaining biodiversity in inland water ways.
Protection and Conservation of Fish Act, 1950 (Amended 1963, 1970, 1982, 1995, 2000)	This Act provides various measures for the protection and conservation of fish including specifying waters in which the catching of certain fish species is prohibited without a valid license, and specifying fish species of which the catching or sale in certain periods is prohibited; prohibiting the erection of fixed engines in rivers and canals; prohibiting the destruction of fish through the use of poison or explosives; and licensing and regulations with regard to frogs. In recognition that fish fry collection from nature may result in long term ecological destruction the government, in 2000, prohibited the collection of fry or post larvae of fish, shrimp and prawns of any kind, in any form and in any way, in estuary and coastal waters, diverting or blocking water flow that hinders fish movement/migration. The Rules contain a provision	Relevant as intervention area is located within Hilsha fish migratory route of the country. The project will be implemented with due care so that minimal/no damage occur to fishery for conservation of fishery resources. No intervention will be in place during Hilsha

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	for conservation by empowering the government to declare any fish reserve in which fishing and any other detrimental activities can be prohibited.	breeding periods.
The Forest Act, 1927 and Amendment 1989	The Forest Act of 1927 as amended in 1989 grants the government several basic powers, largely for conservation and protection of government forests, and limited powers for private forests. The 1927 version of the act was amended in 1989 for extending authority over "any [Government-owned] land suitable for afforestation".	Relevant to the study in question. EMP is prepared in consideration of this Act.
Bangladesh Wildlife (Conservation & Security) Act, 2012 (previously known as Bangladesh Wildlife (Preservation) Order, 1973; amended as Bangladesh Wildlife (Preservation) Act 1974)	The previous Wildlife (Preservation) Order, 1973 & Wildlife (Preservation) (Amendment) Act, 1974 have been revamped to Wildlife (Conservation & Safety) Act of 2012. The Act has adopted new types of protected areas for conservation and protection of wildlife resources, created avenue for community conserved areas and also community based management of protected areas. This Act protects 1,307 species of plants and animals; and mandates imprisonment and fines for wildlife poaching, capturing, trapping, and trading. Bangladesh Wildlife (Preservation) Order (1973) and Act (1974) regulates the hunting, killing, capture, trade and export of wild life and wild life products. It designates a list of protected species and game animals.	Relevant as intervention may affect wildlife habitation, obstruct movement. The EMP is prepared to address this aspect.
Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009	The Government of Bangladesh has prepared the Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009. The BCCSAP is built on six pillars: i. Food security, social protection and health to ensure that the poorest and most vulnerable in society, including women and children, are protected from climate change and that all programs focus on the needs of this group for food security, safe housing, employment and access to basic services, including health. ii. Comprehensive disaster management to further strengthen the country's already proven disaster management systems to deal with increasingly frequent and severe natural calamities. iii. Infrastructure to ensure that existing assets (e.g., coastal and river embankments) are well maintained and fit for purpose and that urgently needed infrastructures (cyclone shelters and urban drainage) is put in place to deal with the likely impacts of climate	Relevant as the country particularly the project area is vulnerable to climate change effect. Proposed interventions are designed to address climate induced effect.

Policies, Laws and Regulations	Description (Policies, Laws and Regulations)	IWT Compliance
	change. iv. Research and Knowledge management to predict that the likely scale and timing of climate change impacts on different sectors of economy and socioeconomic groups; to underpin future investment strategies; and to ensure that Bangladesh is networked into the latest global thinking on climate change. v. Mitigation and low carbon development to evolve low carbon development options and implement these as the country's economy grows over the coming decades. vi. Capacity building and Institutional strengthening to enhance the capacity government ministries, civil society and private sector to meet the challenge of climate change. RMIP will contribute towards achieving the objective of pillars such as (i), (ii), (iii), (iv), and (vi).	
The Embankment and Drainage Act, 1952	Consolidates the laws relating to Embankments and drainage providing 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.	Disposal of dredged spoil may create drainage obstruction. So adherence to relevant section of the Act is addressed in the EIA.

2.1.2 Compliance with DOE EIA Guidelines

Department of Environment (DoE) under the Ministry of Environment and Forest (MoEF) is the sole entity to issue environmental clearance to any Governmental, Non-Governmental or private Organization intending to develop a project or set up an industry. Environmental Impact Assessments (EIA) should be conducted before projects are undertaken.

All existing industrial units and projects and proposed industrial units and projects, that are considered to be low polluting are categorized under "Green" and shall be granted Environmental Clearance. For proposed industrial units and projects falling in the Orange-A, Orange-B and Red Categories, firstly a site clearance certificate and thereafter an environmental clearance certificate will be required. A detailed description of these four categories of industries has been given in Schedule-1 of ECR'97. Apart from general requirement, for every Red category proposed industrial unit or project, the application must be accompanied with feasibility report, Initial Environmental Examination (IEE), Environmental Impact Assessment (EIA) based on approved terms of reference (ToR) by DoE, Environmental Management Plan (EMP). As per ECR'97, water resources development projects fall under 'Red' category project. Therefore, the project is also categorized as 'Red' which requires IEE, EIA and EMP for environmental clearance from DoE.

The ECR'97 describes the procedures for obtaining Environmental Clearance Certificates (ECC) from the Department of Environment for different types of proposed units or projects. Any person or organization wishing to establish an industrial unit or project must obtain ECC from the Director General. The application for such certificate must be in the prescribed form together with the prescribed fees laid down in Schedule 13, through the deposit of a Treasury Challan in favor of the Director General. The fees for clearance certificates have been revised in 2010. Rule 8 prescribes the duration of validity of such certificate (three years for green category and one year for other categories) and compulsory requirement for renewal of certificate at least 30 days before expiry of its validity.

The Department of Environment may take up to sixty days to approve the EIA and thirty more days to issue the Environmental Clearance, provided everything complies with the requirements (Figure 2-1). This may be quite a lengthy process if DoE uses the full extent of the time limits.

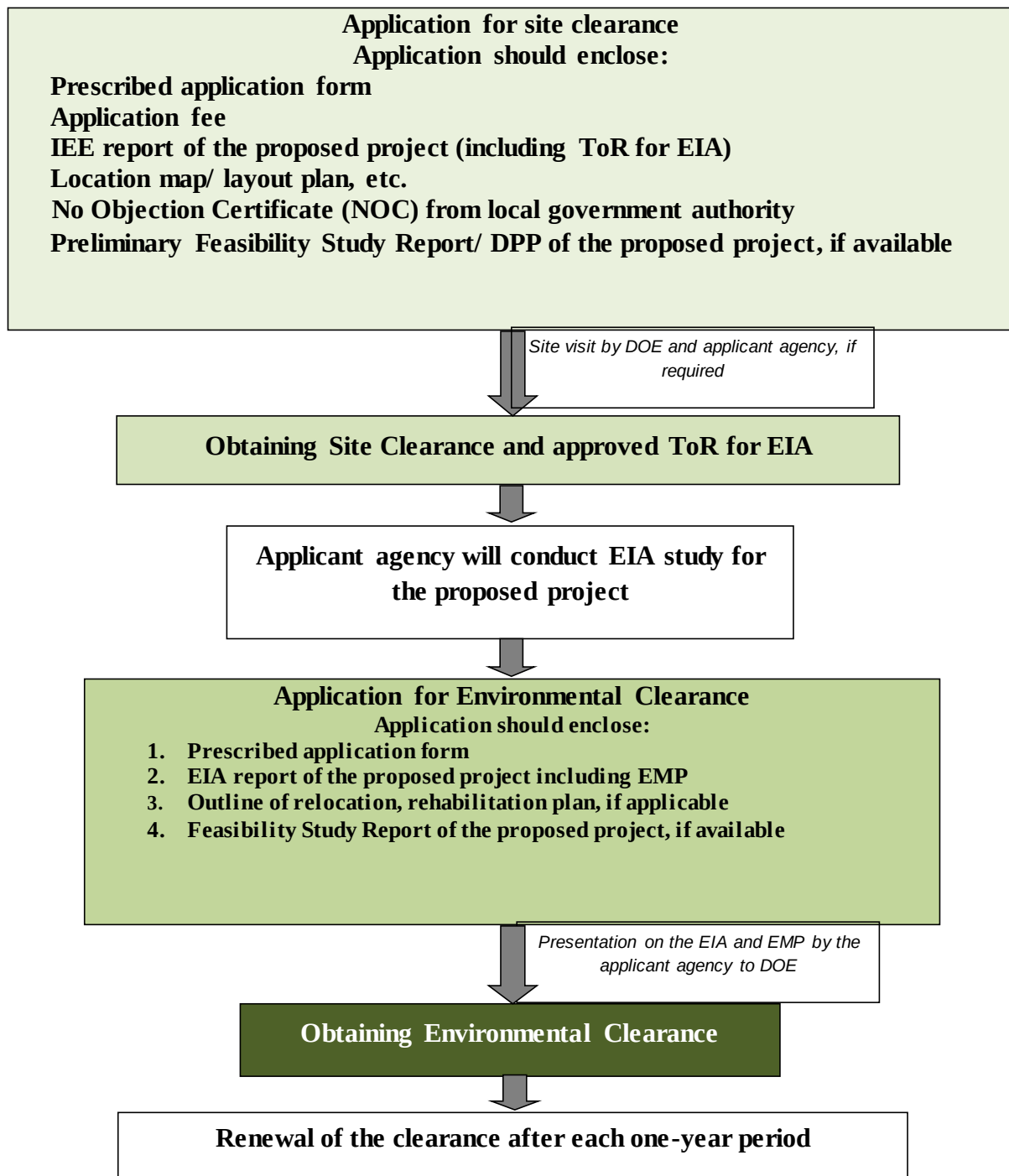


Figure 2-1: Process of Site and Environmental Clearance conforming ECR 1997.

2.2 International Treaties

Bangladesh is signatory to several International conventions and treaties including MARPOL 73/78 (Prevention of Pollution from Ships), OPRC (Oil Pollution Preparedness Response and Cooperation) or the LC Convention 72 (dumping of ship wastes). The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is subject to enforcement in Bangladesh marine and coastal waters. Therefore, ships in Bangladesh Ports are subject to inspection for the purpose of enforcing MARPOL 73/78. Bangladesh has signed most international treaties, conventions and protocols on environment, pollution control, bio-diversity conservation and climate change, including the Ramsar Convention, the Bonn Convention on migratory birds, the Rio de Janeiro Convention on biodiversity conservation and the Kyoto protocol on climate change. An overview of the relevant international treaties and conventions is shown in Table 2-2.

Table 2-2: International Treaties, Conventions and Protocol

Treaty or Convention	Brief Description	IWT Compliance
London Convention	The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, commonly called the "London Convention" or "LC '72" and also abbreviated as Marine Dumping, is an agreement to control pollution of the sea by dumping and to encourage regional agreements supplementary to the Convention. It covers the deliberate disposal at sea of wastes or other matter from vessels, aircraft, and platforms. It does not cover discharges from land-based sources such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention. It entered into force in 1975. As of 2013, there were 87 Parties to the Convention. The London Convention consists of 22 Articles and three Annexes. The main objective of the London Convention is to prevent indiscriminate disposal at sea of wastes that could be liable for creating hazards to human health; harming living resources and marine life; damaging amenities; or interfering with other legitimate uses of the sea. The 1972 Convention extends its scope over "all marine waters other than the internal waters" of the States and prohibits the dumping of certain hazardous materials. It further requires a prior special permit for the dumping of a number of other identified materials and a prior general permit for other wastes or matter.	The Convention is indirectly relevant for the present EIA as dredging operation is planned not only in the major river routes but also in the delicate coastal ecosystem of the country.

Treaty or Convention	Brief Description	IWT Compliance
	Since its entering into force in 1975, the convention has provided a framework for international control and prevention of marine pollution within which the contracting parties have achieved continuous progress in keeping the oceans clean. Among its milestones are the 1993 ban on ocean disposal of low-level radioactive wastes and the resolutions to end the dumping and incineration of industrial wastes. The efforts of the Parties are supported by a permanent secretariat hosted by the International Maritime Organization (IMO). On 17 November 1996, a special meeting of the Contracting Parties adopted the "1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972" which is to replace the 1972 Convention, subject to ratification. In line with UNCED's Agenda 21, the 1996 Protocol reflects the global trend towards precaution and prevention with the parties agreeing to move from controlled dispersal at sea of a variety of land-generated wastes towards integrated land-based solutions for most, and controlled sea disposal of few, remaining categories of wastes or other matter. Among the most important innovations brought by the 1996 protocol is the codification of the "precautionary approach" and the "polluter pays principle." Reflecting these principles, the protocol embodies a major structural revision of the convention the so-called "reverse list" approach. Now, instead of prohibiting the dumping of certain (listed) hazardous materials, the parties are obligated to prohibit the dumping of any waste or other matter that is not listed in Annex 1 ("the reverse list") of	

Treaty or Convention	Brief Description	IWT Compliance
	the 1996 protocol. Dumping of wastes or other matter on this reverse list requires a permit. Parties to the protocol are further obligated to adopt measures to ensure that the issuance of permits and permit conditions for the dumping of reverse list substances comply with Annex 2 (the Waste Assessment Annex) of the protocol. The substances on the reverse list include dredged material; sewage sludge; industrial fish processing waste; vessels and offshore platforms or other man-made structures at sea; inert, inorganic geological material; organic material of natural origin; and bulky items including iron, steel, concrete and similar materials for which the concern is physical impact, and limited to those circumstances where such wastes are generated at locations with no land-disposal alternatives. In addition, the 1996 protocol prohibits altogether the practice of incineration at sea, except for emergencies, and prohibits the exports of wastes or other matter to non-Parties for the purpose of dumping or incineration at sea. The 1996 protocol has effectively moved the scope of the original London convention landwards, relating it to the policy and management issues of land as well as sea wastes disposal.	
MARPOL Convention	The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973 at IMO. The Protocol of 1978 was adopted in	The Convention is in line with the study in question. Most of the Annexes of MARPOL is required to be observed by the project proponent strictly as per EMP recommendation advocating strict observance to this and other relevant Conventions as Bangladesh is a signatory to this Convention.

Treaty or Convention	Brief Description	IWT Compliance
	response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes. Annex I Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983) Covers prevention of pollution by oil from operational measures as well as from accidental discharges; the 1992 amendments to Annex I made it mandatory for new oil tankers to have double hulls and brought in a phase-in schedule for existing tankers to fit double hulls, which was subsequently revised in 2001 and 2003. Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983) Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992). Annex IV Prevention of Pollution by Sewage from Ships	

Treaty or Convention	Brief Description	IWT Compliance
	(entered into force 27 September 2003) Contains requirements to control pollution of the sea by sewage; the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or when the ship is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; sewage which is not comminuted or disinfected has to be discharged at a distance of more than 12 nautical miles from the nearest land. Annex V Prevention of Pollution by Garbage from Ships (entered into force 31 December 1988) Deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed of; the most important feature of the Annex is the complete ban imposed on the disposal into the sea of all forms of plastics. Annex VI Prevention of Air Pollution from Ships (entered into force 19 May 2005) Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances; designated emission control areas set more stringent standards for SO_x, NO_x and particulate matter. A chapter adopted in 2011 covers mandatory technical and operational energy efficiency measures aimed at reducing greenhouse gas emissions from ships.	
Ramsar Convention	Protection of wetlands. Broadly applicable for wetlands in and around the project	The operation may affect wetland habitat. Mitigation measures included in EMP to address potential

Treaty or Convention	Brief Description	IWT Compliance
	influence area.	impacts on wetlands and associated resources as well.
Protocol on Waterfowl Habitat	Amendment of Ramsar Convention to protect specific habitats for waterfowl.	Broadly applicable for wetlands in and around the project influence area. Mitigation measures included in EMP address potential impacts on wetlands and associated ecological resources as well.
CITES Convention (Washington)	Ban and restrictions on international trade in endangered species of wild fauna and flora.	Not directly relevant to the the project intervention since the project does not involve in any international trade of endangered species of wild fauna and flora. General restrictions have however been included in the Environmental Code of Practice.
Prevention and Control of Occupational hazards (Geneva)	Protect workers against occupational exposure to carcinogenic substances and agents.	Compliance to this is taken care of in the EMP of the EIA report due to the fact that interventions involve occupational risks to some extent.
Occupational hazards due to air pollution, noise & vibration (Geneva)	Protect workers against occupational hazards in the working environment.	Relevant as there will be pollution due to gaseous emission from dredging equipment, vehicle movement as well as noise. Appropriate mitigation and protective measures have been included in the EMP and vibration.
Occupational safety and health in working environment (Geneva)	Prevent accidents and injury to health by minimizing hazards in the working environment.	Broadly applicable to the project activities under the project. Compliance is attached in the EIA to ensure health and safety to workers through prevention of accidental risks. Appropriate mitigation and protective measures have been included in the EMP.
Occupational Health Services (Geneva)	To promote a safe and healthy working environment.	Broadly applicable to the project activities under the project. Compliance to this will be adopted as there will be involvement of both skilled and unskilled manpower. Appropriate mitigation and protective measures have been included in the EMP.

Treaty or Convention	Brief Description	IWT Compliance
Bonn Convention	Conservation of migratory species of wild animals.	Broadly applicable to the migratory birds in and around the project influence area. Project activities are not likely to have any significant impacts on these species; precautionary measures have nonetheless been included in EMP.
Civil liability on transport of dangerous goods (Geneva)	Safe methods for transport of dangerous goods by road, railway and inland vessels.	Broadly applicable to transportation of substances such as fuels during the project construction phase. Appropriate mitigation measures are included in the EMP.
UN framework convention on climate change (Rio de Janeiro)	Regulation of greenhouse gases emissions (GHGs).	The study will take due care of the convention as the intervention area is located within climate vulnerable zone. Appropriate mitigation and protective measures have been included in the EMP to minimize emissions of GHGs.
Convention on Biological Diversity (Rio de Janeiro)	Conservation of bio-diversity, sustainable use of its components and access to genetic Resources.	The EIA will be prepared addressing conservation of biological species as these are subject to be affected by the project intervention. Appropriate mitigation and protective measures have been included in the EMP for the conservation of biodiversity.
International Convention on Climate Changes (Kyoto Protocol)	International treaty on climate change and emission of greenhouse gases.	The EIA is prepared with due note to the Kyoto Protocol as the project interventions are in the climate vulnerable area. Appropriate mitigation and protective measures have been included in the EMP to minimize emissions of GHGs.

2.3 World Bank Safeguard Policies

2.3.1 Overview of OPs and Guidelines

The main purposes of the Bank's safeguard policies are to (i) avoid harm to the environment and affected people and provide affected people an opportunity to participate in the development process; (ii) improve project design and performance; and (iii) protect the reputation of the Bank. The current set of safeguard policies cover a broad range of topics from environmental assessment to natural habitats, forests, resettlement, and Indigenous Peoples and others. The policies are the reflection of international conventions and internationally accepted principles of good practice in project preparation and implementation.

Table 2-3 precisely presents World Bank Safeguard Policies and their applicability to the Project.

Table 2-3: World Bank Safeguard Policies and their Applicability to the Project.

OP Number	Brief Description	IWT Compliance
OP 4.01 - Environmental Assessment	The World Bank requires an Environmental Assessment (EA) for all projects proposed for Bank financing to ensure that these projects are environmentally sound and sustainable. The proposed BIWTA project is classified Category A, because of the scope of the expected impacts from dredging operation, river training, vessel shelter construction and operation, the impacts of land acquisition, and the expected impacts on the natural environment.	Triggered. EIA has been prepared considering A Category project as per OP 4.01.
OP 4.04 - Natural Habitats	There are no designated conservation areas or nature reserves in the project area. However OP 4.04 does apply since the intervention area covers major navigation routes including lower Meghan and part of estuary which consists of natural char lands in the active Meghan floodplain, with typical floodplain habitats and breeding grounds that might be affected by the project.	Triggered. The EIA report is prepared in consideration of all ecological sensitive areas. In addition, a biodiversity management plan is prepared as part of EIA.
OP 4.10 Indigenous People	For purposes of this Policy, the term 'Indigenous Peoples' is used in a generic sense to refer to a distinct, vulnerable, social and cultural group possessing the following characteristics in varying degrees: ¹ self-identification as members of a distinct indigenous cultural group and recognition of this identity by others;	Not triggered. The social impact assessment of the Project indicates that there are no indigenous communities residing in the project influence area and therefore, no impacts on them are

¹ Excerpts from the OP 4.10.WB Operational Manual. July 2005.

OP Number	Brief Description	IWT Compliance
	• collective attachment to geographically distinct habitats or ancestral territories in the project area and to the natural resources in these habitats and territories; • customary cultural, economic, social, or political institutions that are separate from those of the dominant society and culture; and • an indigenous language, often different from the official language of the country or region. The OP defines the process to be followed if the project affects the indigenous people.	expected under the project. This has been confirmed in the selected reach where operation will be carried out under the proposed project. Therefore, this OP is not triggered.
OP 4.11 Physical Cultural Resources	The World Bank's general policy regarding cultural properties is to assist in their preservation, and to seek to avoid their elimination. The specific aspects of the Policy are given below.² • The Bank normally declines to finance projects that will significantly damage non-replicable cultural property, and will assist only those projects that are sited or designed so as to prevent such damage. • The Bank will assist in the protection and enhancement of cultural properties encountered in Bank-financed projects, rather than leaving that protection to chance. In some cases, the project is best relocated in order that sites and structures can be preserved, studied, and restored intact in situ. In other cases, structures can be relocated, preserved, studied, and restored on alternate sites. Often, scientific study, selective salvage, and museum preservation before destruction is all that is necessary. Most such projects should include the training and strengthening of institutions entrusted with safeguarding a nation's cultural patrimony. Such activities should be directly included in the scope of the project, rather than being postponed for some possible future action, and the costs are to be internalized in computing overall project costs. • Deviations from this policy may be justified only where expected project benefits are great, and the loss of or damage to cultural property is judged by competent authorities to be unavoidable, minor, or otherwise acceptable. Specific details of the	Triggered. As part of the environmental and social assessment studies for the project, a full baseline assessment has been carried out, including consultations, to identify any physical cultural resources (PCR) in the project influence area. Though there are no identified PCRs located in the subproject sites which would likely be directly affected or displaced by proposed works, there could be chance finds. 'Chance find' procedures will be included in the EMPs for all works activities.

² Excerpts from the OPN 11.03.WB Operational Manual. September 1986.

OP Number	Brief Description	IWT Compliance
	justification should be discussed in project documents. This policy pertains to any project in which the Bank is involved, irrespective of whether the Bank is itself financing the part of the project that may affect cultural property.	
OP 4.12 - Involuntary Resettlement	The project may require land acquisition for management of dredged material handling as well as construction of vessel shelter.	Triggered. Separate social studies are carried out and resettlement action plans (RAP) is being prepared. These aim to minimize resettlement while offering adequate compensation or settlement alternatives in conformity with World Bank policies and Bangladesh law.
OP 4.36 Forests	This Policy recognizes the need to reduce deforestation and promote sustainable forest conservation and management in reducing poverty. The Bank believes that forests are very much essential for poverty reduction and sustainable development irrespective of their location in the world. The Bank assists borrowers with forest restoration activities that maintain or enhance biodiversity and ecosystem functionality. The Bank also assists borrowers with the establishment and sustainable management of environmentally appropriate, socially beneficial, and economically viable forest plantations to help meet growing demands for forest goods and services. The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical forest areas or related critical natural habitats. Furthermore, the Bank does not finance projects that contravene applicable international environmental agreements.	Triggered. This OP is triggered since the dredging operation will be over a long period located in different reaches including coastal area having mangrove vegetation and social forestry. The ESMP section of the EIA has dealt these aspects in the light of this OP. However, dredging operation will avoid any such environmental hot spot. Also disposal of dredged materials will not be considered on mangrove vegetation or in social forest area.
OP 4.09 Pest Management	Through this OP, the WB supports a strategy that promotes use of biological or environmental control methods and reduces reliance on synthetic chemical pesticides. Rural development and health sector projects have to avoid using harmful pesticides. Other pesticides can be used, but only as an element of an Integrated Pest Management	Not triggered

OP Number	Brief Description	IWT Compliance
	Plan (IPMP) that emphasizes environmental and biological controls.	
OP 4.37 Safety of Dams	The Policy seeks to ensure that appropriate measures are taken and sufficient resources provided for the safety of dams the WB finances.	Not triggered. This OP is not relevant since the proposed Project does not involve construction of dams.
OP 7.50 Projects on International Waterways	Projects on international waterways may affect the relations between the World Bank and its borrowers, and between riparian states. Therefore, the Bank attaches great importance to the riparian making appropriate agreements or arrangements for the entire waterway, or parts thereof, and stands ready to assist in this regard. A borrower must notify other riparian of planned projects that could affect water quality or quantity, sufficiently far in advance to allow them to review the plans and raise any concerns or objections.	Triggered. This Policy is triggered since the navigation route include international waterway. However, as Bangladesh is the most downstream country of the Major river system, the proposed project is not expected to adversely change the quality or quantity of water flow to the other riparian countries.
OP 7.60 Projects in Disputed Areas	Projects in disputed areas may raise a number of delicate problems affecting relations not only between the Bank and its member countries, but also between the borrower and one or more neighboring countries. In order not to prejudice the position of either the Bank or the countries concerned, any dispute over an area in which a proposed project is located is dealt with at the earliest possible stage. The Bank may proceed with a project in a disputed area if the governments concerned agree that, pending the settlement of the dispute, the project proposed for country A should go forward without prejudice to the claims of country B. ³	Not triggered. This OP is not triggered since no part of the Project influence area is located in any disputed territory.
BP 17.50 - Public Disclosure of Information	According to the Bank Policy as well as ToR obligation the EA should be made available to the public by disclosure at public libraries or other places accessible to project affected groups, including a Summary EA in the local language.	The EIA and RPF documents have been disclosed in BIWTA web site and through public consultations at Ashuganj and Barisal. The EIA and RPF reports are also disclosed in World

³ Excerpts from the OP 7.60.WB Operational Manual. November 1994.

OP Number	Brief Description	IWT Compliance
		Bank website. The ESA Executive Summary has been translated into Bangla and disclosed in BIWTA website and made available to local community at local BIWTA offices. During EIA preparations several consultations meetings were held in the project area including a national workshop in Dhaka

2.4 World Bank EHS Guidelines

IFC Environmental, Health and Safety Guidelines of World Bank Group are presented in Table 2-4.

Table 2-4: World Bank Environmental, Health and Safety Guidelines.

EHS Guideline	Brief Description	IWT Compliance
Environmental Health and Safety Guidelines	The Environment, Health, and Safety (EHS) Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities or project by existing technology at reasonable costs.	These Guidelines will be applicable to the Project particularly with respect to air emissions, ambient air and noise quality standards, waste water quality, hazardous material and waste management, and occupational and community health and safety management.
Environmental, Health, and Safety Guidelines PORTS, HARBORS, and TERMINALS	The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the General EHS Guidelines document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. The EHS Guidelines for Ports, Harbors, and Terminals are applicable to commercial ports, harbors, and terminals for cargo and passengers transfer. Shipping (including repair and maintenance of ships), fuel terminals, or railways are addressed in separate industry sector EHS Guidelines, specifically the EHS Guidelines for Shipping, Crude Oil and Petroleum	Relevant as the project includes provision of improved navigation routes and terminal facilities. ESMP section of the EIA report has been dedicated to mitigate adverse impact due to the proposed intervention.

	Product Storage, Railways, respectively.	
The EHS Guidelines for Shipping	The EHS Guidelines for Shipping include information relevant to the operation and maintenance of ships used for the transport of bulk cargo, and goods. Cargo handling, vessel maintenance, and other in-port activities are covered under the EHS Guidelines for Ports and Harbors while issues specific to the transfer and storage of bulk fuels are covered in the EHS Guidelines for Crude Oil and Petroleum Product Terminals.	Broadly applicable as the project provides improved navigation routes and terminal facilities. The EMP is prepared to address mitigation measures due to proposed interventions.

3 PROJECT DESCRIPTION

3.1 Background

3.1.1 Details of Dhaka-Chittagong Corridor

D-C corridor and adjoining routes under study are considered artery of IWT network. It is estimated that these routes generate more than 70 percent of total IWT output. Most of major inland ports namely Dhaka, Narayanganj, Ashuganj-BhairabBazaar, Munshiganj-Mirkadim, Chandpur and Barisal are located along routes under the present study.

A total of 80 way side landing stations were developed by BIWTA along these routes. With all these infrastructures and facilities accessibility to rivers for the purpose of transport has enhanced dedicated jetties and ware houses. Larger industrial units, power plants established along the banks of rivers in these routes depend almost completely on IWT for transportation of bulk raw materials required for industrial units. About 300 passenger launches with average capacity of 250 passengers are departing daily from Dhaka, Narayanganj, Barisal and other stations. While almost 300 launches arrive daily at those stations. Besides, state owned BIWTC has its passenger service. With all these, it can be estimated that these routes provide transit of 200,000 passengers daily. Cargo and passenger throughput in the following table (Table 3.1) in major four inland ports namely Dhaka, Narayanganj, Chandpur and Barisal along these routes will further describe the importance:

Table 3-1: Passenger and Cargo Throughputs of River Ports

Port	2011-2012		2012-2013		2013-2014	
	Passenger (in million)	Cargo (in million tonne)	Pass (in million)	Cargo (in million tonne)	Pass (in million)	Cargo (in million tonne)
Dhaka	19.05	6.00	21.11	6.70	20.55	7.53
Narayanganj	23.13	10.53	22.72	12.76	24.17	13.61
Chandpur	2.10	0.42	2.27	0.47	2.28	0.50
Barisal	5.75	0.60	5.81	0.66	6.47	0.68

Source: BIWTA.

3.1.2 Inflow of maritime transport

D-C corridor and adjoining routes connect maritime ports in Bangladesh. Chittagong, being the main maritime port shares more than 90 percent of international sea borne trade. Intermodal distribution of goods handled at Chittagong largely depends on this corridor under study.

Coastal and inland vessels transport imported goods from Chittagong to different destinations inland. Average number of annual sailings from Chittagong to different destinations mainly Dhaka-Narayanganj area is almost 18,000. Annual volume of carriage of goods is 22.45 million tonnes. These are mainly: clinker, urea, wheat, raw sugar, soya seed, coal, salt, feldspar, ball clay, gypsum, lime stone, slag, yellow peas, rock phosphate, soda, HR coil, billet, TSP, MOP and maize. These are dry bulk and about 70 percent of imports are transported by river. One vessel can load 1,300 tonnes on average and takes a steaming time

of 36 hours to reach Dhaka / Narayanganj. Transport of POL and liquid bulk largely depends on this corridor. About 220 oil tankers with average capacity of 1,500 each provide services for transport of POL and liquid bulk. About 6.7 million tons of POL and 1 million ton of soya bean oil are transported inland by this corridor annually.

3.1.3 Trans- boundary inland navigation

There exists a Protocol between Bangladesh and India on Inland Water Transit and Trade envisaging utilization of river resources of both the countries for commerce between the countries and for passage of goods between two Indian places through inland waterways of Bangladesh. Since its signing in 1972, working of this Protocol continues without any disruption. Protocol decided eight routes including two dormant routes of Rajshahi and Dhulian. In the remaining six routes D-C corridor and adjoining routes are common. It means that the corridor and adjoining routes contribute towards sub-regional transport cooperation. This Protocol has two aspects: carriage of inter-country trade cargo and carriage of transit cargo. During recent years, volume of inter country trade cargo is growing fast. These are mainly fly ash required by cement manufacturers and other commodities like food grain, gypsum, slag etc. These are mainly low price goods in bulk coming from Kolkata to mainly Narayanganj. This is an one way traffic since Bangladesh has nothing in bulk to export to India. Most interesting matter in this regard is that Bangladesh vessels share more than 90 percent of total tonnage despite a provision of sharing of cargo on equal tonnage basis. Table 3.2 illustrates the growth of inter country trade cargo:

Table 3-2: Cargo of Bilateral Trade (in ton)

Year	Indian Vessel	Bangladesh Vessel	Total
2006-2007	-	8,81,011	8,81,011
2007-2008	1,900	9,94,345	9,96,245
2008-2009	-	9,30,094	9,30,094
2009-2010	-	12,77,436	12,77,436
2010-2011	12,697	14,24,176	14,36,873
2011-2012	55,558	14,29,443	14,85,001
2012-2013	39,256	15,07,357	15,46,613
2013-2014	18,953	19,12,622	19,31,575

Source: *Traffic Department, BIWTA*

Unlike bilateral trade, volume of cargo of transit traffic is significantly declining. This has the two following reasons:

- i) Development of transport infrastructure in the chicken-neck of India consisting of northern West Bengal and upper Assam.
 - ii) Problem of navigability in rivers of north-eastern Bangladesh, especially in the Kushiara.
- Table 3.3 will demonstrate current state of transit traffic:

Table 3-3: Volume of Transit Trade

Year	Volume (in tonnes)
2006-2007	12,557
2007-2008	8,230
2008-2009	14,628
2009-2010	4,474
2010-2011	590
2011-2012	2,695
2012-2013	18,685
2013-2014	2,373

Source: *Traffic Department, BIWTA*

3.1.4 Inland container traffic

Growth of international sea-borne trade depends mainly on intermodal distribution of goods handled at maritime ports. The main maritime port of Chittagong shares almost 90% of sea borne trade is connected with Dhaka-Narayanganj area by these routes. Container traffic to and from Bangladesh is growing very fast. Of the total containers handled at Chittagong Port, 70% are destined for or originating from Dhaka-Narayanganj area. To meet the growing demand of container traffic, utilization of this corridor to full extent is inevitable. Railway suffers from capacity constraint and road does not have the bearing capacity to accommodate trailers. So, all the studies conducted recently recommended inland waterways to this end. An inland container terminal has already been developed at Pangaon, Dhaka by BIWTA. The most positive aspect in container traffic is that substantial interest of private sector has been manifested in development of infrastructure. At this moment, constructions of four river side container terminals in and around Dhaka-Narayanganj are nearing completion. As such, one of the main factors for revival of IWT in near future would be container traffic in this corridor. At the outset of sub-regional cooperation and understanding, these routes will also accommodate goods to and from the region beyond the border. To this end, construction of a multi-purpose inland container terminal under the Indian credit line is underway.

Projection of IWT container traffic by Pacific International, Japan

The Pacific International, Japan conducted Techno-Economic Feasibility for a Deep Sea Port in Bangladesh in 2009 wherein the following projection was included;

- 2020: 3.33 million TEU
- 2035: 8.52 million TEU
- 2055: 19.62 million TEU
- Modal split in IWT: 38%
- Vessel requirement: 55 in short term, 152 in mid term and 305 in long term.
- IICD requirement: 5 in short term, 10 mid term and 24 long term.

3.1.5 Need for maintenance dredging

Rivers in Bangladesh are deteriorating. Navigability is reducing and modal share of IWT in transport is declining. Road cannot meet growing transport demand resulting congestion, accidents and unmanageable maintenance of road. Even with rapid expansion, road will not be able to meet growing demand of trade and commerce.

Most of the recent studies on transport sector in Bangladesh recommended revival of IWT to meet growing demand. Bangladesh is proceeding gradually from lower middle income country to be an upper middle income country by 2021. To this end, facilitation of trade and commerce is. And for the growth and facilitation of trade an efficient multi-modal transport network is the main pre requisite. Only revival of IWT may ensure such efficient and cost effective network.

Being the main artery D-C corridor cannot demonstrate efficiency in terms of efficient navigation. Existing navigational quality does not ensure uninterrupted navigation. Vessels are to wait for high tide or to plan navigation adjusting time of high tide at different hot spots. In both cases, cost and time of transportation increase. Groundings of vessels and subsequent accident have become more frequent. Users lost confidence on IWT and looking for modal shift.

In view of the above, maintenance of waterways is inevitable. Smooth and sustainable navigability in D-C corridor and adjoining routes under study can ensure revival of IWT. Maintenance of fairways will ensure sufficient water at all seasons and more water in rivers will ensure better eco system.

3.2 Project Description

The Project will provide US\$360 million in IDA funds to finance interventions aimed at improving IWT for cargo and passengers along the heavily-trafficked Chittagong-Dhaka-Ashuganj river routes, and in so doing, stimulating traffic growth on the waterways and away from the already heavily congested roads along these routes. These fall under the jurisdiction of the Bangladesh Inland Water Transport Authority, a Government authority mandated to oversee sector development. Main interventions include: navigation channel maintenance and improvement; navigation safety improvements; the construction, rehabilitation, and modernization of select river terminals; development of River Information Systems; institutional capacity development; and, funding for research and development to enable continuing sector improvement and sustainability. This includes work on sector policies and strategies needed to: improve revenue collection and management; incentivize public and private sector investments especially related to container transport; and, mitigate and improve IWT's impact on the social and physical environment. The Project consists of three components as follows:

Component 1: Improved Inland Waterway Navigation (IDA financing: US\$235 million).

This component shall include work to guarantee advertised depths and widths of navigation channels on select river routes (Table 3-4). The work also includes provision of aids to navigation. The work is to be done on an Output- and Performance-based Contracting method designed to increase the efficiency and effectiveness of river asset management and maintenance. It is designed to ensure that the physical conditions of the rivers under contract are adequate for the need of river users, over the entire period of the contract which is six to seven years. This type of contract significantly expands the role of the private sector, from the simple execution of works to the management and conservation of river assets. This is a departure from the traditional river maintenance contracts used in Bangladesh which have been less-than-optimal. Even where works have been carried out according to plan, the nature of the rivers has meant that advertised depths, aids to navigation and other river infrastructure

do not last as long as they should because of deficiencies in the original design, aggravated by inadequate maintenance. The beneficiaries of the new concept are expected to be the river users. In a wider sense, future generations will be able to benefit from a better maintenance of past investments. River users will be able to know the Service Level they can expect in return for the payments they make for the use of the infrastructure (tolls, tariffs, user fees, taxes, etc.). The River Administration shall also benefit by obtaining better overall river conditions with reduced levels of expenditure.

Table 3-4: Route wise Dredging Length and corresponding dredging volume

Route No.	Channel width meter (no slope)	Dredging depth m	Dredging Length (Km)	Base Line Dredge Volume
1 & 2	76	-4.3	1.0	37,500
2 (South of chandpur)	76	-4.3	25	597,400
3 & 4	76	-4.3	4.6	22,600
5	76	-4.3	7.5	236,000
19	76	-2.8	1	25,100
20	76	-2.8	6	387,000
21	76	-2.8	2.2	392,300
22	76	-2.8	4.4	396,500
<i>Sub-Total</i>			50.7	2,094,400
7&8	76	-2.8	11.7	370,000
12	76	-2.8	0.7	152,800
13	76	-2.8	3.5	76,400
13a	76	-2.8	0.6	1,000
<i>Sub-Total</i>			16.5	600,200
9	30	-2.1	25	126,800
10	30	-2.1	3.9	33,274
15 & 16	30	-2.1	4.3	607,500
17	30	-2.1	1.6	500
<i>Sub-Total</i>			34.8	768,074
<i>TOTAL</i>			102	3,462,674.00

Also included in Component 1 is work to provide safe harbors (storm shelters) whereby users can seek shelter from stress of weather in the Meghna Delta area during tropical cyclones. The Bay of Bengal is responsible for the formation of some of the strongest and most destructive tropical cyclones in the world. Adverse wave conditions, heavy rainfall and associated storm surges from these cyclones are a major cause of loss of life and infrastructure damage in the maritime delta area. With projected climate change, these effects are likely to intensify in coming decades. It is intended that the storm shelters shall be constructed under the same Output and Performance-based Contractor, using dredged material as a resource. Among others, this component will finance the following activities: (i) bathymetric and other surveys to determine the extent and types of dredging required, river training, environmental protection or other works; (ii) visual aids for day and night navigation such as light buoys, radar beacons, leading lines and other aids; (iii) limited and selected performance-based dredging to guarantee Least Advertised Depth; and (iv)

development of six vessel shelters shown in Table 3-5, within cyclone prone areas along project routes equipped with mooring buoys to ensure safety for the vessels.

Table 3-5: List of proposed vessel shelter

River Name	Project Component
	Vessel Shelter
Upper Meghna	01 (Shatnal Nala), chandpur
Lower Meghna	02 (Char Bhairabi, Chandpur)
Ilisha	01 (Mehendiganj)
Open Sea	02 (Nolchira, Sarikait), sandwip

Component 2: Improved Services at Priority Inland Waterway Terminals and Landing Ghats/Stations (IDA financing: US\$75 million). This component supports the development of two cargo terminals, four passenger terminals and 14 landing ghats/stations (Table 3-6).

Table 3-6: Location of waterway terminal landing station and vessel shelter.

River Name	Project Component		
	Passenger Terminal	Cargo Terminal	Launch Ghat
Upper Meghna		01 (Ashuganj)	1(Bhairab)
Buriganga	01 (Shasanghat)	01 (Pangoan)	
Shitalakhya	01 (Narayanganj)		
Lower Meghna	01 (Chandpur)		02 (Alubazar, Horina, Moju Chowdhury)
Kirtonkhola	01 (Barisal)		
Ilisha			01 (Bhola)
East Shahbazpur			01 (Chairman ghat) near Bhola
West Shahbazpur			03 (Daulatkha near Bhola, Tojumuddin near Char Mozammel, Monpura)
Sandwip Island			01 (Sandwip)
Tentulia			03 (Hijla, Laharhat, Beduria)
Open Sea			01 (Tomuruddin), Bhola

The development of passenger and cargo terminals is within existing inland waterway port areas under the jurisdiction of BIWTA. It includes the modernization and extension of existing facilities to cater for increased demand. Terminals and landing stations are part of the network of about 448 river terminals, 374 landing stations, 23 coastal terminals and 25 pilot stations already provided by BIWTA. The passenger terminals and landing stations will specifically incorporate the needs of women users and less abled users, and all investments will address safety-related issues for all users. Specifically, this component will finance the following:

The cargo terminals include: (i) extension of the existing Pangaon Container Terminal with new general cargo vessel berths and land access infrastructure on the Buriganga river; and, (ii) rehabilitation and modernization of the existing general cargo terminal at Ashuganj including river bank erosion prevention, the replacement of pontoons, gangways and other

dilapidated marine structures, the extension of berthing space.

The passenger terminals include: (i) construction of a new passenger terminal at Shashanghat, downstream of the existing terminal at Sadarghat where landside congestion preclude the development of additional berths; (ii) rehabilitation works for the passenger terminal at Narayanganj; (iii) rehabilitation of works for the passenger terminal at Chandpur; and, (iv) extension of the existing passenger terminal at Barisal

Rehabilitation works or new construction of 14 landing stations or launch ghats under this Project are designed to provide access for rural communities, some of which in the lower Meghna delta have no alternative means of transport.

Component 3: Institutional Capacity Development and Sector Sustainability (IDA financing: US\$50 million). A series of activities are proposed that will support BIWTA's overall enhancement of its management systems and human resources capacity for modern, efficient, and high quality management of the IWT sector in line with international standards, and to help BIWTA achieve long-term operational and financial sustainability. In addition, to ensure the long term sustainability of project investments and to mainstream climate resilience and climate sensitivity across the organization, the project will support the establishment and initial capacity building of a permanent Environment and Social and Climate Change Unit (ESCCU) within BIWTA's permanent organogram. The safeguards Cell within the PIU will provide training to the permanent unit, and will integrate preparatory studies on climate change in the IWT sector, will be closely overseen by the new permanent Unit, with support from the PIU's Safeguards Cell as required.

Activities to be supported include: (i) the development of River Information Systems to help BIWTA improve data collection for the planning, maintenance and development of IWT, as well as enhance climate resiliency of the IWT sector in Bangladesh by creating a more systematized baseline understanding of river hydrology and navigational implications, and provision of a Automatic Identification System (AIS), Electronic Nautical Chart (ENC) for Traffic Monitoring System for passengers and cargo; (ii) improvement of Human Resources capacity for better management of the IWT sector through upgrading and modernizing the IWT Deck and Engine Personnel Training Centre (DEPTC) equipped with modern laboratory facilities into a regional IWT Training Center with open access to all users in the Region and the world, a provision for equipped of testing laboratory for multipurpose inspection vessels (iii) a project preparation facility to finance feasibility, surveys, design, study on climate change issue and safeguards studies for continuous sector development; and, (iv) support for the Project Implementation Unit of the project in terms of providing Training both local and foreign, exposure visit both local and foreign, conduct research and documentation, sharing learnings at different levels (national, regional and international).

3.2.1 Project Development Objectives

The Dhaka-Chittagong river corridor and stemming-out route connecting Barisal is the country's prime IWT route that carries around 80% traffic. On the one hand realizing its importance in the role of mass transport of the country, on the other hand reducing the pressure on the Dhaka-Chittagong road and rail transport, the government has set a priority of enhance and improve this Class I route and also to upgrade associated routes from Class II and III to Class I.

The project development objective, therefore, is to increase the capacity, reliability and safety of inland water transport in the said routes. Besides, importantly, the activities are intended to attract more private sector investment in IWT sector, and country boats and vessels in inland transport. However, these huge works shall be accomplished in two phases. In the first phase the earlier four will be dealt with. As approach of maintenance work, the project aims to pilot a new approach and that is - it will employ a performance-based contracting modality to carry out the works, and hence the contractor shall be engaged on a relatively long term period (proposed 6 years) and they will be paid based on satisfactory performance to be determined by continual maintenance of specified river depths.

The proposed activities may produce considerable environmental and social impact in the future. The project is to be financed by the World Bank and implemented by BIWTA, government of Bangladesh – both have environmental and social guidelines regarding impacts. With this end in view for the project components taken in the first phase, this Environmental Impact Assessment and Social Impact Assessment study are being carried out under a set of terms of references. The main object of the study as set out in the TOR is to accomplish comprehensive EIA and SIA. Among others, this EIA study shall prepare Environmental Management Plan (EMP) and Resettlement Policy Framework (RPF) in carrying out maintenance dredging work, spoil management along the routes, ferry crossings, and activities involving construction and maintenance of vessel shelters.

Expected output and outcome

Output of the project will be reflected a great increase of movement of passengers and goods in D-C corridor and adjoining routes under study. At the same time larger transport output in these routes will influence IWT output in other routes also.

As regard to passenger movement between Dhaka-Narayanganj area and the greater southern region, the Padma Bridge is considered to be the great threat. The Padma Bridge may not reduce the cost of transport by road to and from southern and other districts, but will certainly reduce transportation time substantially. And if, the state of navigation remains the same passenger movement in IWT will experience a sharp decline with the implementation of the Padma Bridge. But if the navigability improves with implementation of D-C corridor and other routes Project, IWT will remain competitive with road in terms of time and attractive in terms of cost. As such, IWT will contribute larger output in passenger-km. Unlike passenger movement, passenger movement in IWT has not any threats from competing modes of transport. Even with implementation of current projects road and rail will not be able to meet the growing demand of transport demand for freight movement. Rather, IWT has got considerable strengths and opportunities. Strengths are: natural advantage, linkage with India, choice of poor people in respect of cost, comparatively attractive for bulk and container traffic etc. While opportunities are: commitment of the Government to combat deteriorating rivers, environmental advantage in respect of carbon emission, dominating and growing private sector participation, development of river side container terminal, increased bilateral cooperation in respect of trans-boundary inland navigation. With the improvement of navigability, freshwater flow in the rivers will enhance/ facilitate the breeding and migration of fishes and other aquatic/ river biodiversity.

As maritime ports have no other alternatives but to depend on inland waterways for growing demand of international sea-borne trade, IWT in Bangladesh will experience increased output in ton-km in coming years. When container traffic by inland waterways will be unlocked, modal share of IWT will rise comparatively. It is expected that modal share of container traffic to and from Dhaka-Narayanganj area by river may grow up to 45% in a period of five years.

Outcome of the project will be demonstrated in decreasing steaming time and decreasing time for turn around. These will enable vessels to increase capacity utilization and increase profitability. If current navigational problems remove and draft accommodation capacity of routes increases, transportation time will be reduced and higher economy of scale will be achieved.

3.2.2 Project Plan and Design: Project River Routes and Ferry Crossing

This project comprises with distinct physical components. These are i) Improvement of navigability of Dhaka-Munshiganj-Gazaria-Chandpur-Chittagong River route, ii) Three associated river routes: Munshiganj-Demra-Ghorashal River route, Munshiganj-Ashuganj River route, and connecting routes (emerged from Dhaka-Chittagong route) approaching to Barisal, iii) Three ferry crossing routes (Chandpur-Shariatpur, Lakhmipur-Bhola and Beduaria-Laharhat), and iv) Six vessel shelters on the threat of cyclones and norwesterly at proposed locations along the routes. As physical interventions, capital and maintenance dredging at selected locations for the said river routes for the earlier three components have been planned, and construction of vessel shelters for the last one.

Dhaka-Chittagong river route is 280 km long in which the length from Dhaka to Munshiganj is 30 km and from Munshiganj to Chittagong is 250 km. According to BIWTA route classification, the entire route is classified as Class I. Ghorashal extension route is 57 km long that contains River Class I and III (Ghorashal-Demra section is of Class III that is, under this project, planned to be upgraded to Class I). Ashuganj extension route is 244 km long that contains river routes of Class I, II, III (Narshindi loop and Bancharampur loop). Barisal extension is 222 km long which is under River Class I (approach to Aat Hazar via Illisha in the Meghna River, and Aat Hazar to Jhalokathi in Bishkhali river), Class II (approach to Aat Hazar via Hijla), Class III (approach to Aat Hazar via Muladi). Bangladesh is crisscrossed by rivers which necessitate construction of bridges over the rivers to ensure uninterrupted transportation. Almost a dozen of bridges have been constructed over important rivers but still there are rivers flowing between road-heads and road vehicles have to depend on ferry vessels to cross the rivers. Three ferry crossing routes are taken under the project for obstacle-free movement. They are crossing between Harina (on the left bank of Meghna river under Chandpur) and Alu Bazaar (under Shariatpur) across the Meghna River, between Maju Chowdhury's Hat (under Lakshmipur) and Illisha Launch Ghat (Bhola) across the Meghna River, and between Beduria (Bhola) and Lahar Hat Launch Ghat (Barisal) across the Tentulia River. BIWTA have been carrying out survey work for the purpose of this project. For all river routes and ferry crossings, therefore, locations of dredging in the river sections, its alignment, extent, depth of dredging, estimation of volume, and probable spoil management would be determined basing on the survey results. Dredging works along the main routes, three associated routes, across three crossings are broken into 18 work-items with two priorities – primary and secondary. Of them, the Dhaka-Chittagong main route, the

Ghorashal-Demra route, the Demra-Munshiganj route, the Ashuganj-Munshiganj route, the approaching routes to AatHazar via Muladi, via Hijla. Via Illisha, and three ferry routes will get primary importance in survey and subsequent maintenance dredging. Initially BIWTA selected six locations generally with a view to developing safe vessel shelter facilities at Shatnol (under Matlab North Upazila), Amirabad (under Chandpur), Chandpur, Patarhat (under Mehendiganj upazila), Hatiya, and Sandwip. BIWTA is now actively considering the process of their development - their distribution along the main route, types of shelter, their detailed planning and design. The authority will get contributory input to this developing process towards finalization from the current EIA study so that the benefits of the proposed shelters are optimized from safe sheltering point of view.

There is no duplication of dredging with any of the other projects. Some rivers (Chalar Char-Baliakandi-Kashiyani River Route) have been excluded from the existing dredging project to avoid duplication (see **Annex Q**: Ministry of Shipping Meeting Minutes of 06 June 2017).

3.2.3 Proposed Interventions

Required Draught

Indicated draught for the Class I navigation route is 3.6 m (BIWTA Master Plan, 1989). About 26 years has been elapsed after establishing the draught of 3.6m. Vessel with higher depth may have been introduced over this time. In view of this and to be in the safer side, required depth in the route could be maintained with 4.5 m.

Estimated Dredge Volume

Not all the paths along the navigation route will undergo dredging works. Only river/channel sections that contain areas of shallow depths, obstacles by bars, constrictions etc. shall be taken into consideration for dredging. However, actual location, extent, depth etc. will be determined after analyzing survey data. Total navigation route is 838 km however, dredging length should not be more than 102 km (Table 3-9). Total dredging volume along this dredging length is therefore 3.46 Mm³. Considering 50% resiltation rate volume of maiintenance dredging is 5.20 Mm³.

Dredging intervention [as obtained from BIWTA]

Engineers responsible for navigation dredging in BIWTA were consulted for determining locations for dredging intervention in D-C corridor and adjoining routes under study. They do not have any updated survey nor any data for dredging interventions. However they shared and indicated some locations and indicative area of shoals. Such indications may be seen in

Table 3-7.

Table 3-7: Locations of dredging at submerged chars and shoals Source: BIWTA

Route /(River)	Number of shoal	Area of shoal
Laharhat-Bheduria (Tetulia)	3	1. Bheduria Ferry Ghat (1800m×35) 2. Sripur (700m×35m) 3. Laharhat channel (1500 m × 35 m)
Bhola- Lakshmipur (Lower Meghna)	2	1. Ilisha Ferry Ghat (1500m×35m) 2. Moju Choudhurir Hat (2000×35)
Harina-Alu Bazaar Ferry route (Meghna)	3	1. Alu Bazaar Ferry Ghat (1000m×70m) 2. Lakhsмир Char (1000m×70m) 3. Confluence of Meghna and Lakhsмир Channel (1000m×70m)
Chandpur-Barisal (Meghna,	10	1. Miarchar (1000m×70M) 2. Bhasanchar

Route /(River)	Number of shoal	Area of shoal
Kalabadar)		(1500m×70m) 3.Jalalpur (1500m×70m) 4.Char Bhairabi (700m×70m) 5. Tengramari (1200m×70m) 6. Charnainda (500m×70m) 7. Char Bogadia (500m×70m) 8. Bamnirchar (1500m×70m) 9. Pirerbari (500m×70m) 10. Sheora (600mx70M)
Barisal Port Area (Kirtan Kola)	1	Port basin (1000m×100m)
Hatiya-Sandwip (Meghna estuary)	1	Char Nurul Islam (6000m×70m)

There is no duplication of dredging work under the present project. Initially Dhaka-Chittagong and Chandpur-Barisal routes of the present project were included in “Twenty four river route project” of BIWTA. BIWTA excluded these two river routes from twenty four river route project in a meeting in the shipping ministry held on 24th June 2017 (**Annex Q; review meeting of Planning Commission dated 01/11/2016**).

BIWTA also change the name of Project named "Mongla and Chittaging to Pakshi" to "Mongla Port via Chandpur-Mawa-Goaland to Pakshi river route navigation improvement" to avoid the duplication of Dredging work in the present project. This decision was taken in a meeting in the shipping industry which was held on 20th June 2017 (**Annex Q**)

Table 3-8: Past Present and Future dredging volume estimated by BIWTA

Programs	Volume of Dredging (million m ³)
2017-18	
Developmemnt dredging	21.18
Maintenance dredging	13.49
2018-19	
Developmemnt dredging	12.49 (up to Feb, 2019)
Maintenance dredging	11.02 (up tom Feb, 2019)

Source: BIWTA

The annual estimated dredging volume of the project routes is in the range of 6-7 million m³. Analysis of bathymetric chart of 2015 shows there is a need of dredging in the navigation routes under this project.

The dredging volume in the different rivers under the present project is presented in the Table 3-9.

Table 3-9: Estimated dredging volume based on present bathymetric survey the navigation routes under the present D-C Corridor project

Route No.	Priority	Route Class	Channel width meter (no slope)	Dredging depth m	Dredging Length (Km)	Base Line Dredge Volume	Potential Annual Volume with 50% re-sediment rate	Potential Contractor Split (By Geographical Area)
1 & 2	A	1	76	-4.3	1.0	37,500	56,250.00	PBC-1
2 (South of chandpur)	A	1	76	-4.3	25	597,400	896,100.00	PBC-2
3 & 4	A	1	76	-4.3	4.6	22,600	33,900.00	PBC-1
5	A	1	76	-4.3	7.5	236,000	354,000.00	PBC-1
19	A	2	76	-2.8	1	25,100	37,650.00	PBC-1
20	A	2	76	-2.8	6	387,000	580,500.00	PBC-2
21	A	2	76	-2.8	2.2	392,300	588,450.00	PBC-2
22	A	2	76	-2.8	4.4	396,500	594,750.00	PBC-2
Sub-Total					50.70	2,094,400.00	3,141,600.00	
7&8	B	2	76	-2.8	11.7	370,000	555,000.00	PBC-1
12	B	2	76	-2.8	0.7	152,800	229,200.00	PBC-1
13	B	2	76	-2.8	3.5	76,400	114,600.00	PBC-2
13a	B	2	76	-2.8	0.6	1,000	1,500.00	PBC-2
Sub-Total					16.5	600,200	900,300	
9	C	3	30	-2.1	25	126,800	190,200	PBC-1
10	C	3	30	-2.1	3.9	33,274	49,911	PBC-1
15 & 16	C	3	30	-2.1	4.3	607,500	911,250	PBC-2
17	C	3	30	-2.1	1.6	500	750	PBC-2
Sub-Total					34.8	768074	1152111	
TOTAL					102.00	3,462,674.00	5,194,011.00	

Note: Volume calculations estimated using BIWTA Multi Beam and Single Beam bathymetric data, Global Mapper software.



Locations of Vessel Shelters

Initially 6 locations were selected by BIWTA for vessel shelters, and they are broadly at, in the sequence from upstream to downstream, Shatnol, Amirabad, Chandpur, Mehendiganj, Sarikait in Sandwip, and Nolchira in Hatiya. The same selection but with a little variation is found on typical plan-layout of vessel shelter. They are Shatnol Nala (branch of the Meghna River), Amirabad Nala (the Meghna River), Dakatia River, Kaliganj, Hatiya, Sandwip. Members of the study team (Syed Monowar Hossain and M. A. S. Sikder) held discussion meeting on distributing the shelters and selecting the location. The meeting decided to implement a shelter on Majer Char (opposite of Char Bhairobee in Haimchar Upazila) on the reason that Amirabad is close to Chandpur, on the other hand, if at Amirabad, no sheltering provision do exist between Mehendiganj/Hijla and Chandpur where the section of the Meghna river is much stronger, wider, more exposed to cyclone, more significantly all passenger vessels from southern Bengal passes through this. The said members paid field visits with the company of BIWTA concerned officials at Shatnol, Chandpur, some places of river section between Shatnol and Chandpur, Barisal, Mehendiganj and river network around them for the purpose of selecting locations at Shatnol, Chandpur and Mehendiganj. BIWTA extended all out cooperation in every part of the visits. During the visits they discussed with a number of Class I Masters of large passenger launch plying between Dhaka and Barisal, field personnel of Conservancy and Pilotage of BIWTA, local people, and held meetings with BIWTA officials of Chandpur and Barisal, also held meetings with some owners of passenger-vessels of Dhaka-Barisal navigation route and of other routes.

Shatnol as shelter location. Shatnol Nala (a branch of the Meghna River) can deserve to be vessel shelter location. In comparison to choosing other point at Shatnol, the Nala can be a better candidate since being a natural channel it can serve a natural harbouring, hence saving money and effort in its development as a safe vessel shelter. Shatnol as a location has many strategic importance. Firstly, it is hub for vessels coming down from Buriganga, Dhaleswari, Shitalakhya, Meghna and Gomti. Secondly, with respect time, many passenger vessels set for in the afternoon and reach Gazaria, Shatnol at late afternoon or at dusk. In norwesterly season there are chances of being caught by nor-westerly. In a short time the apprehending the potential danger can take shelter here at Shatnol vessel shelter. Thirdly, everyday huge numbers of passengers arrive here from Dhaka and other upstream locations by IWT and change their mode of transport by taking standard and non-standard road transport in reaching their destinations in Matlab, Chandpur, and adjoining area. They prefer such journey in saving their time.

Location of shelter at Chandpur. A bend area relatively shallow just upstream of the present ad-hoc Madrasa Ghat terminal on the left bank of the Meghna River could be selected/ used as vessel shelter. There is an attempt by the government in developing and constructing a new port and terminal with sufficient facilities. Henceforth, the harbor can get the support of these port facilities. Again, Chandpur can enjoy additional facilities of existing new terminal on the right bank of the Dakatia River. This terminal appears to be in a good condition.

Note: Historically the river port for Chandpur was located inside the Dakatia River on the right bank near the railway station. This old port had fallen under severe attack and the most part of the facilities were engulfed by the river around 2002. Therefore, a new port was constructed afterwards a little upstream of the old terminal. Besides, at the same time another ad-hoc terminal was developed at Madrasa Ghat on the left bank of the Meghna River. The said new terminal on the Dakatia River was on usual operation except a few monsoon months (around July to September). During these monsoon months, until 2013, Madrasa Ghat terminal was used. However, the entire operation around the year was brought to the Madrasa Ghat terminal from 2014. Hence, existing terminal on the Dakatia River is no longer used. Again, however, it has very limited use by local small vessels. Also, this terminal is used by idle vessels to stay over and a kind of sheltering purposes.

Location around Hijla Bazaar. In the attempt of selecting a point of location for safe vessel shelter between Majer Char and Barisal port, a point of location either adjacent to Hijla Bazaar or between Hijla Bazaar and northwest corner of Miar Char on the right channel of Miar Char (while going to Barisal) should be selected. Patarhat should not be the proper location since this is not the route of Majority of the vessels plying from southern Bengal towards Dhaka. Kaliganj should not deserve to be the candidate since it is out right on the Meghna River, entirely exposed to the Meghna River, channel remains very rough, bank has been retreating at an alarming rate. Mallikpur or nearby location should not be selected since it is nearby the Meghna River proper (so exposed to hazard). Moreover, importantly, vessels to-and-from Barisal/Bhola/Patuakhali/Barguna usually do not follow this path unless depth problem compels the driver to pass by Mallikpur. Vessels like to follow the river-path on the right side of the Miar Char (while going Barisal) past Dhulkhali Launch Ghat. Following Mallikpur route than Miar Char route do incur around half-an-hour time more in reaching Barisal. Miar Char channel needs to be dredged and can be given high priority among the dredging works in this project. Near Hijla Bazaar is situated at a natural meeting point of four big channels, upazila is very nearby. There is an existing launch ghat. If Miar Char Channel is dredged, most vessels towards southern Bengal will pass by the Hijla Bazaar. Therefore, as a location nearby Hijla Bazaar should be the better option. This shelter can give multiple facilities i.e., by setting better landing facilities the place can be used as significant traffic transfer point. At the same time, the navigation people, passenger will get facilities of a upazila level location.

Location in Hatiya. Nolchira is selected by BIWTA as a location for vessel shelter at Hatiya. It is at the middle position of the north side of Hatiya.

Location in Sandwip. Sarikait is selected by BIWTA as a location for vessel shelter at Sandwip. It is located on the south-west side of Sandwip.

The locations of required dredging along the routes are presented in the Figure 3.1 and the locations of vessel shelters are shown in the Figure 3-2

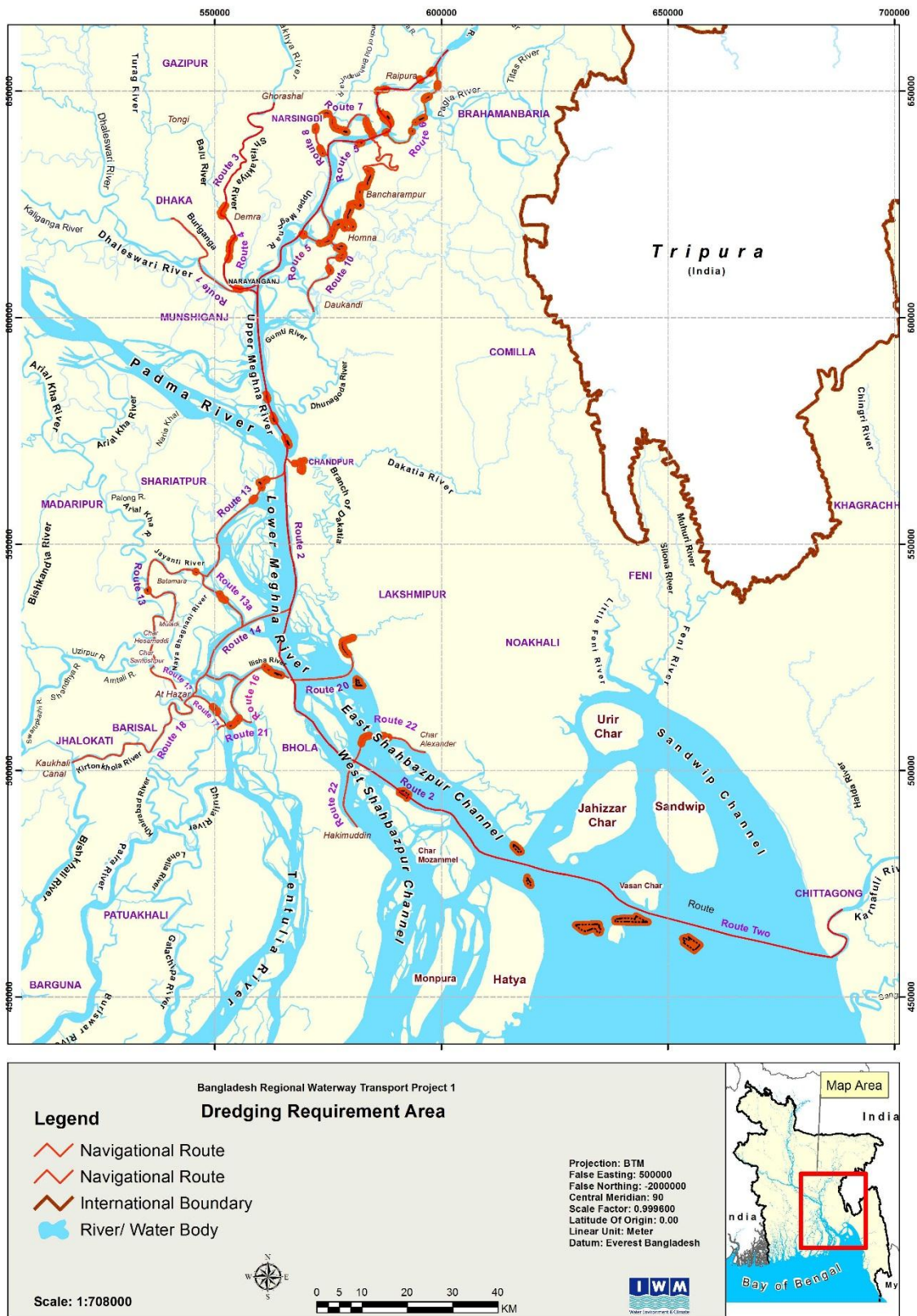


Figure 3-2: The locations of required dredging along the routes and vessel shelter Map not showing the point of vessel shelters.

Conceptual Design of Vessel Shelters

Under this project new vessel shelters will be established for the safety of vessel and passengers. In some sense it would, therefore, be interesting and challenging for BIWTA and concerned parties with respect to their development and construction. Towards objectives of real time risk mitigation and management for vessels plying through the routes under his project, a number of important issues/realities and considerations should be taken into account (but not limited to these only):

- The largest navigational route in terms of width, depth, current speed, involving coastal water, degree of exposure to southern wind, norwesterly, and cyclonic wind and surge
- Prime navigational route in terms of traffic volume, both passenger and freight, number of vessels, size of vessels, frequency of to-and-fro communications
- Design hazard/critical hazard: which one – nor-westerly or cyclone play role more in endangering the vessels. This should be the most important considerations, since observations on the past fatal disasters indicate that most major accidents occurred around Munshiganj, Gazaria, Shatnol, due to norwesterly.
- Direction and speed of wind
- Since question of saving of vessels, hence the traffic, as a type a kind of harbouring facilities must be there
- Inside harbour, point of across-berthing/anchoring or alongside berthing/anchoring. The final objective for an endangered vessel would be to stay along in an optimum alignment so that the vessel gets most stability and least wind thrust
- It is known that berthing/anchoring with a pantoon not actually safe since vessel may be destroyed, broken by repeated collision
- berthing/anchoring with a hardened bank by block-revetment or boulder work seems to be not safe at all, since vessel may be destroyed, damaged, broken by repeated collision
- Keeping safer distance apart from one vessel to another
- Most importantly, all 6 vessel shelters should not be in the form of same planning and design (type, size, components etc.), location specific criteria (orientation with river, chance of degree of danger, level of exposure, size of vessel) must be considered
- Open end or dead end. If designed newly a dead end harbouring facility can be designed depending on the physical orientation of the land and water situation around. However, any existing nala or branch of a river is selected where both ends are open. It is suggested to use natural channels/canals/branches wherever possible.
- Convenient approach channel to the vessel shelter, ample clearance in the rear-side for maneuvering so that other vessels already in the harbour do not get hampered, damaged
- Size of a shelter. As mentioned above, shelter might be variable in size. It has to be taken mind that as time passes bigger vessels are introduced than the previous ones. For example,

Parabat 9 is now the longest passenger ship having length of around 95 m. Size should be such that at least 10 vessels of various sizes can take shelter at the time of danger.

- Fencing by thick tree planting. Encirclement of vessel shelter by planting such variety of trees that grow with thick bushes, firm roots, can also withstand against cyclone winds
- Road connection, where there is potential for transfer of passengers i.e., where possibility of multiple use
- In case of shelter at Chandpur, natural water-body near the left bank immediately upstream of present Madrasa ghat BIWTA terminal can be used as shelter, so constructing a separate additional harbour may not be necessary. But the area needs to be so improved that impart sufficient safe harbouring/ sheltering facilities.
- Multiple facilities. More facilities, where possible, apart from sheltering can be planned and designed so that the facilities of sheltering can be utilized during normal time. Such as, where there is traffic potential, a reasonable pontoon and other facilities can be developed so multiple benefits can be obtained.

Typical Plan for Shelter by BIWTA

A layout vessel shelter titled ‘Typical plan for shelter at different station’ is available with BIWTA having trapezoidal dimensions in which the length of parallel sides are 170m (landside) and 230 m respectively, and the length of two other lateral sides are 300m with two pontoons facilities, each with size of 30m×10m (Figure 3-3). A breakwater system is planned of 75m long in the middle of the entry of the sheltering water-area, with two opening of 77.5 m on either side of the rubber float/breakwater. Pontoon is planned with the objective of multiple/additional use of the facilities during normal time. As planned, the requirements are (as seen in the layout plan): land acquisition, excavation/dredging for navigation and basin, slope/bank protection, berthing facilities (spur, ram, gangway, pontoon), mooring facilities, breakwater system, approach road, attendant room, external and internal electric supply, water supply, water forecasting

It is to be noted that a couple of obvious weaknesses are:

- a unique design must not serve the purpose of all location
- orientation for a vessel with respect to shelter of entering, turning, staying, exiting etc. not clear
- a kind of traffic control/SOS facility is missing that appears to be essential, since still most of the vessels lack of such modern communication facilities.

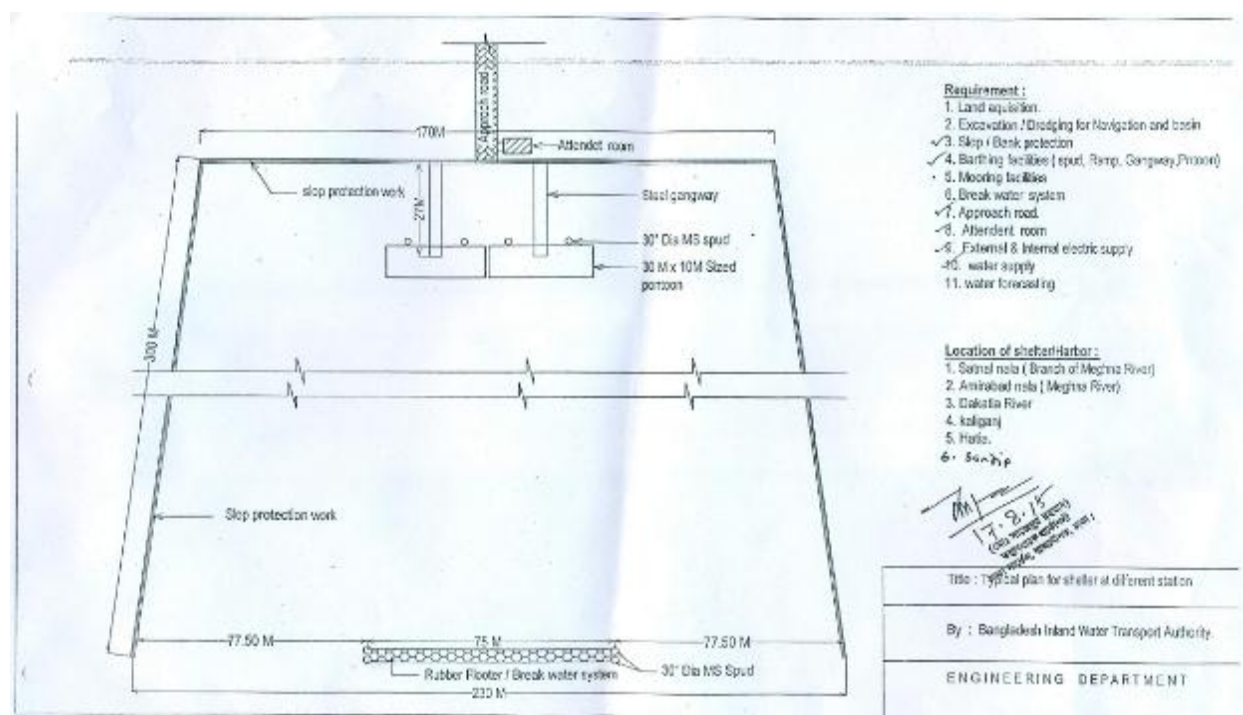


Figure 3-3: Typical layout-plan for shelter at different station by BIWTA

3.3 Implementation Methodology

3.3.1 Contracting Modality, Sequence of Construction

Contracting Modality

Basic Considerations on Modality of Contract for Maintenance Dredging

Performance-based contract. In contrast to traditional ‘waterfall’ approach, the contract mode should be performance-based, because it is a result-achieving contracting means that procurement organization definitely seeks in order to improve performance and lower the project cost.

Experience and resourcefulness of a contractor. In the effort of enlisting of dredging contractor attention and importance must be given to, among others, two principal qualities – experience and resourcefulness. Apart from enlistment of contractor, these criteria must be sought in preparation of bidding documents so that fit ones are screened in.

Experience with large alluvial rivers and coastal areas. In examining past dredging experience of a contractor, experience with large alluvial rivers where the river reach is very dynamic and sediment load and dynamics are huge and random.

Tenure of initial contract. Obviously, a huge endeavour and investment for a dredging company/contractor are involved in mobilization of resources and actual operations, as such tenure must be sufficient enough so that it should attract experienced and resourceful

contractor. In the D-C corridor project, initial contract for the performance-based dredging it is suggestive that the tenure be of 5 (five) years.

Possibility of extension. If performed well with desired standard and BIWTA does require more services, the contract can be extended or revised on a yearly basis meaning from a year to another.

Multiple fitness criteria in bidding process. The bidding system must include two separate bids 'Technical Bid' and 'Financial Bid'. Selection system should be such that a contractor has to pass through both of them. However, due weight must be given to technical resourcefulness in terms of qualified and experienced personnel, modern machineries and equipments, and sharp management.

Reach-wise/ route-wise contract. Not as a whole, contract and bidding can be made river reach-wise/ route-wise so as to create a competitive environment in participating dredging contract and practical dredging operations.

Mentioning appropriate time and duration of dredging work. Appropriate time of dredging work should involve such time in a year when rivers and estuaries lie on a considerably low stage.

Sequence of Activities involved in maintenance of navigation channel

- Since all the routes-along the river will not be dredged nor will a whole wide cross-section undergo as part of maintenance dredging, in the first instance, therefore, current and potential navigation channels/routes should carefully be indentified giving necessary wit. A morphologist can play a role.
- Then, depending on the routes draft requirements should be considered, identified.
- Then, when water recedes considerably, at the start of dry season or during dry season, for the purpose of coarse estimation of horizontal extent of dredging need, all sorts of obstacles – constrictions, inadequacy of navigation width, shoals, semi-submerged, submerged bars and islands should be identified. Concerned personnel in Conservancy and Pilotage Department (CPD) of BIWTA can play an important role here. They can provide suggestions-input into Hydrographic and Dredging Department of BIWTA. Also, when dredging is done by external agency (by outside consultants, and contractor), they can advise that agency with their regular experiences. Some types of identification marker can be put to demonstrate this 'coarse extent of dredging need'.
- Then, during a suitable time (dry period, avoiding monsoon and high stage, it is a matter of practical judgement), detailed survey work can be carried out over river reaches in which extent of dredging need already identified. Survey endeavour also be carried out over some shallow river reaches where there may be potential problems.
- Then, a survey data have to be analysed and results shall be made available.
- Then, hence final dredging locations, extent, depth, volume of dredging shall be quantified. Accordingly, a clear and practically useful dredging map shall be made available. This map shall guide the dredging work in the field.

- In parallel, along the routes, spoil management – whether rainbowing into the flowing water or transporting onto bank. When decision is made such that spoil should be placed on the land over bank, then a dumping and distribution plan have to be clearly chalked out. Also, a further use of spoil a plan can be made. This spoil management plan can go with the dredging map. Hence, both can work together. In this D-C corridor, it is suggestive that spoil should be dumped overbank instead of rainbowing into water.

Some important issues for effective dredging as follows:

In order to make the dredging endeavour practically effective, dredging operations shall be carried out in dry season when river-water stage is considerably low.

- Until next season of dredging is arrived, some form of monitoring and feedback can be sought from concerned CPD personnel at BIWTA and the practical users – masters, owners of vessels in the corridor and adjoining routes.
- Then, these feedbacks shall be brought into the considerations in order for preparing dredging-plan and activities. Again, steps as mentioned above should be followed.
- Selection of types of dredger which will be suitable for the D-C corridor project shall depend on, among others, the location of dredging, efficiency of dredger, spoil management plan etc., **Section 3.3.2** can be referred to.

Introduction of Performance Based Contract for Maintenance

In traditional contracting approach and methods, contracting focuses more on aspects of mile stone reporting, how works are done, completion of work steps in order to get certificate of completion and get payments from the procurement/contracting organization. The main disadvantage of this method of contract is that the target of the contractor is to completion of work and not achieving the real goals and objectives of the project for which the contractor was called for. In contrast to the traditional contracting method, contracting body should rather prefer performance based contract that is a practical action oriented contracting method which aims at quantity of outputs and quality that tie at least contractor's payment, contract extension, renewal etc. to the achievements of set objectives through measureable standard of performance. The check words in distinguishing the performance based contract modality from traditional ones are '*what work/output is to be achieved*' not '*how it is to be completed*'.

In developing a performance based contract it is necessary to develop a set of specifications. There are two tools to develop such specifications which are then used in performance checking. They are Performance Work Statement (PWS) and Statement of Objectives (SOO). Performance Work Statement should include the following:

- Description of works in terms of targeted results, not the way it is to be done or mentioning working hours. For example, in D-C corridor project it is to achieve assured targeted navigation depth 4.5 m.
- Setting measureable standard for performance which will enable to assess the actual work.
- Sticking to the set standard of performance and financial incentives so that can create a congenial and competitive environment for the contractors. As a result, contractors will get encouraged to develop innovative and cost-effective ways.

Such contract mode should have the following aspects: developing measure of performance, identifying incentives and disincentives, choosing the right contractor, managing performance. In developing standards of measureable performance, the following should be remembered:

- the standard shall be set on quantitative output, quality, timeliness
- care must be taken so that un-necessary overburden is created
- Looking at an optimality of cost – not so high which creates burden on the government/contracting organization, not so low that hinders quality of work and becomes disincentives to the contractor.

Selecting a right contractor is very important element in the entire contracting process. Without getting an experienced and resourceful contractor quality work cannot surely be expected. Therefore, selection should be on qualifications and experiences and the process should be such congenial and fair so that good ones can come forward and compete. Also point of due diligence – qualified bidders might be invited for a period of due diligence. Arrangements can be made for site visits, meetings, supplying required data and information so that they can be competitive in tailoring client's need.

Managing performance is another important aspect of the contract and work process. There should be a guide that helps both parties in progressing and managing the work load and performance of work. Usually, mainly management of contract performance is guided by the terms and conditions set out in the contract and, importantly, the relationship between the contractor and the contracting authority.

In a word, in order to improve performance to ultimately get the desired results and lower the cost of the project, a performance based maintenance contract should have such features as: describing the required results, setting the measurable performance standards, quality assurance plan for evaluating contractor's performance, and use of incentives – both positive and negative. It is suggestive that this D-C corridor project shall consider these aspects of performance based contract for maintenance dredging.

3.3.2 Dredging

Dredging Technologies and Potential types of dredger

Dredging is the process of dislodging, raising, handling and transporting mainly soil underwater from layers of the earth in order to create/maintain artificial depths. The dredging process when applied to construction of harbours and trenches for foundations/pipelines is called 'Capital Dredging'. However when applied for removal of siltation in existing harbours, rivers and clearance of siltation in lakes etc. is termed as 'Maintenance Dredging'. The dredging process can be split up into the following four sub systems:-

- Pre-treatment
- Excavation
- Transportation and
- Disposal

The pre-treatment consists of treating the ground surface before the excavation process. This is mainly required for dredging of rock and similar hard materials in order to fragment/loosen the same either mechanically or by use of explosives.

The excavation process is a combination of two operations, namely, disintegration and movement of soil. The disintegration of soil can be performed either mechanically or hydraulically.

The transportation process involves the movement of the dredged material from dredging site to disposal site. For transportation four systems are normally adopted, namely, self contained hopper, self-propelled barge and pipelines. In case of self-contained hopper, self-propelled and dumb barges, the material is released from the hopper into water either by bottom opening doors, valves or sliding doors. In some dredgers, pumps are used for employing the material from the hopper through a separate pipeline. The selection of method of transportation depends upon the distance between the dredging and disposal site. The dredgers are classified into the following categories:

- Mechanical dredgers
- Hydraulic dredgers
- Pneumatic dredgers
- Special dredging equipments

The types of the dredgers mentioned above mainly differ in method of dislodging the soil.

Mechanical Dredger

The mechanical dredgers use mechanical means for dislodging the soil, the examples of this type of dredger are grab dredgers, dipper dredger, bucket dredger, rock breaker and back hoe dredger. The salient features of these types of dredgers are as under:

Grab Dredger

These are the most common types of dredger. This type of dredger consists of a slewing type of crane fitted with grab and mounted on a pontoon or self propelled hopper barge. Upto 4 grab cranes can be conveniently installed on a dredger. This type of dredger can be used with almost all types of soil and is ideally suited for working in confined areas such as docks, alongside berths etc. The capacity of grab type of dredger is normally rated by their bucket capacities which vary from 1 cum to 35 cum and the output depends upon the number of cycles that could be achieved and varies from 300 to 400 cum per hour. The limits of operation of grab type pontoon/hopper type dredgers are provided in Table 3-10.

Table 3-10: Operational Limit of Grab type pontoon/hopper

	Grab Pontoon Dredger	Grab Hopper Dredger
Minimum water depth to operate	1m	3m
Maximum water depth to operate	50m (Extendable)	45m (extendable)
Wave height	2 m	2 m
Maximum cross current	1.5 knots	1.5 knots
Minimum Turning circle	--	75 m
Maximum Shear strength(clays)	300 KPa	100 Kpa
Maximum Compressive strength	1 MPa	--

Dipper Dredger

The dipper dredger is basically a power shovel operating from a pontoon/barge. The bucket is attached to the extremity of a hinged right arm and a forward leading hoist wire supplies the digging power. Since large horizontal forces have to be applied to the ground by the bucket, it is necessary for pontoon to have positioning spuds to prevent transfer of force to anchor wires. Dipper dredgers are ideal for dredging of hard material such as blasted rock, weak rocks, stiff clays, boulder clays etc. The output of dipper dredgers is about 200 cum per hour. The limiting operational conditions for this type of dredger are as under:

Minimum water depth to operate	=	3.5 m
Maximum water depth to operate	=	20 m
Maximum width of cut	=	30 m
Minimum width of cut	=	Bucket width
Maximum wave height	=	1.5 m
Maximum swell height	=	1.0 m
Maximum cross current	=	2.5 knots
Maximum Compressive strength (intact rock)	=	12 Mpa

Bucket Dredgers

In this type of dredger, the dredging action is achieved by a continuous chain of buckets which scoop material from the seabed and raise it above water. The buckets are inverted as they pass over the top tumbler and discharge under gravity onto chutes which convey the dredged material to barge alongside. The heavy bucket chain is supported by a fabricated steel ladder and driven electrically or hydraulically via the top tumbler. The ladder is mounted on the centerline of a pontoon, which is positioned and moved by a pattern of five or six winches. The bucket capacities of the dredger varies from 150 to 1200 litres and bucket speeds upto 30 m/min. and output varies from 250 to 1000 cum/hr. The advantage of this type of dredger is continuous dredging process without significant dilution of the dredged material which facilitate high load factors in the barges without excessive over spilling and uniform dredged level with good control of depths.

The main disadvantage of this type of dredger are low efficiency when required to remove only a small depth of material and the sticky cohesive material, higher noise level etc. The limiting operational conditions for the bucket dredger are as under:

Minimum water depth to operate	=	5.0 m
Maximum water depth to operate	=	35 m
Maximum cut width (single pass)	=	150 m
Maximum Wave height	=	1.5 m
Maximum Swell	=	1.0 m
Maximum cross current	=	2.0 knots
Maximum particle size	=	1500 mm
Maximum compressive strength (intact rock)	=	10 Mpa

Back-hoe Dredger

This dredger is basically a backhoe excavating machine mounted on the pontoon. Back hoes are powered by line pull or direct hydraulic linkage. The outer arm of the backhoe has cutting edges and the teeth are fitted to increase the point pressure on the material to be dug. This type of dredger is ideal for dredging of stiff clays, weak rocks, blasted rocks etc. The back hoe dredgers are normally rated according to the maximum size of digging bucket that machine can handle. The capacities of the bucket range from 1 to 20 cum. The output of this type of dredger varies from 100 to 400 cum/hour. The limiting operational conditions for this type of dredger are as under:

Minimum depth of water to operate	=	2 m
Maximum depth of water to operate	=	24 m
Maximum width of cut	=	25 m
Minimum width of cut	=	Bucket width
Maximum wave height	=	1.5 m
Maximum swell height	=	1.0 m
Maximum cross current	=	2.0 knots

Maximum compressive strength (intact rocks) = 10 Mpa

Rock Breaker

The rock breaker consists of a heavy pointed chisel (upto 30 t) having cast steel point mounted on a pontoon. The chisel can be hoisted and dropped vertically on the rock to be broken. Modern rock breakers have pneumatic or hydraulic hammers, which break rock with a frequency of 1.2 to 2 blows per second. The average output of a 15 t chisel is 8 to 12 cum/hr.

HYDRAULIC DREDGERS

The hydraulic dredgers employ hydraulic techniques such as suction, jetting etc. for dislodging the soil particles and then drawing up by a centrifugal pump. The various types of hydraulic dredgers being used worldwide are as under:

- Plain Suction Dredger
- Cutter Suction Dredger
- Trailer Suction Dredger
- Water Injection Dredger

The salient features of the above mentioned dredgers are given in following paragraphs.

Plain Suction Dredger

These types of dredgers are equipped with a centrifugal pump for raising the mixture of water and soil to deliver material into the transport system. This type of dredger is suitable for loose type of material. The output of such type of dredgers is limited. To improve the output of these types of dredgers special types of suction head or cutter or jets are mounted and advanced type of dredgers such as trailer suction dredgers, cutter suction dredgers have been developed.

Trailing Hopper Suction Dredgers

The trailing hopper suction dredger is essentially a self propelled, self loading and self-discharging sea going vessel with one or more flexible suction pipes equipped with special suction heads i.e. this type of dredgers have ability to dislodge the material to be dredged, suck in and discharge into the hopper contained in its body while moving ahead. Most trailing suction dredgers have twin screw propulsion and a powerful bow thruster, which provide a degree of manoeuvrability. Unloading is normally by means of a bottom-discharge arrangement or by pump discharge. The main advantages and disadvantages of the trailing suction dredger are as under:

Advantages

- Relative immunity to weather and sea conditions
- Independent operation
- Minimal effect on other shipping
- Ability to transport dredge material over long distances
- Relatively high rate of production
- Simple and hence inexpensive, mobilisation procedure

Disadvantages

- Inability to dredge strong materials
- Inability to work in very restricted areas
- Sensitivity to concentration of debris
- Dilution of dredged materials during the loading process

The trailer dredgers are normally rated according to its maximum hopper capacity which is typically 750 to 10000 cum, but exceptionally may be larger.

The maximum depth to which dredging is possible is limited by the vacuum head generated by the dredge pump. If the dredge pump is mounted within the hull the maximum economical dredging depth of a medium size trailer dredger is about 30 m, although for some larger dredgers, dredging depths of upto 80 m may be possible with reduced dredging rates.

The hopper is loaded by pumping soil water mixture and using the hopper as sand trap allowing the suspended solid to settle and water to flow through over arrangements provided in the dredger. The loading time for hopper dredger depends upon the characteristic of the soil dredged. In case of fine grained soil such as very fine sands, silts and soft clays due to their low rate of settlement, it is unlikely that there will be any significant increase in the hopper load achieved by continued pumping beyond the time that hopper overflow commences. However in case of coarse grained soil such as sand loading upto 80% may be achieved. Modern dredgers have Automatic Light Mixture Overboard (ALMOB), to minimise the turbulence in the hopper and improve the loading of the hopper.

When the hopper is loaded, the suction pipes are returned and dredger sails for dumping. The dumping of dredged spoil is accomplished by different methods depending upon the soil type and sea conditions, as shown in **Table 3-11**

Table 3-11: Dumping method of dredge spoil according to soil type

Bottom door : hinged	Clean silt, sand and soft clays in calm water
Sliding	Clean silt, sands and soft clays in shallow water or rough seas
Bottom valves	Clean silts, sands and soft clays in rough seas
Split hull	Any material including those containing boulders or debris for disposal in shallow water and moderate seas
Pump	Silts, sands where disposal is to on shore area for land reclamation
Scraper	Shore discharge of dredged aggregates
Grab	Shore discharge of dredged aggregates

Cutter Suction Dredger

These types of dredgers have a powerful cutter for dislodging the soil particles in addition to the hydraulic suction and transportation arrangements. The main advantages and disadvantages of the cutter suction dredger are as under:

Advantages

- The ability to dredge a very wide range of material by pumping with water directly to the disposal or reclamation area.
- The ability to operate in shallow water and to produce a uniform level bottom with high rates of production.
- The ability, in case of modern dredgers to dredge to a pre-defined profile e.g. in channels.

Disadvantages

- Sensitivity to sea condition
- Limited distance through which dredge material can be economically conveyed
- Dilution of dredged material
- Limited depth of dredging
- High mobilisation costs

The cutter suction dredger is usually rated according to either diameter of the discharge pipe, which may range from 150 mm to 1,100 mm or by the power driving the cutter head, which may range from 15 KW to 4,500 KW. Most of the cutter suction dredging fleet available have installed power from 2,000 to 10,000 HP; though the cutter suction dredgers with higher installed power also exist which are used for dredging of hard soil, soft rock etc. The limiting operational conditions for cutter suction dredgers are as under:

Minimum depth of water to operate	=	0.75 m
Maximum depth of water to dredge	=	35 m
Maximum cut width (single pass)	=	175 m
Maximum Wave height	=	2.0 m
Maximum Swell	=	1.0 m
Maximum cross current	=	2.0 knots
Maximum particle size	=	500 mm
Maximum compressive strength (rock)	=	50 Mpa

In addition to the above pneumatic dredgers, amphibious dredgers, scraper dredgers and other miscellaneous types of dredgers are available which are suitable for specific types of works, such as pneumatic dredgers are suitable for dredging of very soft cohesive soils and Amphibious type of dredgers are suitable for dredging in shallow water e.g. inter-tidal zone, etc.

SELECTION OF DREDGERS

The following factors govern the selection of a dredger for a particular work:

- Site characteristics and conditions
- Nature of soil/rock to be excavated
- The nature of dredged material to be transported
- Environmental factors

The implication of each of the above mentioned factors on the selection of the plant and equipment for dredging has been discussed in the following paragraphs:

The selection of the dredging plant largely depends upon the characteristics of the site such as accessibility, minimum and maximum depth of water, location and accessibility of disposal site, dimensions of the dredging area, proximity to the structures, accuracy of dredging required etc. and the meteorological and oceanographic conditions, traffic etc. and the dredging plants and equipment for a particular site is selected based on site specific information. In case of dredging in shallow areas and inter-tidal zone either dredgers requiring only draft available are selected or dredgers which are able to dredge ahead of their hull such as cutter suction, grab and bucket dredgers are selected so that they can dredge from deep water moving towards shallower depths making room for their movement, or a combination of two types of dredgers are deployed. The small dredging may be used to create a basin of adequate for the bigger dredger, which may subsequently operate from the basin pumping the dredged spoil to the reclamation area.

Similarly wind wave and swells are the main meteorological and oceanographic conditions which affect the working of the dredger. The high wind may make anchoring of dredger and loading on to the barge operation difficult. The dredgers which are located by means of spuds are susceptible to waves which may lead to the damage of the spuds, spud carriages and guides. Anchored vessels are less susceptible to the waves except in the case of dredgers with rigid connections to the excavation face such as cutter suction and bucket dredgers which may get damaged when their ladder strikes bottom. In general most of the dredgers suffer a reduction of efficiency due to lack of control of excavation process and intermittent loss of contact of cutting edge with the sea bed and/or the relative motion between barge and the dredger if barge is used for dumping of the dredged spoil. The limitations on the dredging equipment by wave and swell reported in the literature are shown in Table 3.11

Table 3-12: Limitation of dredging equipment according to wave height

Dredging Plant	Wave height (m), Period 6 to 8 seconds	
	Limited heights For efficient operations	Heights above which operations are dangerous and/or very dangerous
Drilling Pontoon (floating)	1	1.5
Drilling Pontoon (spudded) working	2	3.5

Dredging Plant	Wave height (m), Period 6 to 8 seconds	
	Limited heights For efficient operations	Heights above which operations are dangerous and/or very dangerous
Drilling Pontoon (spudded) moving	1	2
Dipper dredger	0.3	0.6
Back hoe dredger	0.4	0.8
Bucket dredger	0.4	1
Grab dredger (self propelled)	2	3
Grab dredger (dumb)	0.4	1
Cutter suction dredger (small)	0.2	0.5
Cutter suction dredger (large)	1	2
Trailing suction hopper dredger (small)	1.5	2.5
Trailing suction hopper dredger (large)	3	4

Currents mainly affect the manoeuvrability of the dredger and are important when dredging in confined areas. Dipper, backhoe and bucket dredgers given sufficient anchorage can work in current upto 3 knots. In strong current the positioning of grab in case of grab dredgers becomes difficult. In strong currents the production of bucket and grab dredgers also reduces drastically. The cutter suction dredgers suffer from current in two respects; lateral; pressure on the dredger and the floating pipeline. The large cutter suction dredgers can work in the current upto 2 knots. In order to arrive at the rate of dredging in various types of soil using the available types of dredgers the reputed contractors world-wide should be contacted.

Potential types of dredgers and their functions

Dredging technologies and different types of dredgers have been described in details in the earlier section. A little further description is now provided below on two types of hydraulic dredgers since they are mostly used in alluvial environment.

Hydraulic type dredgers mainly of two types: *trailing suction hopper dredger* and *cutter suction dredger*. The trailing suction hopper dredger is practically a ship that by the use of dredging equipment can dredge desired location and discharge into the ship's container and can sail it in order for releasing the dredge elsewhere. This type of dredger can be used in deepening river bed in maintaining navigable waterways, to construct/raise new land or dredge can be dumped into the sea when spoil management becomes a problem either in-stream or on the land. The hopper suction dredger has self-loading and unloading capacity, if required a pressurized discharging aid can be equipped. As an operation procedure, one or two suction pipes having trailing suction head connected to the end descend onto the river bed (desired dredging location). There are nozzles in the head that are connected to a high pressure installation that are capable of loosening

the bed material (sand). Since vacuum is created inside the pipe, the dredge is sucked and conveyed into the holding vessel said earlier. As a discharging method, usually dumping is done somewhere else, usually into the sea. However, by pressing method – liquefying the dredge inside the hopper by high pressure water and discharge can be made possible over a long distance. But this will surely add much extra cost.

Cutter suction dredger consists of a centrifugal pump and the suction tube that has cutting mechanism (rotary blade) at the end. Loosening the sand and cutting are done simultaneously, and the dredged material is sucked by the dredging pump and transported through a pipeline. Usually the distance of transportation pipe line by design could be 2-3 km. However, by adding booster pump to the pipeline the dredge-spoil can be transported/dumped to a further distance.

In this project the dredging operation involves a number of rivers of hundreds of kilometers and most locations of dredging will be well inside the coastline. Therefore, cutter suction type dredger would be the feasible option from both technical and financial point of view. However, while dredging locations are the coastal area, for example downstream of Bhola, Lakshmipur hopper suction type dredger might be considered provided if costing favours in choosing such type. The photograph of a cutter section dredger is presented in Figure 3.3



Figure 3-4: The photograph of Cutter Section Dredger

As known from BIWTA, at present it mostly uses cutter suction dredgers of the sizes 18 and 20 inches for the purpose of their inland dredging. In this project, the contractor will chose the dredger type based on own assessment in compliance with the EMP/BMP.

Dredging frequency and schedule

Though it is debate whether in-stream disposal or over-bank dumping, the schedule should largely depend on this decision. Rivers lose their speed of current from November, during high dry period January to April flow is nearly stagnant except thalweg. Therefore, dredging during such time may result in deposition in nearby places. If in-stream dredging that should be done during high-discharge and high-current speed condition so that dredge can go away much further downstream. But feasible dredging time for convenient and efficient dredging surely would be the dry season provided if the dredge-spoil is managed on the nearby bank.

In scheduling actual dredging operations fish-breeding time must be given due importance. Usually such breeding time, particularly for the hilsa fish, is twice a year – around mid-September to mid-October and March-April.

3.3.3 Management of dredged material

Dredging is a key aspect in keeping the river route navigable. Managing dredged materials will be a key challenge to achieve the project goals, as dumping the dredged materials without a legitimate plan will result in negative impacts like soil contamination and environmental degradation, reduction of yield rate and ultimately transfer the dredged material back to the river. Acquiring community recommendations through consultative process about dredged material management has been an important issue of the proposed study. The dredged materials are expected to have two features; contaminated and no-contaminated. The non-contaminated materials will have also two dimensions i.e., usable for sand filling and another for civil construction. These both categories of materials can be sold to willing buyers/traders or can be used in rural road development, dyke construction or some other purposes. In fact, as means of keeping the materials from the river bank, the first choice of the stakeholders is to sell them to willing buyers/traders or to deposit in a suitable location from where people/community can take away for development purposes. In some sites, the stakeholders advised to use the dredged materials for maintenance and increasing heights of the river bank/polders. Some of them suggested using the sediments for increasing heights of the yards of community properties like school grounds, Eidgah, Madrasah, etc. The contaminated spoils should be managed in scientific way so that there will have no environmental hazards. During consultation meetings with the local people, sand traders, local government representatives and Upazila administration, some effective suggestions have come out. According to their opinion the dredged materials may be used in various sectors effectively that may promote development of the community and local economy. It was also opined that dredged materials may be sold to the local traders and willing buyers or deposited in a suitable location so that community people may use it for their needs. In some areas the dredged materials may be thrown in to the deeper channel of the river especially at Chandpur and lower Meghna. Various suggestions from the stakeholders about dredged material management are hereby listed in Table 3.12 below. Nonetheless, these community preferences need to be balanced with considerations about negative social impacts, costs, administrative challenges (given low institutional capacity of BIWTA on social management), and environmental factors associated with land acquisition or lease and on-land disposal. Therefore, it has been determined by BIWTA that the first choice for dredged material disposal shall be in the river, whenever suitable in-river locations are available, as per environmental criteria and technical considerations. Only when in-river disposal is not a viable option shall on-land disposal be carried out, in accordance with provisions of the EMP and RPF, both of which require consideration of local community needs and interests as well as minimizing negative impacts. This is further discussed and elaborated in the impact assessment and EMP chapters of this report.

Table 3-13: Participants advice on dredged spoils management;

Sl.	Venue of the Meeting	Dredging Requirement	Dredged Spoil Management: Community Opinions
1.	Venue : Sadar Ghat, Ward No. 7 Thana: Kotwali District: Dhaka	Urgently needed	1. It can be used for sand filling in low lying areas using scientific methods. 2. It should be taken far away from people as the sediment is highly contaminated.
2.	Venue : Aganagar Ghat Thana: Keraniganj District: Dhaka	Urgently needed	1. It should be taken away from residential area as the river bed is highly contaminated.
3.	Venue: Jinjira Bottola Thana: Keraniganj District: Dhaka	Urgently needed	1.It is contaminated, so it should be taken far away from residential areas to keep the environment people-friendly
4.	Venue: Munshiganj Launch Ghat Thana: Munshiganj Sadar District: Munshiganj	Dredging is required	1. Some sand businessmen want to buy dredged materials. 2. Stake yard of the businessmen may be used to dump dredged materials.
5.	Venue: Munshiganj Ferry Ghat Thana: Munshiganj Sadar District: Munshiganj	People didn't mention navigation problem	1.They don't feel dredging requirement
6.	Venue: Naranpur Thana: Titas District: Comilla	People didn't mention navigation problem	1.They don't feel necessity of dredging
7.	Venue: Batakandi Bazaar Thana: Titas District: Comilla	People didn't mention navigation problem	1. They don't feel necessity of dredging
8.	Venue: Bhairab Bazaar Launch Ghat Thana: Bhairab District: Kishorganj	Dredging is required	1.It can be used in river bank's improvement 2. It can be used for filling low residential areas and yard of community properties
9	Venue: R J Tower & Resort, Thana: Ashuganj District: Brahmanbaria	Urgently required	1.Some people want to buy the sand 2. It may be used for rural road development and river bank improvement
10.	Venue: R J Tower & Resort Thana: Ashuganj District: Brahmanbaria	Urgently required	1. There are two locations beside the river to deposit dredged materials at the moment: i) near the cargo terminal (150 decimal) and ii) near Ashuganj gas plant (180 decimal) 2. Some locations are already being used as stake yards for sand and the traders may cooperate with the project to take more sands;

Sl.	Venue of the Meeting	Dredging Requirement	Dredged Spoil Management: Community Opinions
			 3. the participants at the regional workshop advised the project to use the dredged material for construction of a 6 km connecting road with Ashuganj and Nabinagar; 4. This connecting road will develop business and transportation opportunities of Ashuganj;
11.	Venue: Shatnal launch ghat Thana: Matlab District: Comilla	People didn't mention navigation problem	1. Dredged materials can be used in road construction 2. Launch ghat should be upgraded with more facilities including connecting road
12.	Venue: Harina Ferry Ghat (Common people including passenger) Thana: Chandpur Sadar District: Chandpur	People didn't mention navigation problem	1. It can be used for sand filling and plinth of the house 2. It may also be used for development of yard of community properties, play ground and rural roads.
13.	Venue: Harina Ferry Ghat (businessmen & Fishermen) Thana: Chandpur Sadar District: Chandpur	People didn't mention navigation problem	1. Non-contaminated sand may be used for household work 2. Can be stored in a particular location so that people can take away for their use 3. Can be sold to traders and willing buyers
14.	Venue: Chandpur launch Ghat Thana: Chandpur Sadar District: Chandpur	People didn't mention navigation problem	1. It may be used in construction work 2. Can be sold to traders and willing buyers, 3. Can be thrown in to the deeper channel of the river nearer to Chandpur
15.	Venue: Boro Station Mul Head (Dakatiya Mohona) Thana: Chandpur Sadar District: Chandpur	People didn't mention navigation problem	It may be used for sand filling and plinth of the house Can be stored in a particular location so that people can take away for their use
16.	Venue: Boro Station Mul Hea (Camp Office) Thana: Chandpur Sadar District: Chandpur	People didn't mention navigation problem	1. It may be used for sand filling or construction works of the roads and buildings 2. Can be sold to sand traders and willing buyers
17.	Venue: Char Bhairab Thana : Haim Char	Dredging is required	1. The dredged materials may be used in construction works

Sl.	Venue of the Meeting	Dredging Requirement	Dredged Spoil Management: Community Opinions
	District: Chandpur		2. Can be sold to traders or deposited in a suitable location so that community can use it for their necessity
18.	Venue: Moju Chowdhury Ghat Thana: Laksmipur Sadar District: Laksmipur	Dredging is required	1.It may be used in riverbank construction 2. Can be filled in low lying areas including play ground and yard of community properties, rural roads
19.	Venue: Boyar Char, Chairman Ghat (Fishermen Community) Thana: Hatiya District: Noakhali	Urgently needed	1.It may be used in ghat construction and rural road development 2. May be sold to willing buyers 3. May be deposited in a suitable location for further use of the community people
20.	Venue: Chairman Ghat (Owner Association) Thana: Hatiya District: Noakhali	Most Urgently needed	1. It may be used for plinth of house, road and river bank construction, and for increasing height of polders 2. Can be sold to willing buyers/ traders.
21.	Venue: Doulat khan launch ghat Thana: Doulat khan District: Bhola.	People didn't mention about navigation problem	1.It may be used as the road construction material 2. Development of yard/play ground may also be done by the dredged materials
22.	Venue: Tajumuddin launch Ghat Thana: Tajumuddin District: Bhola.	Dredging is required	1.It may be used as the road construction material 2. May also be used for development of play ground and river bank as there is erosion threat here
23.	Venue: Bheduriya ferry Ghat Thana: Bhola sadar District: Bhola	Dredging is required	1. It may be used for sand filling in low lying areas/play ground, etc. 2. May also be used for Ghat development and river bank improvement
24.	Venue: Lahar hat (vatikana) Thana: Bandar Thana District: Barisal	Urgently needed	1.It may be used for sand filling in low lying areas 2. People also opined to sell the materials to willing buyers and traders; 3. The area is erosion prone; the participants opined to use the dredged materials for bank protection work;
25.	Venue : Kaliganj Launch Ghat Thana : Mehendiganj District: Barisal	Dredging is required	1.It may be used for sand filling in low lying areas

Sl.	Venue of the Meeting	Dredging Requirement	Dredged Spoil Management: Community Opinions
26.	Venue : Sreenagar Thana : Raipura District: Narsingdi	Dredging is required	There is a large wet land (20-30 acres) under private ownership. There are plenty of fellow land in Sreenagar Mouza (Baghaikandi, Gozariakandi, Gopinathpur village) where a huge quantity of sand may be deposited; Local Chairman (Sreenagar UP) confirmed availability of space for dredged materials deposition. The owners are willing to increase height of their low lying land by dredged materials. at it will increase value of their land; There are also sand businessmen, who are willing to purchase dredged material during implementation;
27.	Venue : Karimpur Thana : Narsingdi Sadar District: Narsingdi	Dredging is required	The locals welcomed the project; But all the fellow land are under private ownership, within the range of 10-20 decimals, which is small compared to volume of dredged materials; People opined to keep dredged materials in a suitable location beside the river so that local people may take it for their/community needs

Source: Stakeholder Consultation Meeting outcomes

Based on community consultation, location of dredging analysing hydrological and morphological conditions of the navigation routes, and environmental and social considerations, locations of dredged material placement have been identified.

In the Meghna Estuary two locations have been identified for dredge material placement. One is along the northern shoreline of Hatiya Island and another one is the eastern shoreline of Bhola Island. Hatiya Island has been experiencing severe erosion over the years at its northern shoreline due to deep scour hole along this shoreline and high current speed. Figure 3.4 shows the location of deep scour hole along the northern shoreline of Hatiya Island

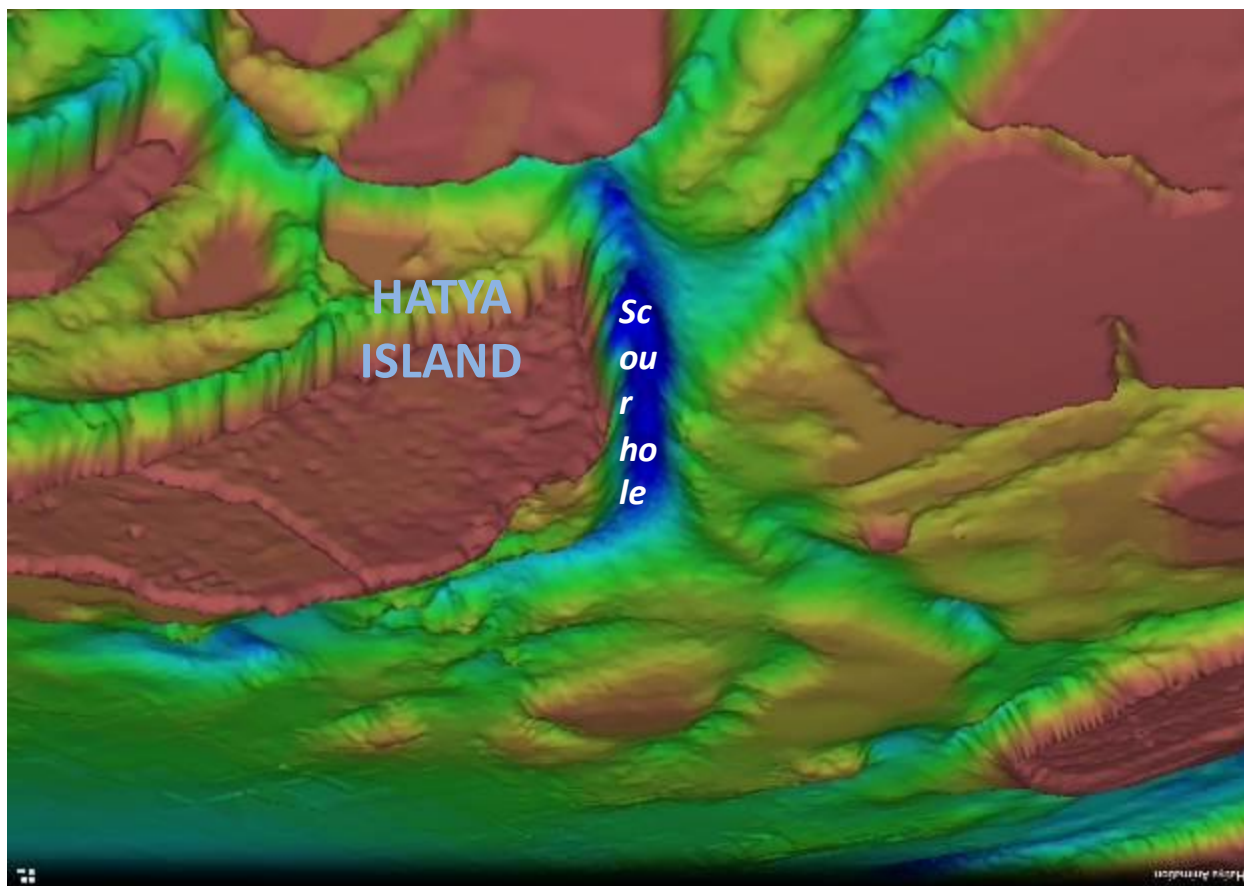


Figure 3-5: Three Dimensional Model of Scour hole at the North East corner of Hatiya Island using Mike 21 modelling software

If dredged material is placed at this location then it will reduce the erosion rate. Morphological model study shows that, this dredged material is distributed naturally with high and low tides. This mechanism is considered as shoreline nourishment with dredged material. Figure 10.1 shows location of dredged material placements.

4 ANALYSIS OF ALTERNATIVES

4.1 No project Alternatives

4.1.1 Current problems with inland navigation

Current problems of inland navigation in the Dhaka-Chittagong corridor and adjoining routes under study can be described according to following:

Dry season navigability

Condition of dry season navigability in the routes under study and elsewhere in IWT network is the core problem of inland navigation caused by deteriorating condition of rivers. Due to recession of water in the rivers vessels have to wait for high tide, run in half-load or under load condition to avoid groundings. take a detour that increase transportation time and cost and turn around time of vessels as well. All these aspects make IWT mode unattractive and create lack of confidence among the users.

Lack of aids to navigation

Inappropriate aids to navigation along the routes create problem combined with dry season navigability. Equipments of aids to navigation installed by BIWTA are considered by navigators not sufficient according to requirement.

Inappropriate loading-unloading facilities

Inland ports in Bangladesh are characterized with marginal facilities that do not provide safe embarkation and disembarkation of passengers and goods. Due to lack of mechanization, head-load still remains the main means of loading / unloading of cargo. This makes inland ports inefficient.

Safety

IWT is safer compared to road transport in Bangladesh. But recent accidents in inland waterways which claimed substantial lives and properties reveal that there exists lack of safety management in IWT.

4.1.2 Consequences of non-maintenance of navigation channels

If the present state of navigational conditions continues or in other words if the channels under study not maintained for smooth navigation, the following conditions will be evident immediately:

- Transportation cost and time will be increased.
- Turn around time of vessel will further increase to such extent that IWT will not remain cost-effective.
- Hinterland connection of maritime ports will be disrupted and will leave ports as inefficient.
- Congestions in roads and maritime ports will further increase.
- Inland container transport by rivers will not be sailed.
- Private investment in IWT sub-sector will be discouraged.

- International sea-borne trade will not be able to meet transport demand.
- Facilitation of trade and commerce will be restricted resulting unemployment.
- Poor people will lose opportunity of cheaper transport.

4.1.3 Marine accidents and safety

Revival of Inland Water Transport: Options and Strategies, 2007 by the World Bank estimated that *the ratio of fatalities of per billion of passenger-km is 158 for roads and 41 for IWT*. So, IWT looks safer compared to road statistically. But the nature of marine accidents so gruesome that attract the attention of millions. Even these marine accidents are not frequent like those on roads but pictures of perished copes published in the media create a state of fear and no confidence in the minds of users. Media reports reveal poor governance in safety management.

Accidents and fatalities on roads in Bangladesh is one of the highest in the world. The World Health Organization (WHO) in its recent report estimated that road accidents in Bangladesh claimed 21,316 lives annually. While Headquarters of Bangladesh Police claimed that a total of 2,067 persons were killed and 1,535 injured due to 2,027 road accidents in 2014. This figure was calculated on the basis of FIR lodged in the concerned Police Stations. On the contrary, number of marine accidents and fatalities during last 15 years may be seen in the Table 4.1

Table 4-1: Statistics of marine accidents

Year	Number of accidents	Number of fatalities
2000	09	353
2001	17	33
2002	17	297
2003	31	464
2004	41	127
2005	28	248
2006	23	51
2007	11	02
2008	22	120
2009	34	260
2010	29	118
2011	22	74
2012	15	162
2013	10	22
2014	16	124
Total	325	2455

Source: Department of Shipping & BIWTA

These are official figures calculated on the basis of FIR lodged in local Thana and cases filed in the marine court. It is evident that number of fatalities derived from number of dead bodies recovered after the accidents. Number of missing persons was not considered.

One example may be mentioned to determine the quality of above figures. In July, 2003 a passenger launch named MV Nasrin capsized in the confluence of the Meghna and Dakatia near Chandpur with about one thousand passengers on board including the owner of the launch. The depth of the river at that spot was about 50 m. The capsized launch could not be located or recovered even with combined salvage operation of Navy, Fire Service and BIWTA for continuous 15 days. The investigation Committee constituted by the Ministry of Shipping estimated that a total of 645 persons were killed in the accident. Committee estimated this number on the basis of dead bodies recovered and registered number of missing persons. According to BIWTA's record 911 persons were killed in 7 accidents in the year 2003. While the above table claims only 464 fatalities in the same year.

However, if we consider the above table this will be found that the rate of fatalities per year is 167 and rate of accident per year is almost 22. Through random analysis of investigation reports of marine accidents, the following causes were found:

- **Dangerous or improper overloading.**
- **Collision,**
- **Poor condition of vessel.**
- **Storm / Cyclone / Tornado**
- **Inefficient operation**
- **Combination of two or more causes.**
- **Breakdown.**
- **Grounding.**

4.1.4 Need for storm shelter

Storm, tornado, cyclones and other natural calamities have become more frequent in Bangladesh. Vessels while in operations have to encounter this challenge. In such contingencies vessels have to take a refuge that is safe and have capacity to provide assistance to vessels in distressed. Not only foul weather, breakdown of marine engine or the propeller may leave the vessel in distressed.

Physical characteristics of rivers in Bangladesh are such that at most of the places vessels in distress find no natural advantage to take refuge. So, planned creation of storm shelters along the accident prone routes and stretches may enable the vessel to avoid threat of capsize and save lives of hundreds.

4.2 Alternatives to the Project

4.2.1 IWT versus road and rail

A sustainable development strategy for transport network must consider costs and benefits inclusive of every element. Costs of a transport mode include development and maintenance of a network, ownership of vehicles and its operation and maintenance costs. These are referred to internal costs or sometimes termed as direct costs. The costs, which could be fixed or variable, have been the primary determinant of the costs of haulage in Bangladesh or elsewhere in the

South Asia. There is, however a growing realization that every mode of transport carries what are known as external costs, hidden costs that burden not only users of the mode but also the society at large. The most prominent externalities that impose such costs in a particular mode are accidents, pollution, climate change, congestion and land-side infrastructure development.

There has been an alarming rise in road accidents in Bangladesh over the past few years. According to a study conducted by Accidents Research Center (ARC) of Bangladesh University of Engineering and Technology (BUET), road accidents claim on average 12,000 lives and lead to 35,000 injuries. According to the World Bank statistics annual fatality rate from road accidents in Bangladesh was found to be 85.6 per 10,000 vehicles.

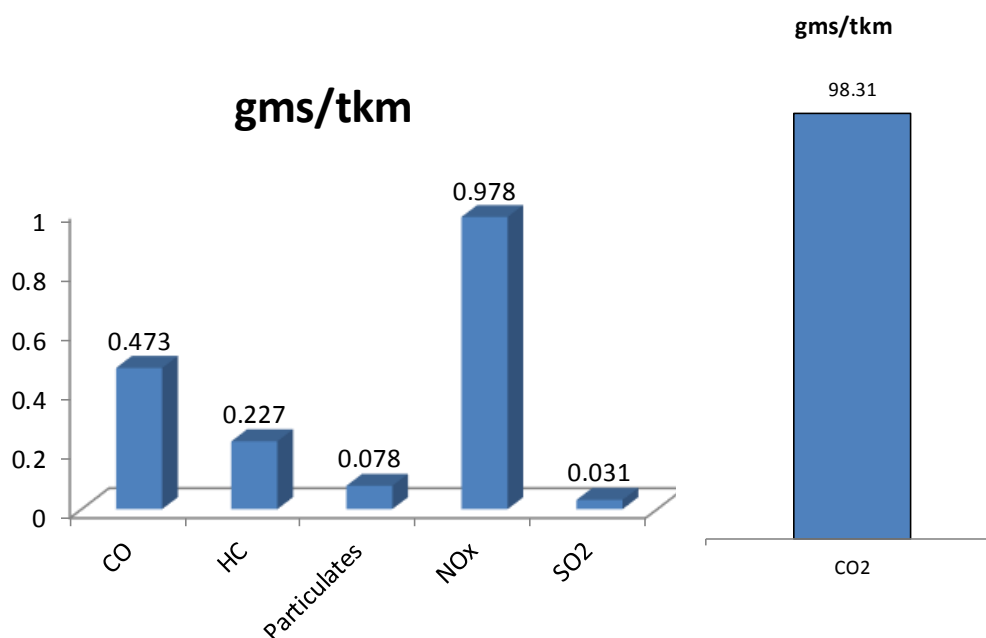
Similarly cost of road congestion particularly in the Dhaka city was estimated by the Metropolitan Chamber of Commerce and Industries, Dhaka through a Study conducted by two engineers of RHD and one transport economist of MCCI according to Table below:

Table 4-2: Cost of Traffic Congestion in Dhaka city

Factor	Cost (Bn BDT)
Loss of business hours	118
Environment	22
Transport industry	20
Additional fuel	5.75
Accident	0.50
Total	195.55

Source: MCCI Study in 2010

Road vehicles pollute the air with carbon monoxide, hydrocarbon, particulates and NO_x leading to a host of respiratory diseases including asthma, bronchitis and setting the stage for growing incidence of cardiovascular disease. Emissions of carbon dioxide from road vehicles cause global warming.

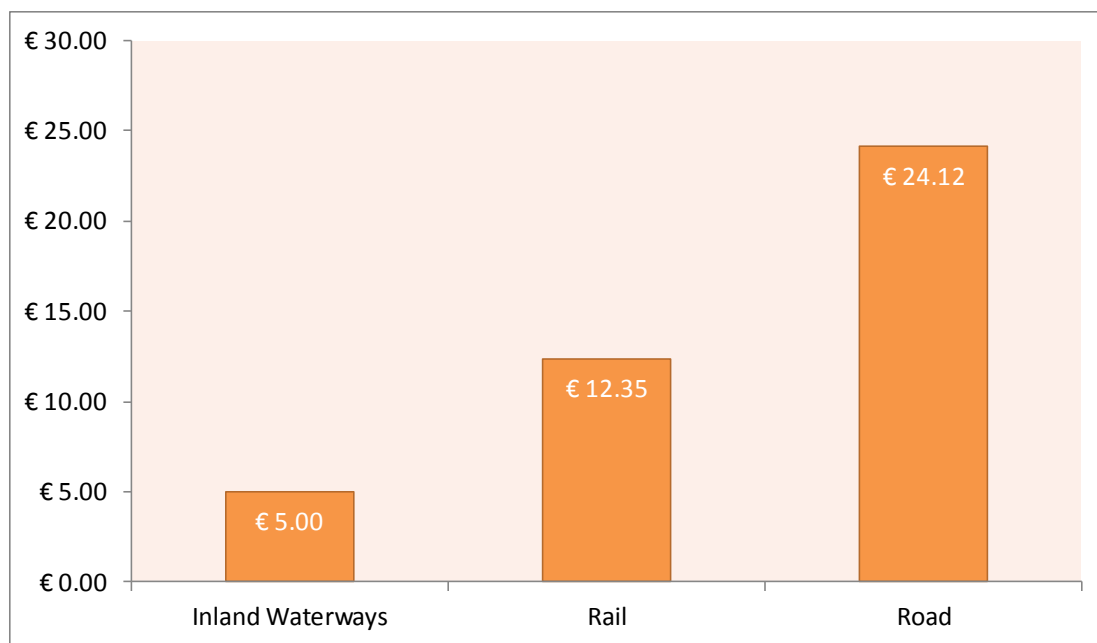


Source: *EU Progress Report on Short Sea Shipping, 1999*

Figure 4-1: Road Transport Emissions

The European Union in 2002 determined that for every 1,000 ton-km of cargo hauled, road transport carries a total hidden external cost of Euro 24.12 as against Euro 12.35 in rail and only Euro 5 for IWT.

Reliable estimates of such external costs in the context of Bangladesh or elsewhere in the South Asia are not available. But given the general conditions of our roads and trucks, it would be eminently reasonable to assume that external costs in Bangladesh of road transport exceed those of IWT by a factor that is decidedly higher than in the EU.



Source: *Transportation cost and benefit, TDM Encyclopedia*

Figure 4-2: External Costs of Transport Modes

Modal option for development strategy of transport sector, environment must be a determinant factor. IWT always remain on the top in terms of carbon saving. One liter of fuel in the river produces 100-200 ton-km of transport output as against 25 ton-km in road, four to eight times lower. The World Bank in its Report on Revival of Inland Water Transport: Options and Strategies, 2007 revealed that with an estimated 1.95 billion ton-km performed by IWT in 2005 excluding country boats, about 58.5 million liter of fuel were saved by using IWT instead of road. Using the Integrated Pollution Prevention and Control (IPPC) conversion factors, this represents 155,000 tons of carbon dioxide.

4.2.2 Alternative routes for Dhaka-Chittagong corridor

Modal option for future development strategy should also be based on social issues. IWT contributes directly to social benefits nationwide by providing a cheaper mode of transport and employment opportunities. According to the World Bank (Revival of Inland Water Transport: Options and Strategies, 2007) total employment in IWT sub-sector is more than 4.64 million. A substantial portion of rural population has no access to any mode of transport other than river.

In view of the country's economy, public investment for future development of IWT is significant and reasonable. The World Bank estimated an amount of savings at BDT 7.5 billion in transport costs of cargo resulting from the use of IWT instead of road (Revival of IWT, 2007). The cost of dredging was estimated at 0.6 billion BDT take at BDT 100 per cum. In other words, benefit of BDT 7.5 billion at the cost of BDT 0.6 billion which is economically justified. The minimum traffic necessary to justify the cost of dredging was obtained by dividing the total costs of dredging by the average benefit from dredging per kilometer. The average cost of dredging

per km was obtained by dividing the total cost of dredging by the length of navigable IWT network. The average benefit from dredging per kilometer was obtained by dividing the difference between IWT and road cost by the number of ton-kilometer for IWT output. This was derived from the volume of cargo traffic transported by inland waterways by the formal sector vessels only. The output of the informal sector was not included as those can play in all condition. Table 4.3 illustrates the comparative per ton-km costs of each mode:

Table 4-3: Comparison of Cargo Tariff by Modes

Mode	Dhaka-Chittagong (BDT ton-km)	Distance (km)
Road	4.50	243
Rail	2.74	260
IWT	0.99	306

Source: *Revival of IWT by the World Bank, 2007*

It should be noted that freight of IWT and rail increased very slightly less than 10% while that of road increased to about 40 percent since 2007.

The study of the World Bank also revealed that in terms of productivity per kilometer of network of different modes railway is the best followed by IWT and road at the bottom. IWT has more than twice the productivity of road for the carriage of cargo as illustrated in Table 4.4

Table 4-4: Productivity of Different Modes

Comparison	Road	Rail	IWT
Network	274,000	2800	24,000
Productivity Passenger-km	359,000	1,500,000	369,000
Productivity Ton-km	57,000	293,000	127,000

Source: *The World Bank in National Workshop on IWT, 2005*

It is mentionable that for calculation of productivity existing networks of road and rail were considered. While for IWT, total geographical not navigable network was considered. If navigable network of 6,000 km was considered, productivity in terms of passenger and goods would increase by 400 percent.

4.3 Alternative Means of Channel Maintenance

There may be ways and means to maintain rivers and stream channels to keep them functioning. However, means of maintaining should largely depend on a number of criteria such as types, size, surrounding hydrological environment, social and economic purpose of the river. There

may be potential ways that are usually used in maintaining river channels, such as dredging, river training, river bank protection works, etc.

Dredging

Whatever be its ultimate purpose and location, in fact, dredging is an excavation activity either done by manually or by using machines and at a part of dredging has to be carried out underwater. Here is the difference between an excavation of a burrow pit in case of constructing a road and excavation of bottom sediment of a middle or point bar of a river. Rivers not only are carrying mass of water but also carrying sediments of varying sizes. Due to varying physique and inputs to river, particularly excessive sediments input create bars and chars constrictions in the river. In order to maintain desired navigational channel and required depth dredging is a necessity.

River Training

River training activities are ways and means that are applied in a river reach so as the reach is expected to show a desired behavior. Training measures that are usually employed are breakwater (groynes, spurs, etc.), hardening river bank. Breakwater means are employed in order to deflect water course away from the bank so that the concerned bank that were under attack becomes safe. Each groyne/spur has some area of influence where it could reduce the flow speed and produce a calmer environment so that gradual sedimentation can happen. In this way the channel course becomes shifted away and a deeper course may develop further away from the bank. However, hardening is a defensive measure that makes a safeguard for the endangered bank or for the bank that has potential danger to be fallen under attack. This type of measure is desirable where important installations, public dwelling of massive scale, towns and cities are under attack or may undergo under attack. Even a dredging activity can be regarded as river training work when it is planned, designed and implemented with the goal of achieving a desired behavior of a river, i.e., river is able to provide safe navigation, the river is not eroding its banks.

As to bank protection works, as its name implies they are a kind of measures whose principal purpose is to protect bank. Obviously, bank protection works are included within the broad class of river training.

Flow path can be deflect away from the bank towards somewhere in the middle by constructing river training structures such as groynes (permeable, solid), bamboo bundles etc. This can be done in the affected side of the bank or even on the both bank. In this way channel augmentation is possible by deepening the river bed. This method might be considered desirable where only bank erosion and protection is concerned. However, where the river is not much wide to accommodate sufficient number of two-way traffic of varying sizes, particularly where large vessels involves this sort of constriction by placing such measures of river training clearly make obstacles to traffic. Hence, they appear not a feasible alternative measure. Again, deepening in

this way may not bring sufficiently required depth for navigation purposes. Here, in this D-C corridor project huge number of two-way traffic of varying sizes is expected and that will be increasing over time with the pace of socio-economic development. Again for rivers like Buriganga, Shitalakhya river width shrinks much with huge lowering of river stage during dry period but navigation requirement is perennial.

A comparative discussion on the measures of dredging, river training as alternative means of channel maintenance:

As pointed out above, though as means river training measures, bank protection works help channel maintenance, that surely should be not be sufficient for maintaining required channel depth for navigation purposes. It is particularly true in case of very large river where river flows in different channels with many shoals, bars and chars. This is the case for D-C corridor project where the most navigation route involves mighty Padma and Meghna River with width of even many kilometers. Also these rivers are highly sediment laden. It is a project which seeks sufficient navigation depths along the entire river navigation routes and ferry crossings, so the need for dredging is inevitable.

Though in this project some rivers – the Buriganga, the Shitalakya, and the Dhaleswari are meandering type not showing middle chars like the Padma and the Meghna. In channel maintenance a kind of river training, bank protection bring some benefit. However, this may not be sufficient for the whole route and in order to achieve required navigation depth particularly when the aim is to improve IWT to allow more passenger and cargo traffic and improve river ports and terminals. Again, river training and bank protection works should not be feasible for river routes of hundreds of kilometer. For example, a river training work was accomplished while constructing Hardinge Bridge to guide the flow and expect that the flow would not have chance to make harm to the bridge abutment. The work has still been performing well. However, that kind of guide bund cannot be built either along the whole river or in many locations in view of cost and other considerations. Therefore, if proper dredging is done with proper spoil management and spoil reuse for beneficial purposes, dredging means can bring useful channel maintenance.

Cost in some past Projects

Obviously, the cost of river training/bank protection works depends on the type, size, and design of structure. Also, it depends on the material to be used and the market rate that change over time. Bangladesh Water Development Board is the main responsible government organization in implementing river training, bank protection works. A good indication of costing can be obtained from some past projects or projects being taken by BWDB. Here are some examples given in the following:

- Bank revetment works to be implemented by placing CC block at Paranpur, Sengati and Sailadah on the Madhumati River involving Polder 36/1. Estimated cost: Tk. 300,000 per meter (USD 2750 per meter).
- Bank revetment works being implemented by placing CC block near Godagari upazila under Rajshahi District on the Ganges River. Estimated cost: Tk. 500,000 per meter (USD 6250 per meter).
- Bank revetment works to be implemented by placing CC block near Mawa on the left bank of the Padma River. Estimated cost: Tk. 446,000 per meter (USD 5575 per meter).
- Proposed bank revetment works to be implemented by placing CC block under Kalni Kushiara River Management Project in the north-east region of Bangladesh. Estimated cost at DPP stage (ie, not design cost): Tk. 252,000 per meter (USD 3150 per meter).
- Bank revetment works suggested for implementation by placing CC block in places along left of the Meghna River under Kamalnagar and Ramgati Upazila in Lakshmipur district. Estimated cost: Tk. 289,000 per meter (USD 3612 per meter).

Note: As observed, BWDB presently as a measure of bank protection prefers bank revetment by placing CC blocks to constructing spurs. Cost per meter for a spur on the Jamuna and Ganges Rivers implemented by BWDB were USD 1,550 and USD 1,019 respectively in 1990s.

4.4 Alternative Dredgers Types (Equipments/Techniques)

Potential types of dredgers and their functions

According to engineering design basically there are 3 kinds of dredgers; they are mechanical, pneumatic and hydraulic dredger. As known, though there are some mechanical dredgers are in use by BWDB, BIWTA (those are being used they are very old), being inefficient this type is not the preferred one.

Hydraulic type dredgers mainly of two types: *trailing suction hopper dredger* and *cutter suction dredger*.

Cutter Suction

Cutter suction dredger consists of a centrifugal pump and the suction tube that has cutting mechanism (rotary blade) at the end. The main technique is applied in dredging is that loosening the sand and cutting are done simultaneously, and the dredged material is sucked by the dredging pump and transported through a pipeline. Though can be used in sandy, clayey soil, due to the capacity of cutting it has preferred use in case of dredging on bedrock or very hard soil or gravel deposits. Usually, the distance of transportation pipe line by design could be 2-3 km. However, by adding booster pump to the pipeline the dredge-spoil can be transported/dumped to a further distance.

Trailing Suction Hopper Dredger

The *trailing suction hopper dredger* is practically a ship that by the use of dredging equipment can dredge desired location and discharge into the ship's container and can sail it in order for releasing the dredge elsewhere. A description of its functionality and uses are also given in **Section 3.3.2**.

In principle, its dragging technique is basically similar to a vacuum cleaner. That means sail-and-drag, sucking by creating vacuum and hence loading, then sailing to unload elsewhere. The hopper suction dredger has self-loading and unloading capacity. As an operation procedure, one or two suction pipes having trailing suction head connected to the end descend onto the river bed (desired dredging location). There are nozzles in the head that are connected to a high pressure installation that are capable of loosening the bed material (sand). With respect to limitation of its uses, since it prepare and collect dredge by loosening sediments and dragging and also steel teeth are not so big, so it is capable of working on relatively loose and soft substance.

As to the components of equipments, apart from the ship with engine, it has rearward extending one or more suction pipes, one or more dredging pumps in order to create suction (under pressure) to extract dredged sediment inside the pipe, transportation pipes in order to send dredge into the hopper, an overflow device to get rid of the redundant water overboard, kind of degassing devices to remove any gas from the substance.

A comparative consideration

Where pumping is possible, hydraulic dredgers are much more efficient than mechanical dredgers. However, any situation that limits the uses of hydraulic dredging other types can be used. For example, due to hard rock, debris or narrow channel with a lot of passing traffic, which does not allow the floating pipeline. In such circumstances, grab dredgers can be used. Again, in such situation hopper barges would be required to convey the dredged spoil to the desired dumping sites. On the whole, choosing an appropriate dredger type is a matter of optimization between the issues - dredging project, constraints and dredging equipments. A good guidance on the suitability of types of dredging equipments depending on the soil condition can be seen in Table 4.5

Table 4-5: Suitable types of dredging equipments on the soil criteria

Type of Equipment	Soil				Site		
	Silt	Clay	Gravel	Rock	OFF SHORE	IN SHORE	
						Traffic	No Traffic
Bucket Dredger	G/R	R/G	R/G	R/G	NA/R	NA	G
Plain Suction dredger	R	NA	G	NA	R/G	NA	G
Cutter Suction Dredger	Good	G	G	R	R	NA	G
Trailing Suction Hopper Dredger	Good	R	G	NA/R	G	G	G
Grab Dredger	R/G	R	G	NA	NA	NA/R	G
Back Hoe	R	G	G	R	R	R	G
Bed Leveller	Good	NA/R	R	NA	NA	G	G

R=restricted NA= NO APPLCATION

[Courtesy: H van Muijen, IHC]

Feasibility under this project

In this project the dredging operation involves a number of rivers of hundreds of kilometers and they are well-wide, and most locations of dredging will be well inside the coastline. From efficiency consideration with respect to all aspects – technical, capacity, cost, the mechanical dredgers would not be feasible. Their use is diminishing day by day, when other robust and efficient devices are available. Using of hydraulic-type would be feasible due to the size of the river (long, wide), type of sediments (no bed rock, all navigation paths and routes pass through flood plains and estuaries, all are late holocene sediments, no debris etc). Therefore, cutter suction type dredger would be the feasible option from both technical and financial point of view. However, while dredging locations are the coastal area, for example downstream of Bhola, Lakshmipur hopper suction type dredger might be considered provided if costing favours in choosing such type. In no way hopper suction would be a viable option for inland rivers, since the sailing distance will surely be very long, the capacity, therefore, be low and hence the cost for each unit volume of sediment would be quite high. As known so far known from BIWTA, it will be using for dredging inside inland rivers 18-inch cutter suction dredger. And in the estuary area either hopper suction or 26-inch cutter suction dredger will be used. Nonetheless, ultimately it is up to the contractor to select the dredging methodology. Therefore, it is possible that the contractor will pick different methodologies as per their own analysis of relative benefits and costs of each method in specific project areas.

4.5 Alternatives to Dredged Materials Management

Dredging is necessary to move water vessels easily throughout the project routes. The most environmentally friendly disposal method in most cases will be in-river disposal, as long as precautions are taken to avoid sensitive aquatic habitats and to minimize sediment suspension in the materials placement process. On the other hand, based on demand of the communities, some dredged material could be kept on the low land nearby the dredging locations. As a result, the people of the project area would be benefited by using materials in case of rural road maintenance, yard of community properties such as Eidgah, Mosque, Madrasah, and play ground of School/college, etc. However, this has to be weighed against potential negative social impacts associated with required land acquisition or lease, and possible displacement of households or livelihood activities. In addition, on-land disposal requires proper environmental management, which entails higher costs than in-river disposal. It may also be deposited along the river within compartment/stake yard of the traders/willing buyers. In case of big rivers the dredged materials may be deposited in the deeper channel of the river. By introducing/adopting latest technology the dredged materials may also be pushed to the sea. In case of contaminated sediment, DOE has instructed that all disposals shall be in the river, at least in the Shitalakhya and Buriganga rivers, which are the only rivers within the project area where contamination was found in baseline sampling surveys. Only in the highly unlikely case that in-river locations are not available for contaminated sediment, shall such sediments be brought on shore. In that case, proper isolation and treatment will be required to reuse to avoid/mitigate environmental hazards.

5 BASELINE ENVIRONMENT

5.1 Physical Environment

5.1.1 Climate

Temperature

The climate of the study area is sub-tropical with three seasons; namely summer from March to May, monsoon from June to October, and winter season from November to February.

BMD (Bangladesh Meteorological Department) take measurement of surface air temperature all day. However, daily maximum temperature indicates the recorded maximum temperature in a day, which normally occurs at noon. On the other hand, daily minimum temperature indicates the recorded minimum temperature in a daily cycle, which occurs at night.

The annual maximum temperature at Dhaka varies from 31.0°C to 42.3°C and in Sandwip from 30.6°C to 39.3°C. Maximum temperature occurs in the month of April to June and minimum temperature in January. Monthly minimum temperature varies from 6.4°C to 11.7° at Dhaka and in Sandwip 7.4°C to 13.0° during the period of December to March. These values of temperature are derived from the time series temperature data from 1967 to 2008 of Bangladesh Meteorological Department. Figure shows the variation of maximum, mean and minimum temperature at Dhaka and Sandwip.

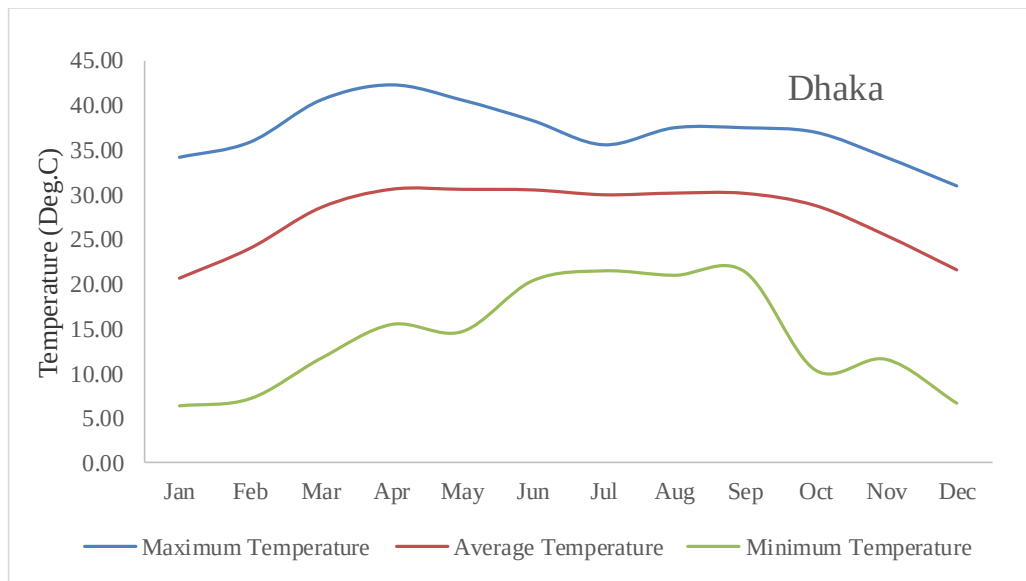


Figure 5-1: Variation of Monthly Maximum, Average and Minimum of Maximum Surface air temperature at Dhaka (**Source:** BMD)

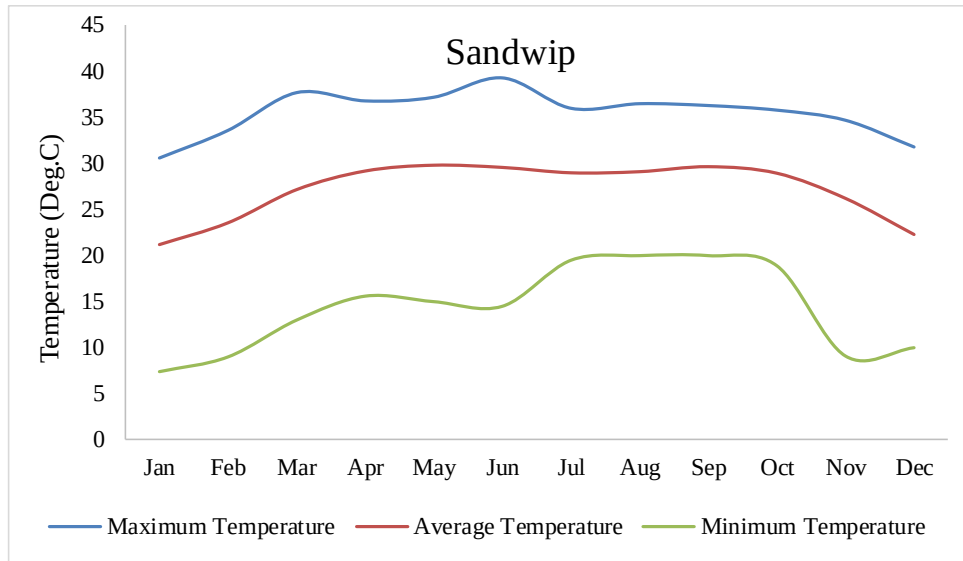


Figure 5-2: Variation of Monthly Maximum, Average and Minimum of Maximum Surface air temperature at Sandwip (**Source:** BMD)

Precipitation

Mean annual rainfall in this region is about 2100mm at Dhaka and 3480mm at Sandwip over a period of 40 years. About 75 to 80 percent of annual rainfall occurs during June to September. The maximum monthly rainfall during June to September varies from 450mm to 850mm in the study area. Monthly accumulated rainfall at Dhaka and Sandwip are presented in the Figure 5-3- Figure 5-4

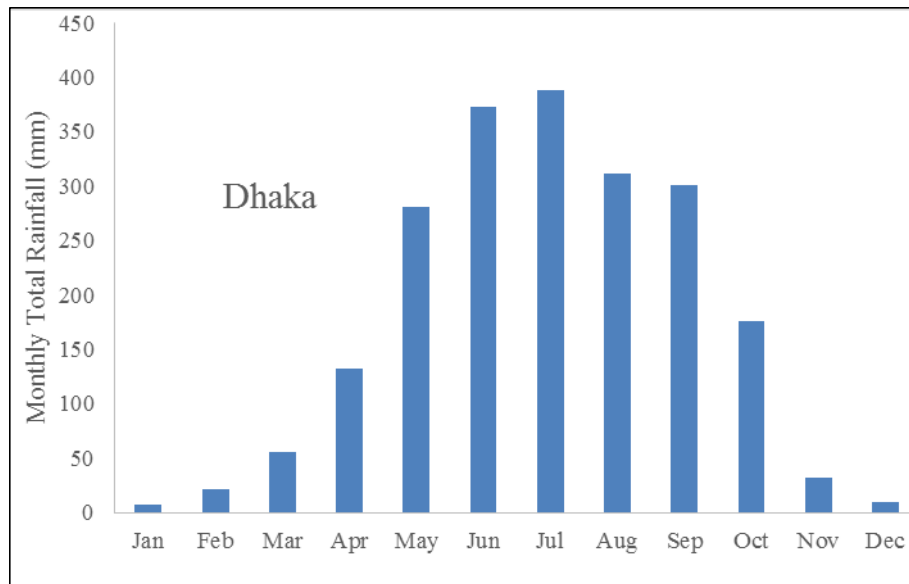


Figure 5-3: Monthly accumulated rainfall at Dhaka (**Source:** BMD)

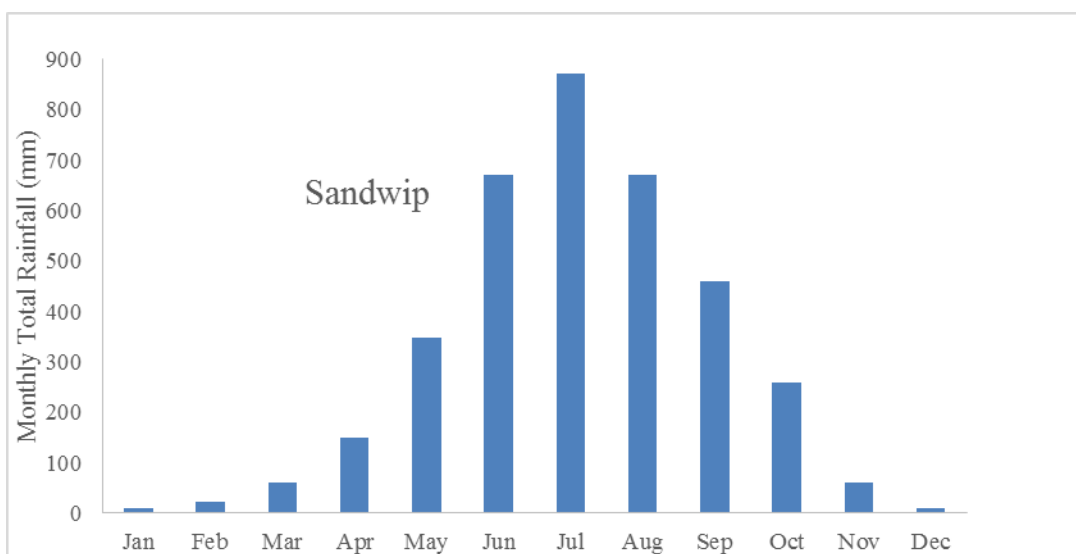


Figure 5-4: Monthly accumulated rainfall at Sandwip (**Source:** BMD)

Wind

The wind regime in the study area shows seasonal variation between the dry season (November to May) and the monsoon season (June to October). During the dry season the prevailing winds are calm. In the monsoon season the prevailing winds are from South-Southeast direction with an average speed of about 3-7.6 knot in the Meghna estuary based on data analysis of Bangladesh Meteorological Department for the period of 1966 to 2009. The maximum wind speed can be in the range of 32-99 knot. Table 5-1 shows the seasonal maximum and average wind speed in Lower Meghna estuary.

Table 5-1: Seasonal maximum and average wind speed in Lower Meghna estuary. (**Source:** BMD)

Seasonal maximum and average Wind speed (knot)								
Station	Pre-monsoon		Monsoon		Post-monsoon		Winter	
	(March-May)		June –September		October- November		December - February	
	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average
Chandpur	35	1.95	32	1.64	52	1.02	40	0.94
Barisal	65	4.47	99	4.23	80	2.86	50	2.87
Bhola	91	3.30	92	3.09	51	1.84	46	1.93
Hatiya	99	4.40	50	4.80	60	1.87	80	2.14
Sandwip	91	3.76	85	4.20	60	1.43	44	1.47
Chittagong	90	6.59	71	7.76	82	2.65	50	2.72

River Hydrology and Morphology

General

Bangladesh is a land of rivers. There are hundreds of rivers in Bangladesh with a large network of navigation routes. Transportation through waterways has always been a natural, environment friendly and relatively cheap mode of transport. Over the decades the navigability during dry season in many rivers of the country has been deteriorating because of morphological processes and for withdrawal of water from the rivers beyond the border and within the country. The navigability has been further aggravated by poor or no maintenance of inland waterways. Navigability of inland waterways is strongly influenced by river hydrology and morphology. River systems in Bangladesh exhibits high seasonality over a year i.e. abundant of water during monsoon and scarcity of water during dry season from December to May. Navigability becomes very critical during dry season in many river routes and ferry crossing because of siltation and inadequate water flow. It is very essential to know the hydrological and morphological characteristics along with biological environment of the river systems under the present study before implementing any navigation improvement measures. The present project includes the following major rivers for navigation improvement. Table 5-2 presents the major river systems of Dhaka-Chittagong corridor route.

Table 5-2: List of river systems under Dhaka-Chittagong Corridor with extension to Narayanganj, Ashuganj and Barisal

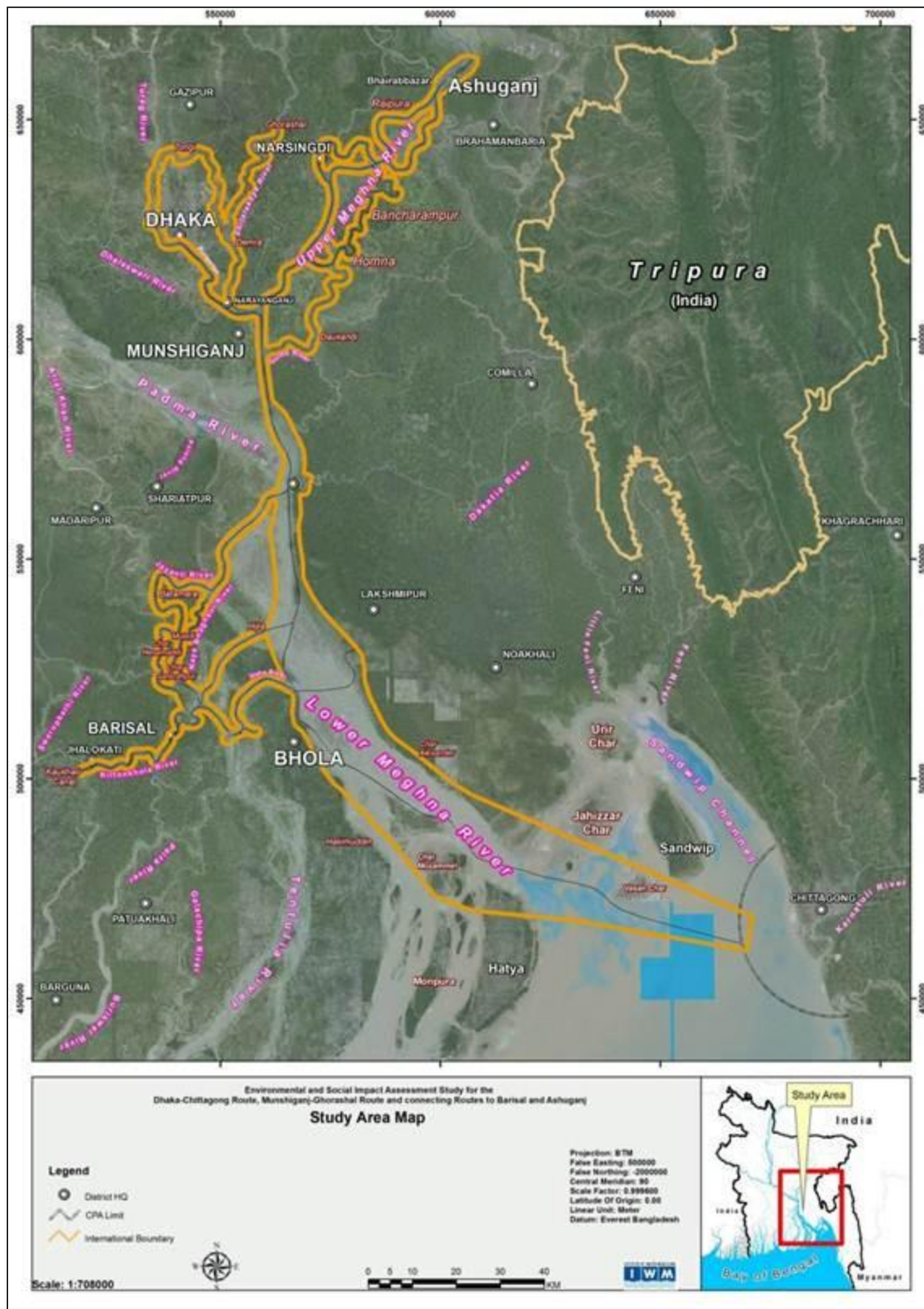
River(s)	From	To	Length (km)	Existing (BIWTA) River Class
Main Dhaka-Chittagong Corridor Route				
Buriganga, Dhaleshwari and Upper Meghna	Dhaka (Zinzira River Ghat)	Munshiganj	30	1
Upper Meghna	Munshiganj	Chandpur	39	1
Lower Meghna and Meghna Estuary	Chandpur	Chittagong	211	1
Narayanganj Extension				
Shitalakhya	Gorashal	Demra	35	3
Shitalakhya and Upper Meghna	Demra	Munshiganj	22	1
Ashuganj Extension				
Upper Meghna	Ashuganj	Munshiganj	83	1
Barisal Extension				
Lower Meghna Meghna Estuary Ariah Khan Naya Bhagnani Tentulia Maskata Kirtonkhola	Approach from AluBazaar North of Batamara up to Aat Hazar		83	2
	Approach via Muladiupto Aat Hazar		40	3
	Approach via Hijla up to Aat Hazar		32	2
	Approach via Ilisha up to Aat Hazar		37	1
	At Hazar	Jhalokati	30	1
Ferry Crossing Routes				
Lower Meghna	Chandpur	Shariatpur		
Lower Meghna	Lakshmipur	Bhola		
Tentulia	Beduria	Laharhat		

Source-BIWTA

Project Influence area

The project influenced area is defined based on navigation routes, vessel shelters, ferry crossing, locations of dredge materials disposal, which covers the rivers, estuary and flood plain within 1km to 7km vicinity on both bank of the rivers. The project influenced area is marked in orange in the

Figure 5-5. Annex-D represents measured data (Discharge and Water Level) within the project influence area during the study period.



Buriganga River

The Dhaka Metropolitan City is surrounded by the Buriganga-Turag, Balu, Lakhya and Tongi khal, which make a system of a circular water route and preserves the natural environment of the city. These rivers are gradually silted up including its off-take from the main source of the Brahmaputra/Jamuna River over the years. Currently, the flow of these rivers during dry season becomes very insignificant, which triggers the river water pollution as a serious problem. Such declined condition of river flows with morphological changes reduces the navigation and water-way communication system. Huge sedimentation at the off-take and river reaches is the major problem in achieving sustainable navigability and other economic development.

The rivers surrounding the Dhaka city receives water mainly from the Jamuna/Brahmaputra River including its floodplain flow during monsoon and during dry period, the off-take is fully cut-off due to huge sedimentation and the tidal water from the Meghna River enters into the river systems. In the dry period (from November to May) all the peripheral rivers are completely tidal and reversal of flow occurs in these rivers.

The Buriganga River, having a length of only 17km, is one of the most important rivers in Bangladesh. This river is economically very important to Dhaka. Launches and country boats provide connection to other parts of Bangladesh. It provides important services to the residents, including water supply, navigation, recreation, sanitation and flood control. This vital river however has become extremely polluted and is close to biological death for several reasons. The tremendous increase in population over the last three decades has created enormous environmental problems, including among others the disposal of solid waste, sewage and drainage problems. River depth is decreasing due to sludge deposition hence affecting the navigation. Proper dredging of the existing river and removing non degradable matters from the river bed are essential for restoring the river for its multi-purpose services.

The headwaters of the Buriganga River have been gradually reducing during the past few decades due to reduced flow, siltation and channel shifting. This has resulted currently to a situation where the flow is bare minimum in the dry season making the Buriganga less suitable for navigation and also the deteriorating the quality of the river water. A typical water level hydrograph at the Millbarak on the Buriganga River, which has little tidal influence, is shown in the Figure 5-6. The high seasonal variation is seen in the hydrograph.

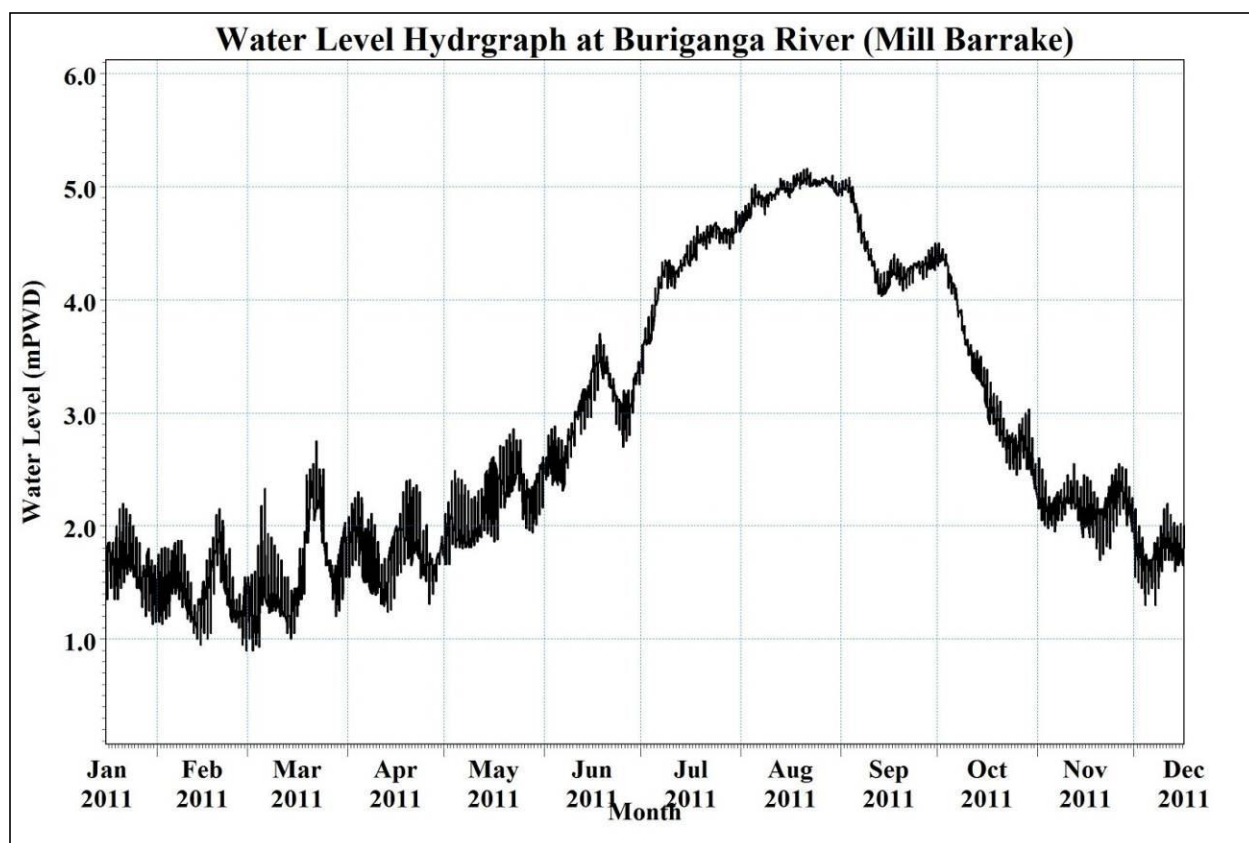


Figure 5-6: Observed water level hydrograph at Mill Barrake on the Buriganga river (**Source:** BWDB)

The monthly statistics of daily water level is illustrated in the Table 5-3. Over the period of 1996 to 2012, it is seen that the minimum water level can fall to 0.52 mPWD and water level can rise to 7.2 mPWD.

Table 5-3: Monthly water level statistics of Buriganga river at Mill Barrake (**Source:** BWDB)

Historical WL at Mill Barrake (Dhaka) on Buriganga River (1996-2012)			
Month	Maximum WL (mPWD)	Average WL (mPWD)	Minimum WL (mPWD)
January	2.2	1.39	0.65
February	2.64	1.24	0.52
March	2.75	1.37	0.6
April	3.17	1.79	0.77
May	3.95	2.38	1.14
June	4.87	3.47	2.04
July	6.68	4.67	2.9
August	6.70	4.95	3.43
September	7.24	4.76	3.32
October	5.41	3.75	1.92
November	3.83	2.42	1.12
December	2.65	1.75	0.9

The minimum daily water level from December to April is below 1 mPWD. However, average monthly water level varies from 1.24 mPWD to 1.79 mPWD for the same period indicating higher navigation depth for a considerable period even in the dry season.

The maximum flow occurs during monsoon, which is 2630 m³/s. The minimum flow over the period of 1996 to 2012 is 110 m³/s. The river exhibits high seasonality of water flow triggering a critical condition for navigability during dry season. Figure 5-7 shows the monthly variation of water flow/discharge of Buriganga River at Mill Barrake.

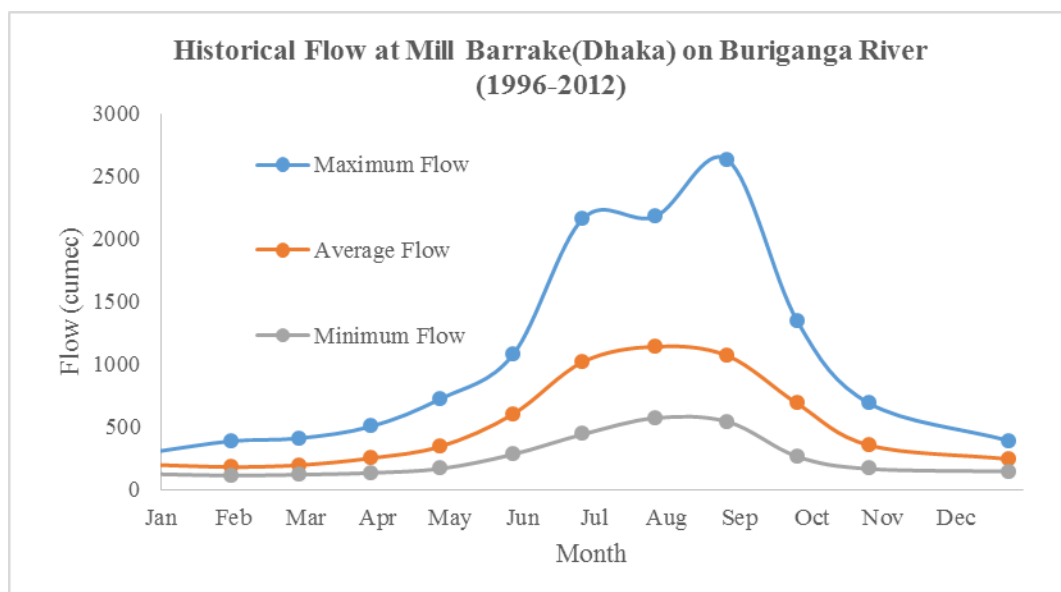


Figure 5-7: Monthly minimum, maximum and average discharge hydrograph of Buriganga river at Mill Barrake (Source: BWDB)

Shitalakhya River

The river Shitalakhya flows along the eastern side of Dhaka and Narayanganj districts and falls into the river Dhaleswari near Madanganj of Narayanganj. The river is 110 km long and 250 m wide, having 375 hectare water area. The river flows through Gazipur. The Shitalakhya River was once an important center for the industry. Even today, there are centres of artistic weaving on its banks. There also are a number of industrial units on its banks, including the thermal power plants. Industrial affluent dumped into the river resulting in high levels of pollution is a cause for concern. There is a river port in Narayanganj, numerous launches move out along the river to different parts of Bangladesh. The government has approved construction of a container terminal on the river Shitalakhya with foreign investment. To understand the seasonal variation, a typical hydrograph at Demra on the Sitalakhya River is shown in Figure 5-8. The water level variation over the years is very high and during dry season the river is influenced by tide as seen in the water level hydrograph.

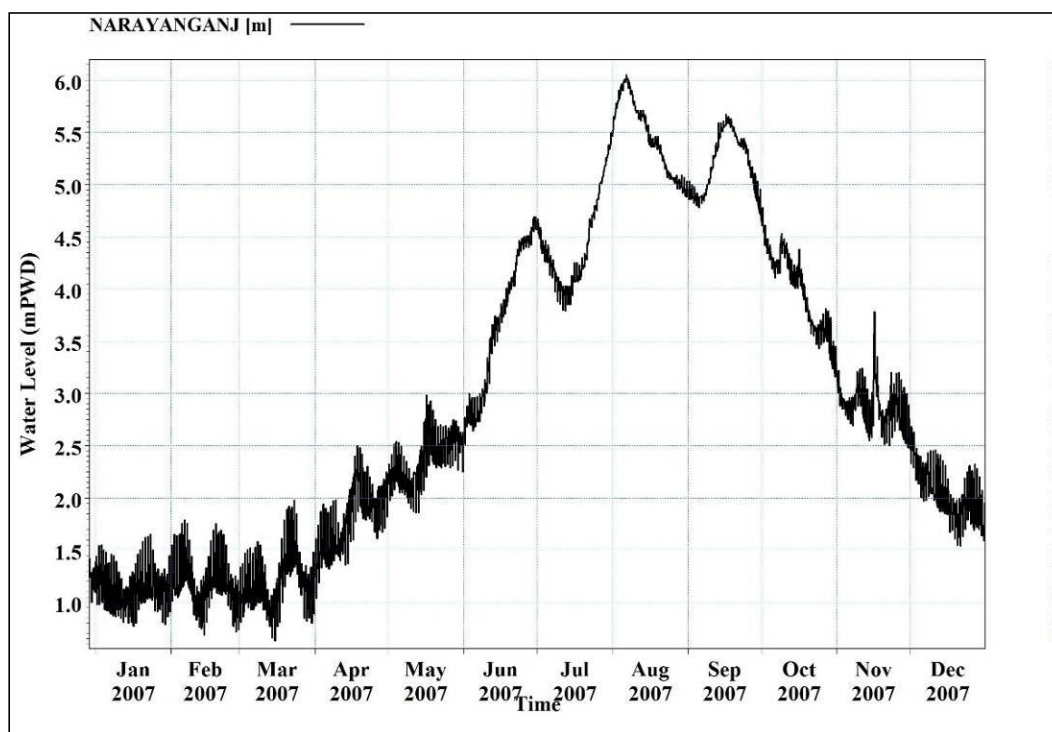


Figure 5-8: Observed water level hydrograph on Shitalakhya river at Demra (Source: BWDB)

Daily water level variation is from 0.72 mPWD to 6.92 mPWD, which implies huge seasonal variation of available navigation depth. Water level starts to rise from the month of April and reach at peak in the month of August as seen in the Table 5-4. Water level remains at higher level from April to November providing good navigation depth in this period of the year.

Table 5-4: Monthly water level statistics of Shitalakhya river at Demra (Source: BWDB)

Water Level Variation in Shitalakhya River at Demra (1990-2012)			
Month	Maximum WL	Average WL	Minimum WL
January	2.57	1.60	0.72
February	2.28	1.49	0.81
March	3.09	1.63	0.74
April	3.41	2.08	1.07
May	4.10	2.71	1.37
June	5.27	3.75	2.33
July	6.70	4.95	3.15
August	6.92	5.25	3.84
September	6.70	5.01	3.85
October	5.57	4.06	2.27
November	3.87	2.65	1.43
December	2.81	1.97	1.15

The water flow varies from 40m³/s to 540m³/s over a year. During dry season the water flow/discharge is very low. The monthly average flow varies from 65m³/s to 75 m³/s during the period from January to March causing low river water level that results in inadequate navigation depth. The monthly maximum, minimum and average flows are presented in the Figure 5-9.

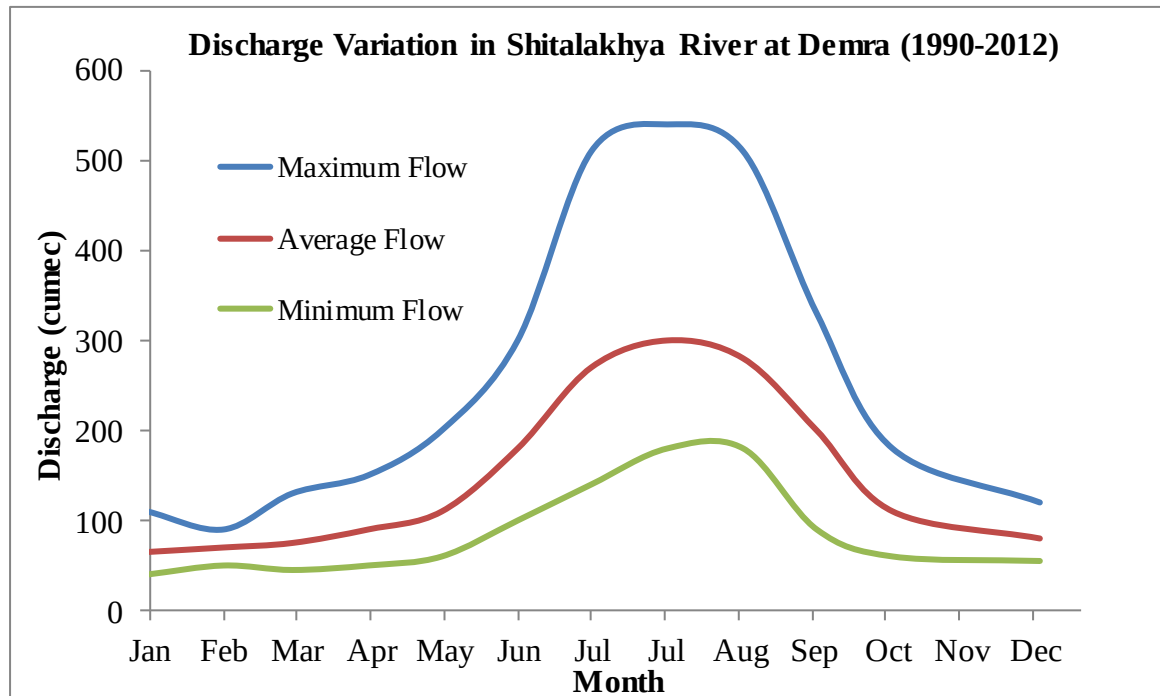


Figure 5-9: The monthly maximum, minimum and average flow hydrographs of Shitalakhya river at Demra (Source: BWDB)

The Sitalakhya system is a stable meandering river. The reduction of the sinuosity of the Sitalakya near its downstream part indicates that the water and sediment charges are in balance with the channels capacity.

Dhaleswari River

The Dhaleswari River is the main left-bank distributary of the Jamuna/Brahmaputra River and is the main channel of a complex river system. The maximum flow in the river is around 1400 m³/s. Off-take morphology of this river from the Brahmaputra/Jamuna comprises a system of watercourses subject to continuous morphological changes thereby influencing the flow entrance as well as location at which it takes place. During the construction period of Jamuna Bridge in 1995, the off-take of Old Dhaleswari became completely closed by construction of closure. However, as an immediate response of the Jamuna, there was a further widening of the already existing small spill channel around 2km downstream of the present Jamuna Bridge location along the left side and got connected to the old course of Old Dhaleswari river. Previously, the pungli was a distributary from the Old Dhaleswari River. Now, the Old Dhaleswari becomes the inland river and the Pungli is directly feeding from the Brahmaputra/Jamuna. The maximum flow in the Pungli is around 600m³/s. The off-taking river, Dhaleswari is flowing full/partly in the

monsoon starting from June to October and other months remain dry in a year (Figure 5-10). The downstream part (near RekabiBazaar) of the Dhaleswari River has little bit tidal influence with a fluctuation of around 0.5m. The percentage historical changes of annual flow volume of the Dhaleswari River with respect to the Bramaputra/ Jamuna flow. The flow through the Dhaleswari River was nearly 7% of the Jamuna flowing 1960's and rapidly declined to 3.5% of its parent river in 1970. This flow continued till the early 1990's. Probably, after closing the north off-take of the Dhaleswari River in connection with the Jamuna Bridge, the flow of the river further reduced to 1% of the Jamuna River and thus various planform parameters of the river adjusted themselves by reducing flow of the river (IWM, 2004). The flow at the offtake of the Dhaleswari River has been analysed to find the minimum, average and maximum flow. Figure 5-10 and Table 5-5 show the monthly flow statistics over the year. It is seen that the upstream flow is almost zero during dry season, which implies that the offtake needs to be dredged for restoring the dry season flow.

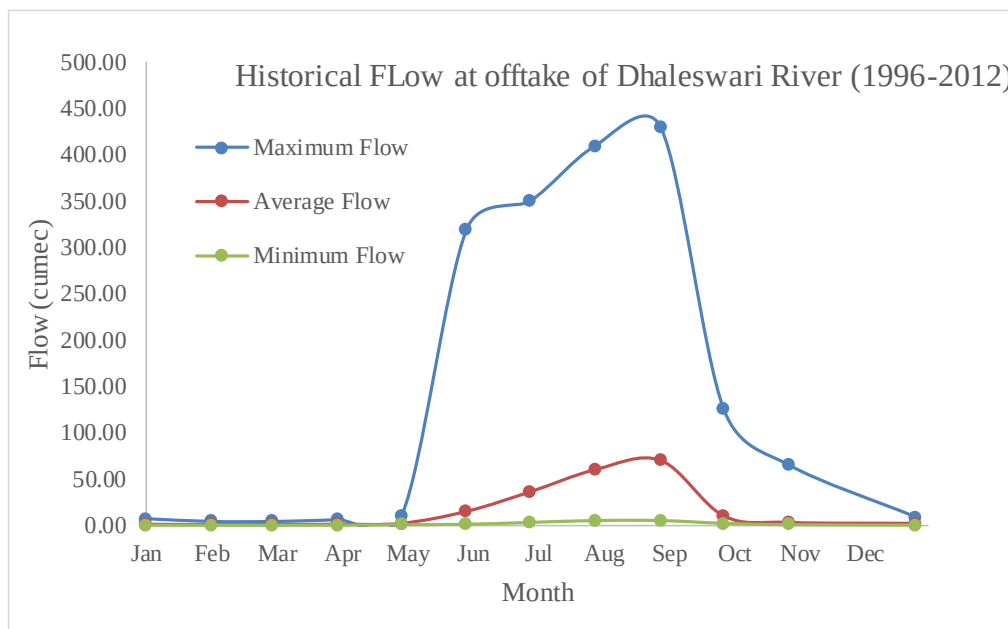


Figure 5-10: Monthly water flow hydrographs of Dhaleswari river at Off-take (Source: BWDB)

During monsoon maximum flow is quite significant and can be 430 m³/s as seen in the Table 5-5.

Table 5-5: Monthly flow statistics of the Dhaleswari river at the Off-take (1996- 2012) (Source: BWDB)

Historical Flow at offtake of Dhaleswari River (1996-2012)			
Month	Maximum Flow (cumec)	Average Flow (cumec)	Minimum Flow (cumec)
January	7.00	1.00	0.00
February	4.00	0.60	0.00
March	4.01	0.70	0.00
April	6.00	1.00	0.03
May	10.00	2.00	0.50
June	320.00	15.00	1.00
July	350.00	36.00	3.00
August	410.00	60.00	5.00
September	430.00	70.00	5.00
October	125.00	10.00	2.00
November	65.00	3.00	0.50
December	9.00	2.00	0.04

Upper Meghna River

The upper Meghna River flows in the north-eastern part of Bangladesh. The Upper Meghna carries the combined flow of the Surma and the Kushiara Rivers which originate in the Indian hills northeast of Bangladesh. The Surma River flows through the Sylhet area which is rapidly sinking away. A number of tributaries of the Surma originate from the Sisang hills in India and from piedmont areas. They bring quite some sediment (boulders, gravel, sand), that most probably settles in the Sylhet area.

Going in downstream direction, the Upper Meghna River is joined by the Old Brahmaputra at Bhairab Bazaar. The Dhaleswari is another tributary (and another distributary from the Jamuna system) and it joins the Upper Meghna River at Munshiganj on the right bank. Some tributaries that originate from the Tripura hills join the Upper Meghna at the left bank. Although having some reaches with a system of various channels, the Upper Meghna River can be characterized as a river mainly meandering within a well-defined high water bed and having flood discharges up to some 16000 m³/s.

1) Water Level

Time series daily water level of Upper Meghna River at Bhairab Bazaar was analysed to find the statistics of water level in characterising the variation of water level over a year. **Error! eference source not found.** presents the monthly variation of water level and Figure 5-11 shows observed water level at Bhairab Bazaar. The daily water levels at Bhairab Bazaar vary between 0.74 m and 7.78 m (see Table 5-6).

Error! Reference source not found. demonstrates water level statistics. The water level along the Upper Meghna is subjected to tidal influence. During low flows in the Upper Meghna River

the tidal range near the confluence with the Padma River is about 1m and under those conditions still a vertical variation in tide of some 0.2 m is noticeable in Bhairab Bazaar.

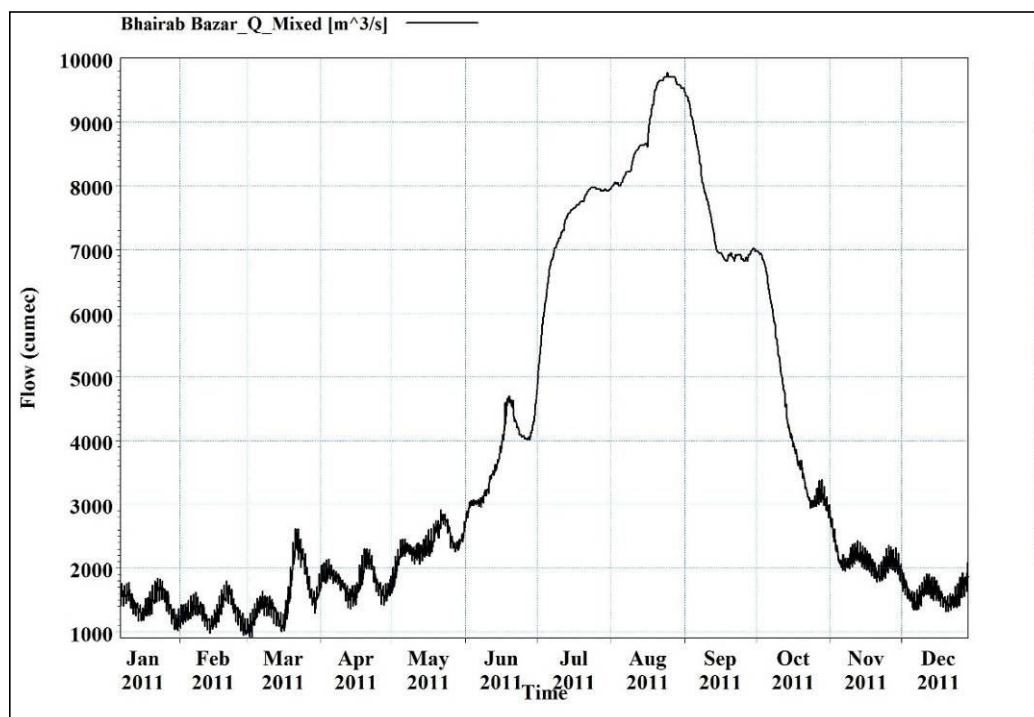


Figure 5-11: Observed water level hydrograph of the Upper Meghna River at Bhairab Bazaar (Source: BWDB)

The minimum water level can fall below 1m from January to March as seen in the monthly statistics of water level and there is every likely to experience inadequate navigation depth in this Class 1 route during this period. Table 5-6 presents the water level statistics. The seasonal variation is quite significant and seasonality index i.e., ratio between maximum and minimum water level over a year is about 9 which implies higher navigation depth from June to October.

Table 5-6: Water level statistics of Upper Meghna River at Bhairab Bazaar (Source: BWDB)

Historical water level at Bhairab Bazaar (Upper Meghna River, Bangladesh) for 1970–2013			
Month	Maximum WL (mPWD)	Average WL (mPWD)	Minimum WL (mPWD)
Jan	2.22	1.59	0.89
Feb	2.29	1.48	0.74
Mar	2.94	1.64	0.90
Apr	3.43	2.16	1.09
May	5.23	2.89	1.63
Jun	6.14	4.21	2.06
Jul	7.78	5.73	3.51
Aug	7.65	6.00	4.29

Historical water level at Bhairab Bazaar (Upper Meghna River, Bangladesh) for 1970–2013			
Month	Maximum WL (mPWD)	Average WL (mPWD)	Minimum WL (mPWD)
Sep	7.66	5.74	4.19
Oct	6.55	4.71	2.31
Nov	4.91	2.89	1.51
Dec	3.14	2.01	1.06

2) Discharges

The major contributors to the river upstream of Bhairab Bazaar are from the Baulai, the Surma and the Kushiya rivers, covering an area of 62,960 km². The river stretch Meghna River from Bhairab Bazaar to Chandpur is about 125 km in length and known as Upper Meghna River. Width of the river varies from 1 km to more than 10 km. The river channel is more or less well defined upstream of its confluence to the Padma. The river bed and banks consists mainly of clayey-silt which is often loosely packed and is susceptible to liquefaction at some places. Of the three major rivers, the Upper Meghna carries relatively less sediment. The range of variation of other characteristic sizes along the Upper Meghna River for single value of D_{50} is 0.130mm. Figure 5-12 shows the minimum, maximum and monthly mean discharge of the river at Bhairab Bazaar.

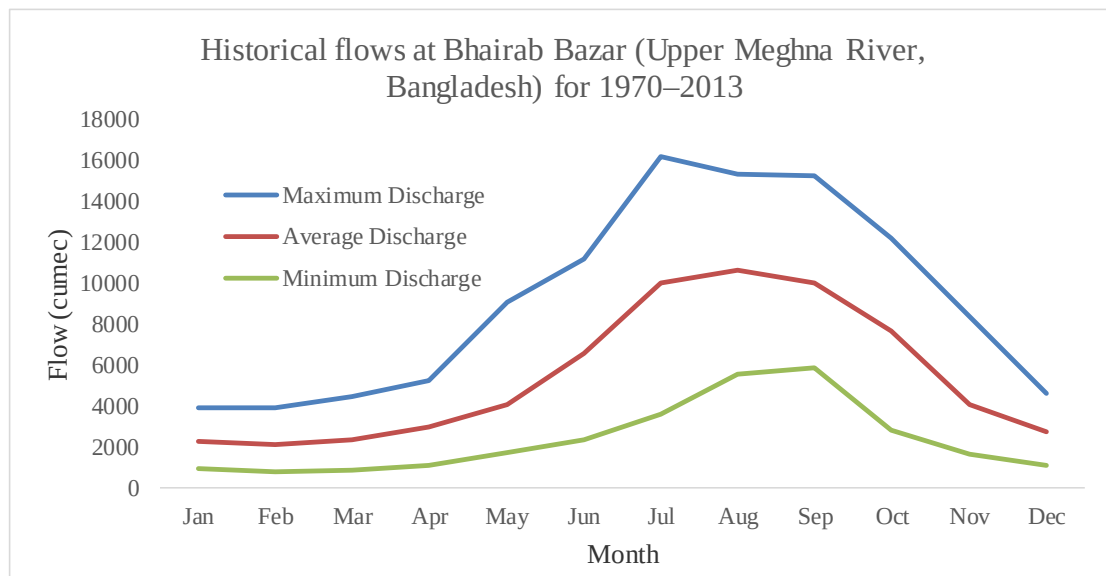


Figure 5-12: Monthly flow hydrograph of the Upper Meghna river at Bhairab Bazaar (Source: BWDB)

The maximum flow is about 16,203m³/s and occurs during July to August. The river discharge falls significantly during dry season and becomes about 800m³/s resulting in very low water level as well as navigation depth.

Water flow in the river governs the navigation depth along the river length. There is a high seasonal variability of water flow in the Upper-Meghna River (Table 5-7). The average daily

water flow at Bhairab Bazaar varies between 0.74m and 7.78 m over a year. The lowest figure demonstrates the small slope along the river during lowest discharges.

Table 5-7: Water flow statistics (1970-2013) at Bhairab Bazaar of Upper-Meghna river, (Source: BWDB)

Month	Maximum Discharge (cumec)	Average Discharge (cumec)	Minimum Discharge (cumec)
Jan	3920	2250	940
Feb	3880	2130	800
Mar	4460	2310	840
Apr	5250	2930	1060
May	9060	4050	1680
Jun	11200	6560	2340
Jul	16200	9990	3620
Aug	15360	10660	5530
Sep	15240	10000	5830
Oct	12230	7630	2800
Nov	8360	4080	1620
Dec	4600	2760	1060

Estuarine and Coastal Hydrology

Tide

The Meghna Estuary is a very dynamic estuarine and coastal system. Here, at the northern end of the Bay of Bengal, the combined flow of two of world's largest rivers, Ganges and Brahmaputra (Jamuna), finds its way through the Lower Meghna River to the sea. Erosion and accretion rates are high and the area is periodically subject to severe storms and cyclones, these latter accompanied by tidal bores and storm surges. Figure 5-13 shows the map of Lower Meghna Estuary.

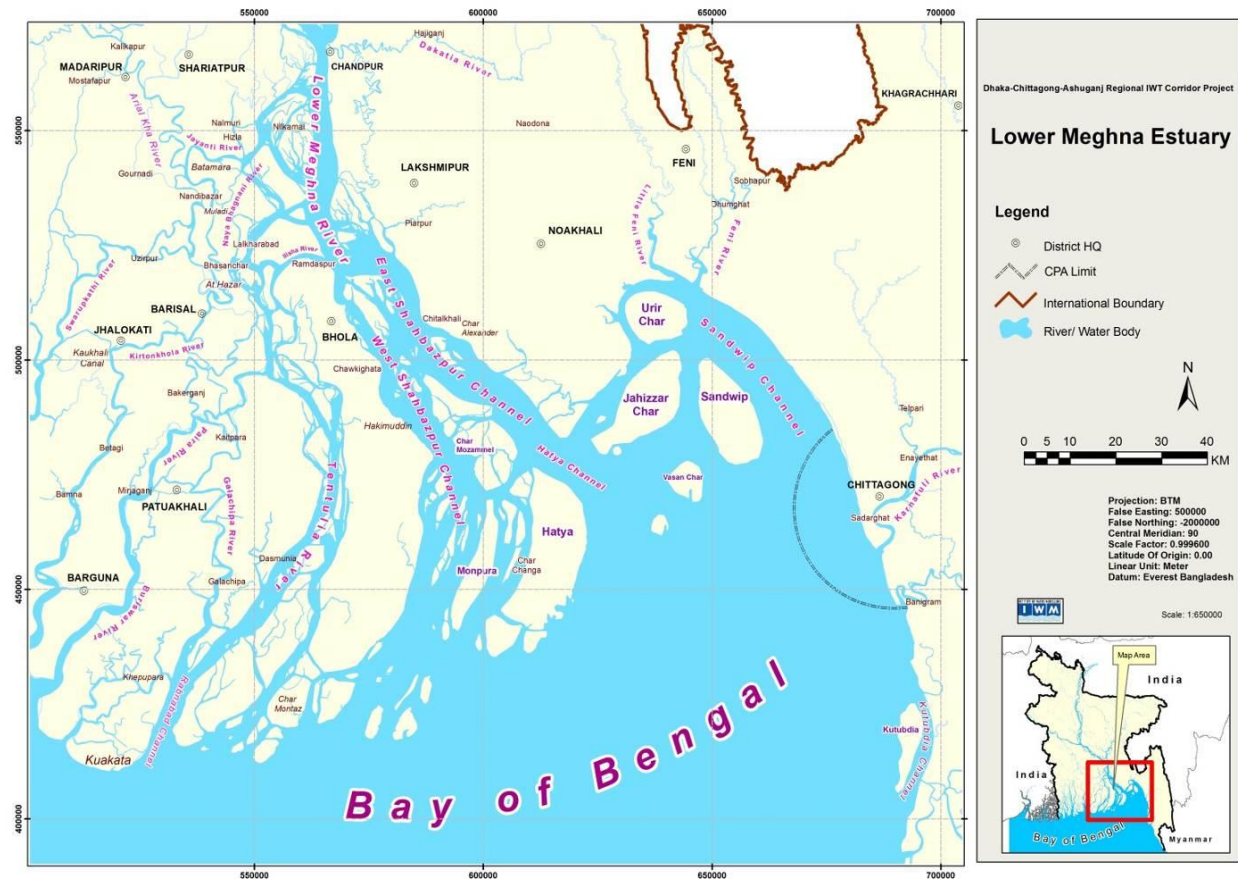


Figure 5-13: Map showing the Lower Meghna Estuary

The Lower-Meghna, Tentulia, Kirthonkhola rivers and Meghna Estuary serve as important navigation routes for Inland Water Transport, which are characterized by tidal and wave actions. The tidal wave from the Indian Ocean travels through the deeper part of the Bay of Bengal and approaches the coast of Bangladesh approximately from the south. It arrives at Hiron Point and at Cox's Bazaar at about the same time. The extensive shallow area in front of the large delta causes some refraction and distortion. Also some reflection of the tidal wave occurs contributing to a significant amplification of the tidal wave in Hatiya and Sandwip Channels.

Tides in the Bay of Bengal are semi-diurnal in nature, exhibiting two high waters and two low waters per day. The amplitudes of the two cycles differ slightly. Over a longer term, a fortnightly variation in amplitude between spring and neap tides is also evident, with spring tide amplitudes approximately 2.5 to 3 times higher than the neap tide. The duration of one tidal cycle is 12hr 25 minutes and duration of 2 tidal cycles is 24hr 50 minutes. The water level variation is dominated by a semi-diurnal tide with a considerable variation from neap to spring tides. In the western part of the coastal area of Bangladesh the average tidal range is approximately 1.5 m. In the area around Sandwip, the tidal range is significantly higher. Figure 5-14 shows maximum tidal variation at the west coast of Sandwip Island. It is seen the maximum tidal range is about 6.6m. The area around Sandwip Island is macro-tidal with variation in tidal range of about 3 to 8 m.

The area between Bhola and Hatiya (Shabhzpur Channel) is meso-tidal, with tidal range of (2 to 4) meter.

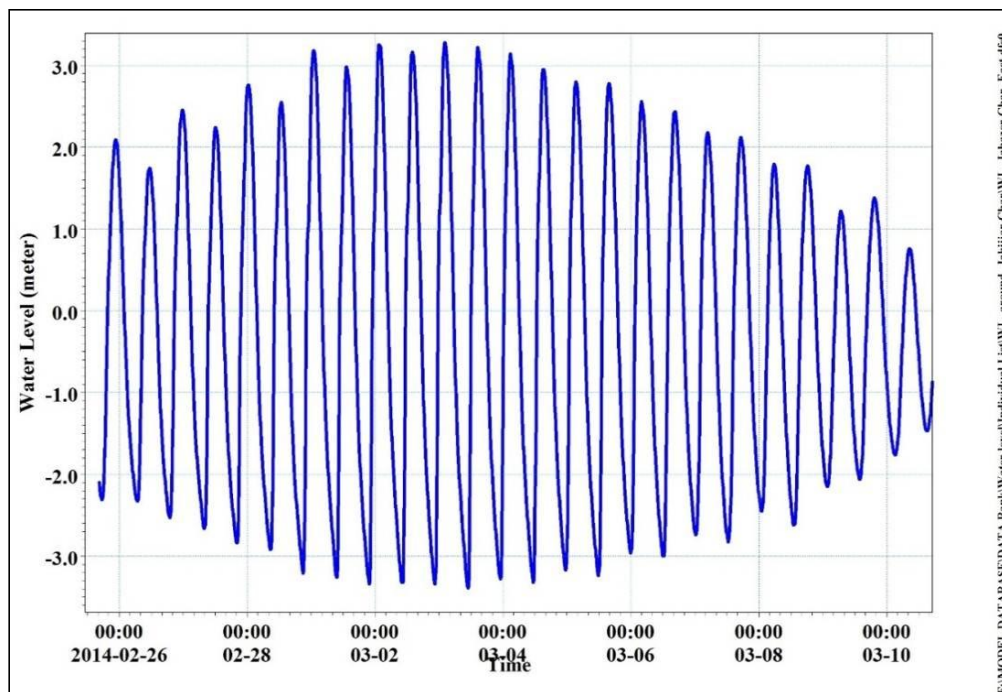


Figure 5-14: Tidal variations at the west coast of Sandwip Island (Source: IWM)

There is a considerable seasonal variation of water level in the Meghna Estuary due to huge onrush of upstream flow and wind setup in the Bay of Bengal during monsoon. This seasonal variation influences the navigability in the river and difference of navigation depth is more than a meter between dry and monsoon. Considering the importance of seasonal variation, the seasonal characteristics of the water level is ascertained.

Moving average considering 56 tidal cycles of half hourly observed water level data was carried out to find the seasonal variation of water level in the Lower Meghna River. Figure 5-15 shows the seasonal variation of the water level in the Lower-Meghna River at Chitalkhali of Lakshmipur district. It is seen that seasonal variation is about 1.4m, which also varies year to year depending of upstream flood flow during monsoon.

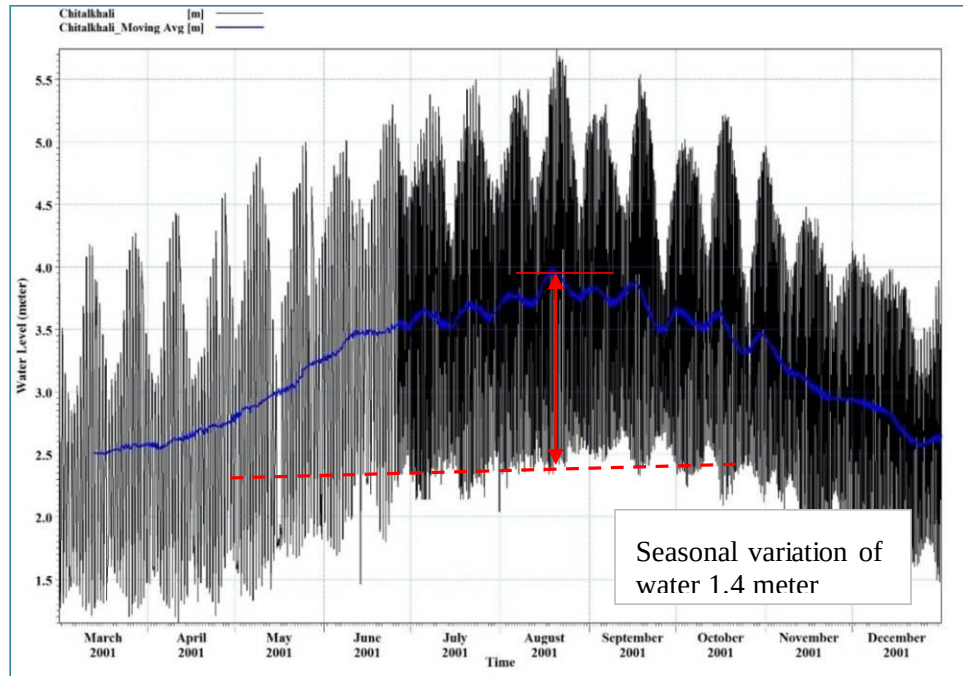


Figure 5-15: Tidal variation, tidal range and seasonal variation in the west of Sandwip Island
(Source: IWM)

The seasonal variation of the mean high water level (from dry to the wet season) decreases significantly along the Lower Meghna Estuary in southwards directions. The seasonal variation of the mean high water level at Chandpur is about 3 m. The variation in the southern part of the Bangladesh coast is about 0.8 to 2.1 m.

The monthly minimum, mean and maximum water level over a year is shown utilizing the time series water level data over a period of 22 years. Figure 5-16 and Table 5-8 shows the monthly variation of water level in the Lower Meghna River at Chandpur. Considerable variation of water level is seen over a year in minimum, mean and maximum water level. It is evident from the table the water level variation is 0.18m, PWD to 5.52m, PWD showing high seasonal variation. However, the navigation depth at and around Chandpur is adequate over the year.

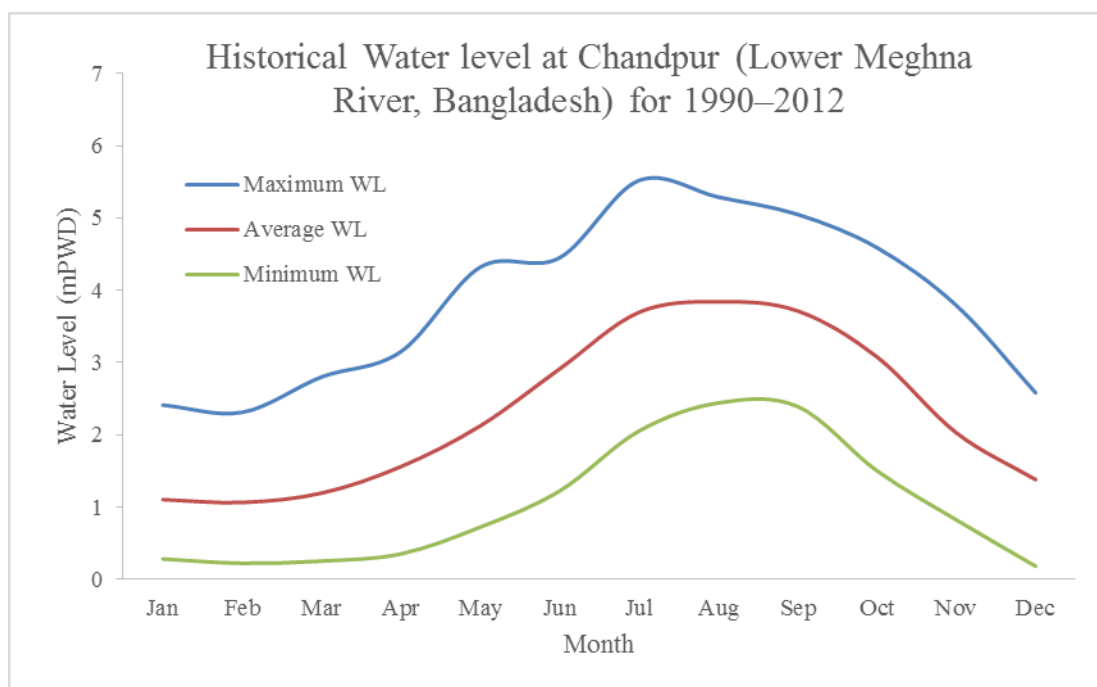


Figure 5-16: Monthly variation of water level in the Lower Meghna river at Chandpur (1970–2013) (Source: BWDB)

Table 5-8: Monthly maximum, average and minimum water level (Lower Meghna River, 1990–2012) at Chandpur (Source: BWDB)

Water level statistics at Chandpur			
Month	Maximum WL (mPWD)	Average WL (mPWD)	Minimum WL (mPWD)
Jan	2.41	1.10	0.28
Feb	2.31	1.06	0.22
Mar	2.8	1.19	0.25
Apr	3.15	1.56	0.35
May	4.32	2.12	0.72
Jun	4.45	2.91	1.22
Jul	5.52	3.69	2.05
Aug	5.29	3.84	2.44
Sep	5.05	3.71	2.39
Oct	4.59	3.08	1.5
Nov	3.79	2.03	0.82
Dec	2.58	1.38	0.18

It is evident from the Table 5.8 and the Figure 5-16 that there is a significant variation of monthly maximum, average and minimum water level at different months. Average monthly water level during dry season (December to May) varies from 1.06 m to 2.12m; the seasonal variation of average water level is about 2.78m over a year. It implies that on an average about 2.78m additional navigation depth is available during monsoon compared to the dry season. However, the Lower Meghna river at an around Chandpur is very deep and usually there is no navigation problem, and there is an evidence of it in the recent bathymetric survey carried out by BIWTA. Water level statistics at different locations of the Meghna estuary is presented in the Table 5-9.

Table 5-9: Water level statistics at different locations of the Meghna estuary (Source: BWDB)

Station	River Name	Dry Season (November-April)			Monsoon (May - October)		
		Maximum WL (mPWD)	Mean WL (mPWD)	Minimum WL (mPWD)	Maximum WL (mPWD)	Mean WL (mPWD)	Minimum WL (mPWD)
Chandpur	Lower Meghna	2.65	1.26	0.18	4.98	3.45	1.22
Chitalkhali/ Laxmipur	Lower Meghna	3.15	1.05	-0.95	4.15	2.05	-0.35
Char Ramdaspur	Tentulia	3.16	1.21	-0.06	4.38	2.35	0.66

The critical period for navigation is dry season and it is seen that the minimum water level drops considerably at the downstream of the Lower Meghna River. The minimum water level is quite low in the East Shabazpur channel and in the Tentulia River. If sedimentation occurs along the navigation channel at these locations then adequate draft for cargo traffic might not be available.

Water flow

The Lower Meghna River conveys the combined flow of Ganges, Brahmaputra and Upper Meghna rivers. Again the combined flow of Ganges and Brahmaputra is known as the Padma river flow, which meets at Lower Meghna River at Chandpur. The discharge of the Padma and Upper Meghna rivers characterise the water flow of the Lower Meghna River. Long-term record of discharge is not available at Chandpur since it is not a routine discharge gauging station of BWDB or BIWTA. Hence, discharge characteristics of the Padma River are used to characterise the water flow Lower Meghna River. The monthly mean discharge of the Padma river varies from 5800m³/s in the month of February to 72,000m³/s in August (Source: BWDB time series discharge data) at Baruria (

Figure 5-17). The average monthly minimum flow in the Padma River is 3700m³/s in February and 33400m³/s in August. These statistics is based on the time series data of discharge over a period of 42 years.

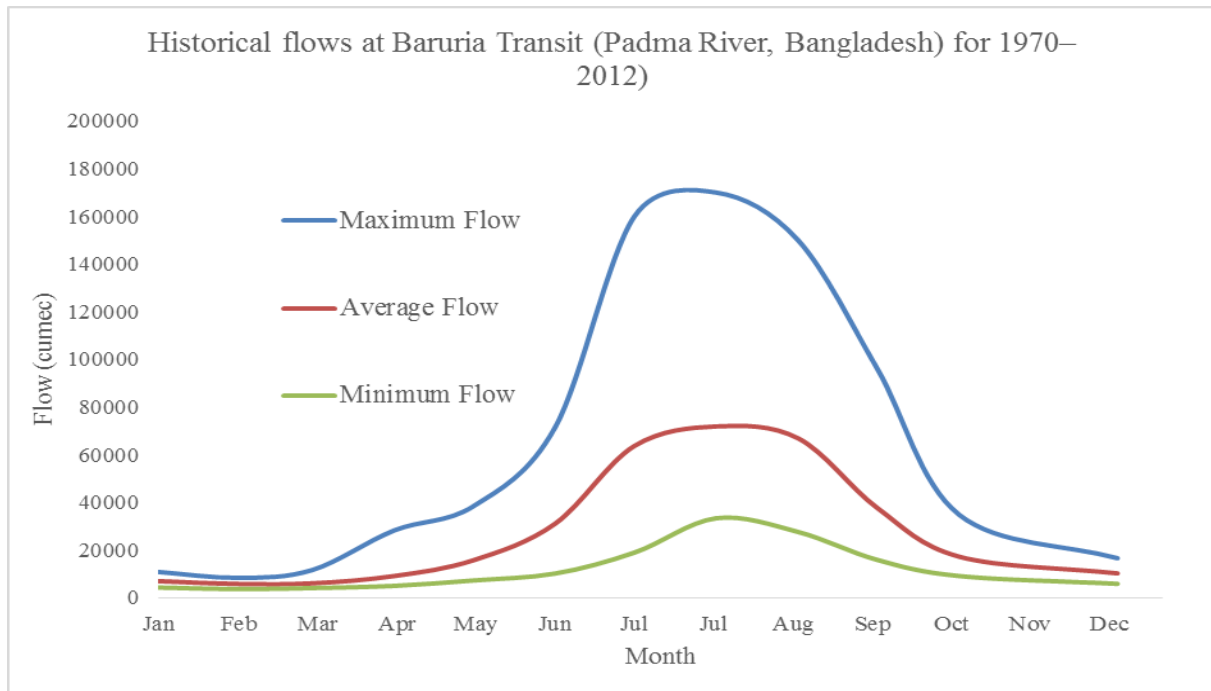


Figure 5-17: Monthly flow hydrograph of Padma river at Baruria (Source: BWDB)

The water flow/discharge in the West Shahbazpur Channel between Bhola and Monpura Island is presented in the Figure 5-18. It is observed that the peak discharge may reach at 100,000m³/s.

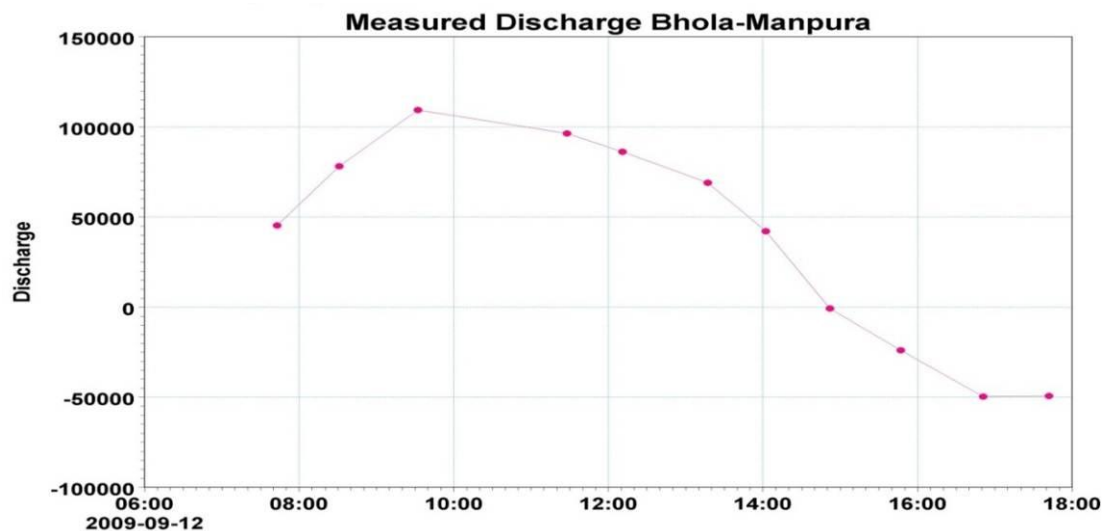


Figure 5-18: Observed discharge in a tidal cycle in the channel between Bhola and Manpura Islands

Flow distribution in the different channel of the Lower Meghna Estuary

Water flow in the channel is the independent variable to ensure the navigation depth and long term stability of the navigation channels. To estimate the overall water flow distribution in the various channels of the lower Meghna estuary the hydrodynamic conditions has been simulated for one month for both dry (February-March) and wet (August) periods for the available flow conditions of 2009. The distribution of flow among the main channels in the Meghna Estuary as found from the simulations is presented in Table 5-10 and Figure 5-19 for the dry season and in Table 5-11 and Figure 5-20 for the wet season.

Table 5-10: Overall flow distribution during Dry Season

Location	Maximum flow (m ³ /s) during flood tide(High Tide) in Dry Season	Maximum flow (m ³ /s) during ebb tide (Low Tide) in Dry Season
Hatiya Channel at North Hatiya	121,601	81,457
East Shahbazpur Channel (at level of Manpura)	41,480	33,737
West Shahbazpur Channel (at level of Manpura)	105,779	89,005
Tetulia	17,772	16,051
East Shahbazpur Channel (at level of Char Gazaria)	74,396	46,950
West Shahbazpur Channel (at level of Char Gazaria)	54,269	49,987

¹⁾ Source: IWM, 2009

Table 5-11: Overall flow distribution during Wet Season

Location	Maximum flow (m ³ /s) during flood tide(High Tide) in Monsoon Season	Maximum flow (m ³ /s) during ebb tide (Low Tide) in Monsoon Season
Hatiya Channel at North Hatiya	154,490	136,818
East Shahbazpur Channel (at level of Manpura)	60,373	58,019
West Shahbazpur Channel (at level of Manpura)	133,856	151,168
Tetulia	17,969	16,739
East Shahbazpur Channel (at level of Char Gazaria)	81,801	105,672
West Shahbazpur Channel (at level of Char Gazaria)	61,361	117,916

¹⁾ Source: IWM, 2009

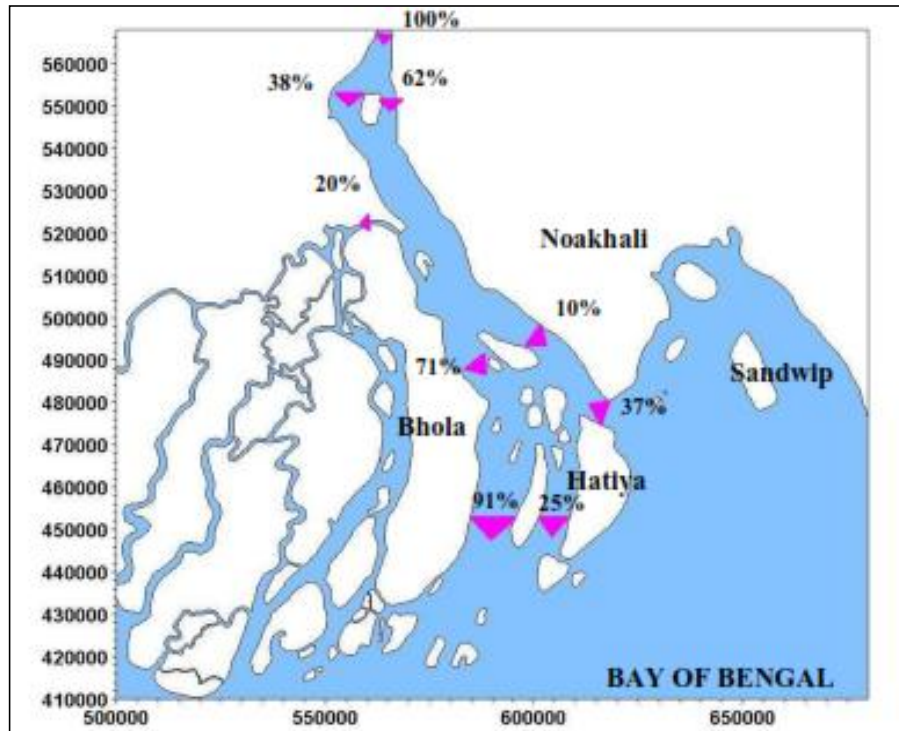


Figure 5-19: Net flow distribution in % of flow at Chandpur during dry season. (Source: IWM, 2009)

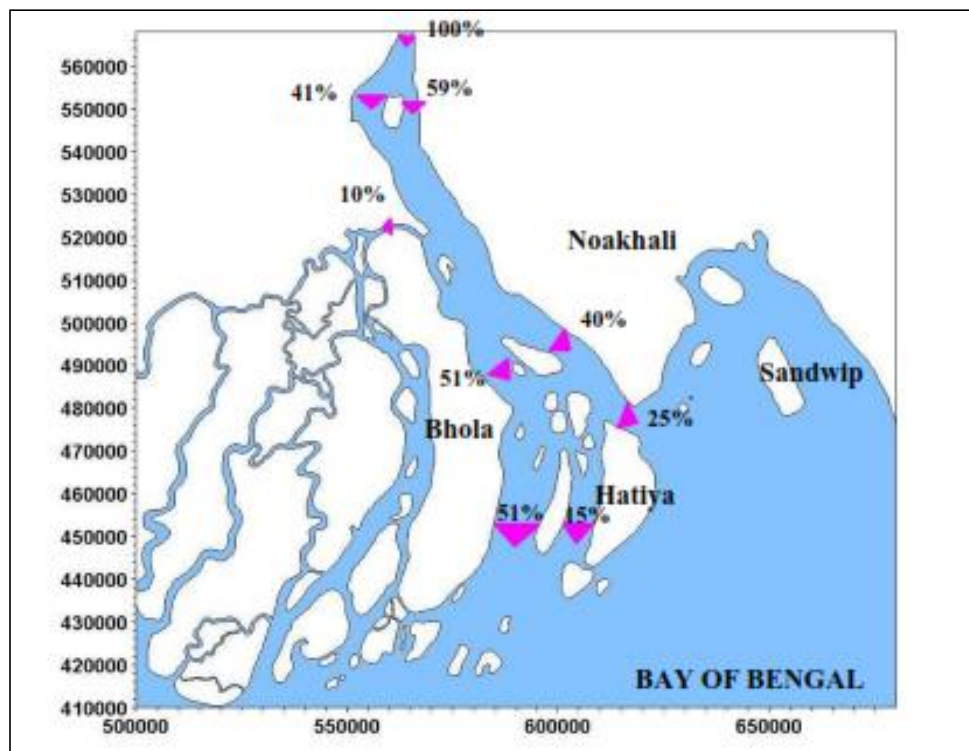


Figure 5-20: Net flow distribution in % of flow at Chandpur during wet season. (Source: IWM, 2009)

Hatiya channel is influenced by tide which results in northward net flow in the channel during dry season. The north tip of Hatiya is experiencing erosion and the flow in Hatiya channel has increased at present time with respect to 2000 as shown in the MES-II study. Most of the Lower Meghna river flow is conveyed along the west part of the estuary through the West Shahbazpur Channel. This is why net flow is high in this channel compared to the other channels of the river system. The model results show that continuous erosion is taking place at the east bank of Char Gazaria and west bank of Ramgati. The net monsoon flow in the channel is found relatively higher in this study than that of MES-II. The net flow through the Lower Meghna River at the east of Char Bhairabi has increased significantly than its west branch. In MES-II study approximately same net flow was found in the two branches. At present the flow through the east branch is much greater than the western branch. Comparison of the two bathymetries in the sediment budget analysis shows erosion in the east branch and deposition in the west branch, which supports this finding.

Salinity

River water salinity in coastal Bangladesh depends on the volume of freshwater discharges from the upstream river systems, the salinity of the Bay of Bengal near the coast, and the circulation pattern of the coastal waters induced by the ocean currents and the tidal propagation to the river systems. A reduction in freshwater inflows from the trans-boundary Ganges River, siltation of the tributaries of the Ganges, and siltation of other rivers following the construction of the polder system has resulted in a significant increase in river salinity in coastal Bangladesh during the dry season. Average salinity concentrations of the rivers in the coastal area are higher in the dry season than in the monsoon because of lack of freshwater flow from upstream. Salinity level generally increases almost linearly from October to late May with the gradual reduction in the freshwater flow from the upstream. The degree of salt intrusion depends on season and climatic conditions. Salt intrusion is an important factor that affects the sediment transport dynamics and hydro-morphological conditions in major portions of the coastal area, in particular during pre-monsoon and post-monsoon. During the monsoon period the salinity in the Meghna Estuary area drops considerably and the water becomes almost completely fresh in the major part of the area.

Salinity level at Chandpur is very insignificant since enormous volume of fresh water from the Padma and Upper Meghna rivers flows through the Lower Meghna River at Chandpur. The maximum salinity level is observed about 0.1ppt (0.1 gram per litre), (IWM, 2013). Observed salinity in the Tentulia River at Ilisha Ghat shows variation of salinity level from 0ppt to 4ppt over over the period from 2012 to 2013 (Figure 5-21).

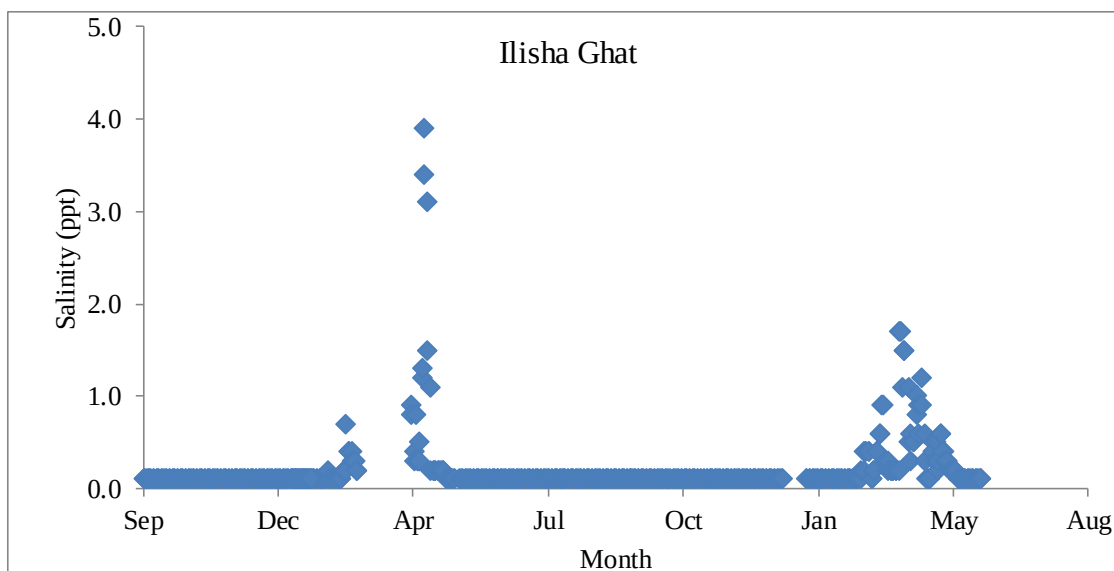


Figure 5-21: Variation of salinity level in the Tentulia river at Ilisha Ghat, 2012-2013 (Source: IWM)

Salinity at this station is zero from May to February. Salt concentration is comparatively higher during March and April. Salt concentration at this period varies from 2.0 ppt to 4.0 ppt; however the salinity level depends on upstream fresh water flow. Salinity station at Daulatkhan is located on the bank of Tajmuddin upzilla of Bhola district in the West Shabazpur Channel. Salt concentration at this station began to build up from February and reach to its peak (8.0 ppt to 9.0 ppt) in the month of April. Salinity level begins to drop from mid-April and water becomes fresh in the month of May when upstream flow is considerable. There is no salinity at this location from May to December.

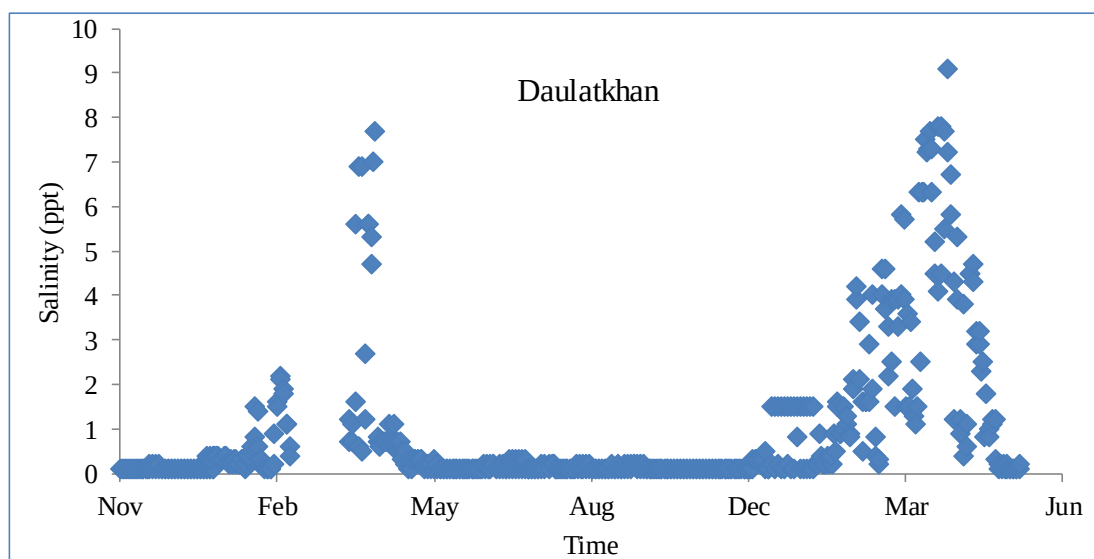


Figure 5-22: Variation of salinity level in the West Shabazpur channel at Daulat Khan, 2012-2013 (Source: IWM)

Salt concentration at Ramgati in the East Shabazpur Channel starts to build up from the beginning of September and reach to its peak at 4.0ppt to 16.0ppt in the month of April. Salt concentration drops from mid-April. (Figure 5-23)

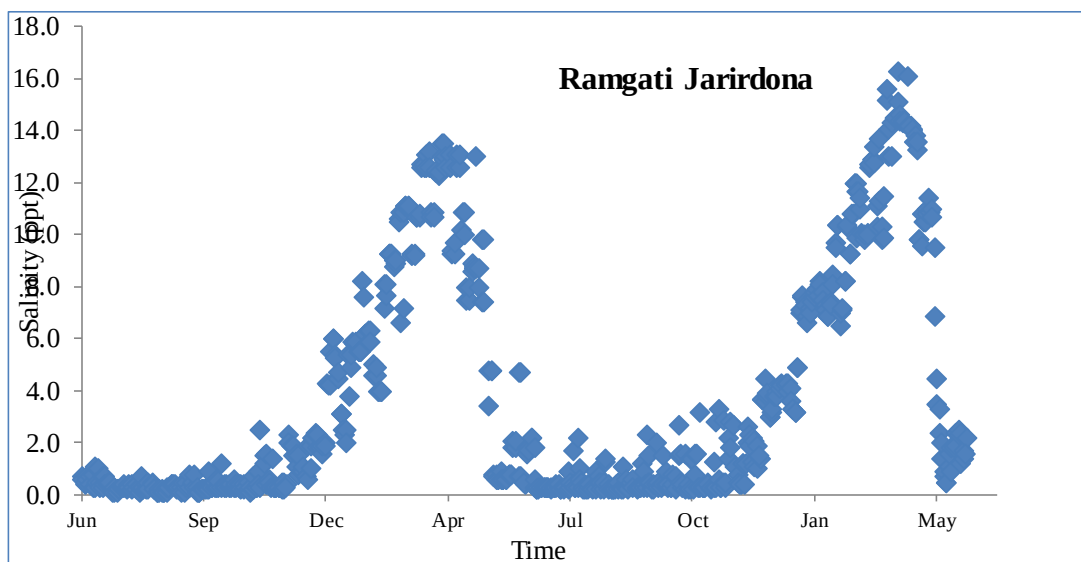


Figure 5-23: Variation of salinity level in the East Shabazpur Channel at Ramgati 2012-2013
(Source: IWM)

Wave

Vessel navigation and manoeuvring is influenced by wind-induced wave conditions. Also, berthing place for vessel needs to be very calm enough (little or no wave influence) so that the vessel can stay at the berth without vertical movement. The influence of the wind-induced waves in the Lower Meghna estuary is limited to the shallow nearshore zone and inter-tidal area. Wave climate in the Meghna estuary is rather mild due to limited depth. Wave model indicates that under the South-southeast wind, the average significant wave height varies between 0.6-1.5m in the nearshore zone to 0.1-0.6m in the landward part (BWDB, 2001). In the dry season, the wave is generally less than 0.6m with peak wave period of 3-4 seconds. During monsoon season, wave heights exceed greater than 2m with periods more than 6 seconds.

Hatiya Channel to Karnaphuli River, it is open sea and significant wave height is more along the navigation route. Significant wave height increases from west to east for all three dominant wind directions i) south-east ii) south-west and iii) north along the Bay of Bengal. Three wave roses have been generated from model simulation results at three locations along the navigational route. The locations are shown in Figure 5-24. The dominant wave direction is from south and south-east here. At location 1, wave height is more and the maximum significant wave height is 1.25m in monsoon. At location 2, maximum wave heights is 1 m and at location 3, maximum wave heights is 0.75 m.

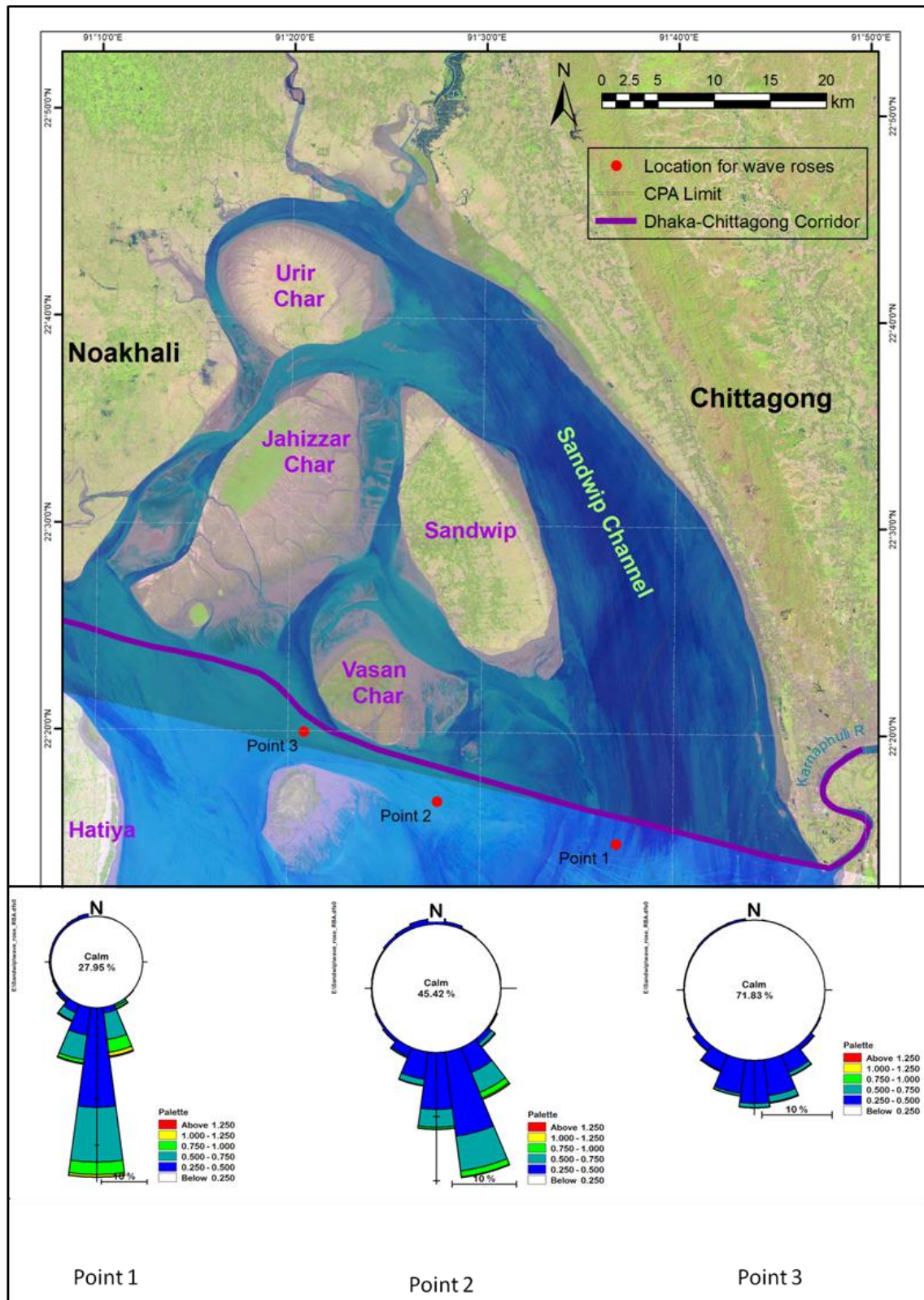


Figure 5-24: Wave roses showing direction and magnitude (Source: IWM)

Hatiya Channel to Karnaphuli River, wave action is very important for vessel navigation. Hatiya Channel to Karnaphuli River, it is open sea and significant wave height is more here. Significant wave height increases from west to east for all three dominant wind directions i) south east ii) south west and iii) north along the Bay of Bengal. Three Wave roses have been generated from model simulation result at three locations along the navigational route. The locations are shown in the Figure 5-24. The dominant wave direction is from south and south-east here. At location 1, wave height is more and the maximum significant wave height is 1.25m in monsoon. At location 2 maximum wave heights is 1 m and at location 3 maximum wave heights is 0.75 m.

Cyclones

Cyclones pose a threat to inland water transport, lives and property in low-lying coastal regions in Bangladesh. Cyclonic storms, occasionally of severe intensity, can occur in the months of March-May and October-November, accompanied by storm surges, high winds and intense rainfall. While the loss of life during these cyclones is being progressively reduced by means of improved storm warnings and continuing construction of cyclone shelters, the damages to property, livestock, crops and livelihoods continue to take their toll.

Major tropical cyclonic disasters in 1970 and 1991 were estimated to have killed an estimated around 300,000 and 140,000 people respectively. The severe cyclone which occurred in November 1970 was followed by one in May 1985, one in November 1988, one in April 1991 one in May 1997, the severe cyclone SIDR in November, 2007 and lastly the cyclone AILA in May, 2009.

Though time-series records of storm-surge height are scarce, existing literature indicates a 1.5–9 m height range during various severe cyclones. Storm-surge heights of 10 m or more have not been uncommon; for example, the 1876 Bakerganj cyclone had a reported surge height of 13.6 m (SMRC 2000).

Overall, it has been estimated that Bangladesh is on the receiving end of about two-fifths of the world's total impact from storm surges (Murty and El-Sabh 1992). The reasons for this disproportionately large impact include the re-curved shape of tropical cyclones in the Bay of Bengal; the wide, shallow continental shelf, especially in the Chittagong, Sandwip, Hatiya and Bhola Islands the high tidal range; the triangular shape at the head of the Bay of Bengal, which helps to funnel sea water pushed by the wind toward the coast, causing further surge amplification. Surges that make landfall during high tide are even more devastating. In general, it has been observed that the frequency of a 10-m high wave (surge plus tide) along Bangladesh coast is about once every 20 years, while a wave with a 7-m height occurs about once in 5 years. In addition, wind-induced waves of up to 3.0 m in height may also occur (MCSP 1993). About 19 major cyclones hit the coastal area of Bangladesh from 1960 to 2009, which is shown in the Figure 5.26.

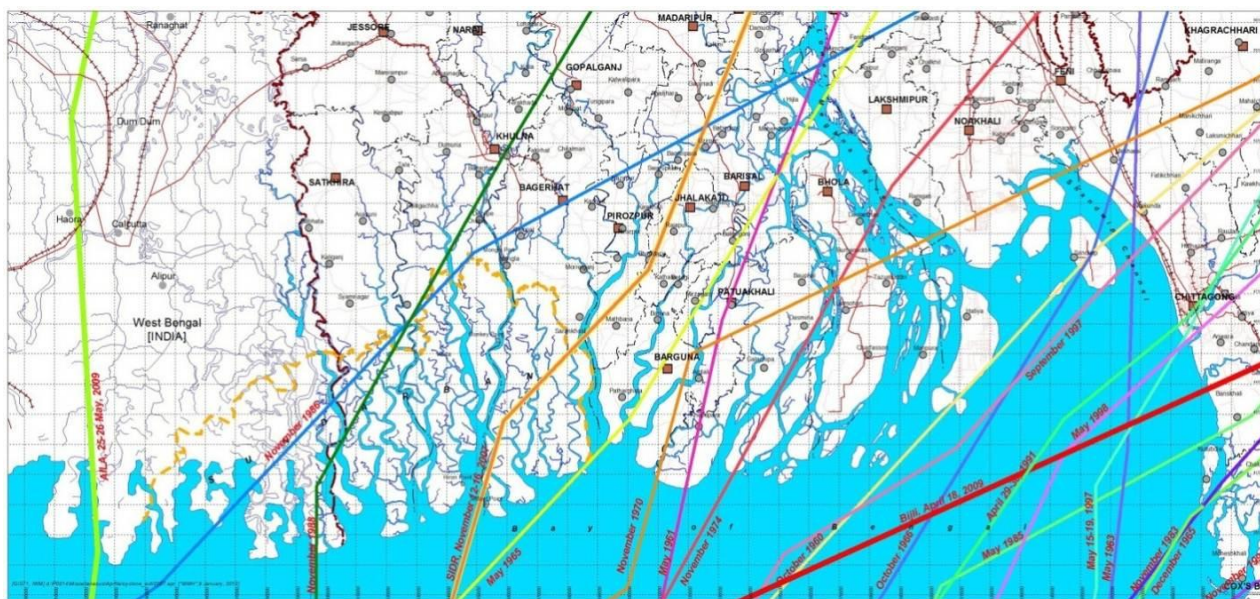


Figure 5-25: Tracks of Major Cyclones (1960-2009) (Data source: BMD)

Sediment Transport and Sediment Budget

Sediment Characteristics

In the Meghna Estuary median diameter of bed samples varies between 0.016 mm to 0.2 mm, and about 50% of the samples has median diameter less than 0.063 mm (silt) (BWDB, 2001, Meghna Estuary Study). The major part of bed sediment consists of a mixture of (very) fine sand, silt and mud. The particles of silt and clay are carried by current, mainly as suspended material.

IWM analyzed bed sediment samples in 2014 near Sandwip and Jahizzer Char under the project entitled “Detailed Technical Feasibility Study for Integrated Development of Jahizzer Char”, which shows that median diameter (D_{50}) varies from 0.01mm to 0.14mm as shown in Figure 5-26.

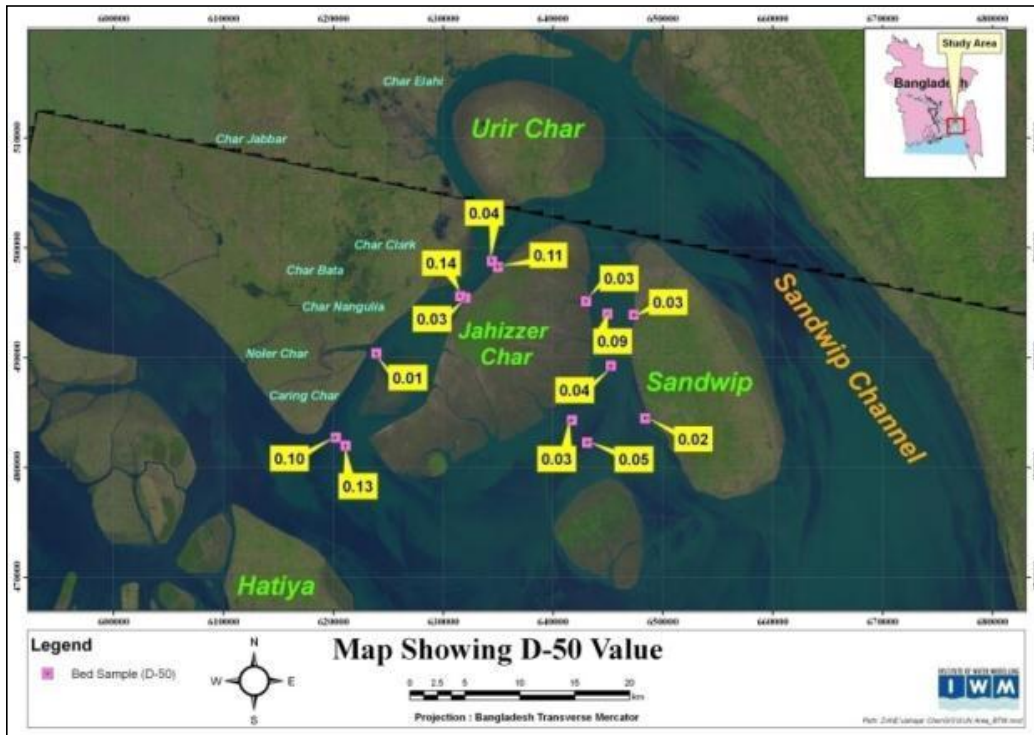


Figure 5-26: D₅₀ values around Jahizzer Char (Source: IWM)

The sediment distribution curve at location-3 (as in Figure 5-24) is presented in the Figure 5-27, which shows that the median diameter is 0.03mm.

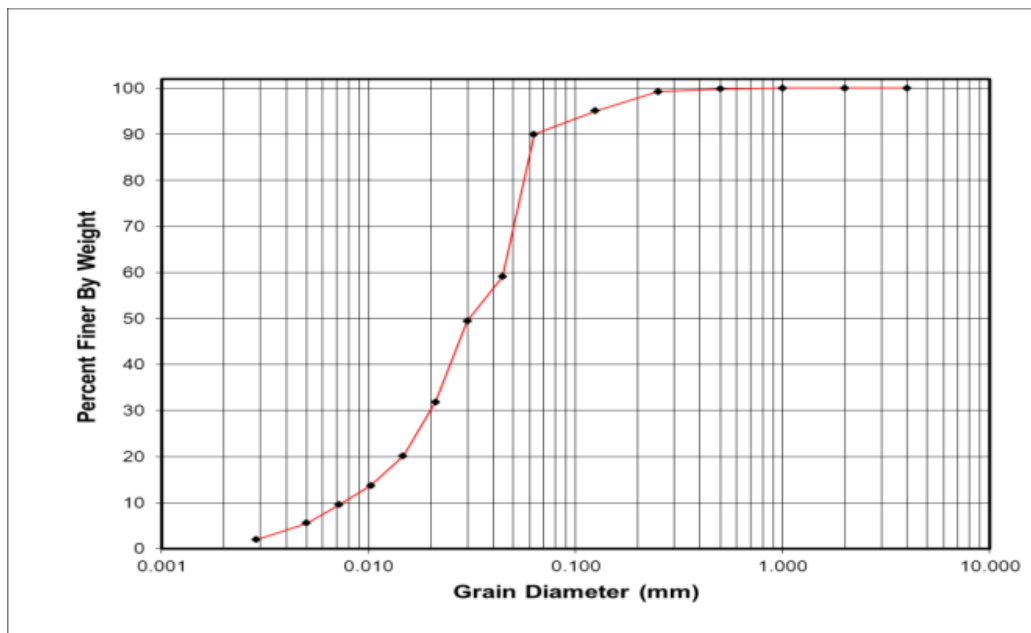


Figure 5-27: The sediment distribution curve (Source: IWM)

The characteristic particle size D50 varies from upstream to downstream of the Upper-Meghna River. The average value of D50 is about 0.14mm in the Upper- Meghna River.

The sediment concentration measurements conducted by BWDB under Meghna Estuary Study (MES) and Land reclamation project (LRP) indicated a variation of the sediment concentration during a fortnightly cycle of the spring and the neap tide. The variation of sediment concentration showed a tendency to increase towards the spring tide. The maximum depth averaged sediment concentration at spring tide was about 2-5 times higher than that at neap tide. The averaged total annual sediment discharge of the Brahmaputra, Ganges and Meghna river systems over the period 1966-1991 was about 1,100 million tons per year. About 70% of the sediment discharge consisted of fine sediment. The observed morphological changes derived from the time series of satellite images over the period 1973 to 1998 and the annual sediment discharge indicated qualitatively that the net gain of land is related to the amount of river borne sediment discharge (BWDB, 2001). The net gain of land and intertidal areas during periods of higher river borne sediment discharge is higher than that during periods of lower river borne sediment discharge.

Sediment Transport

The hydrodynamic factors that shape the Lower Meghna Estuary area are; tides, upstream river inflow, sediment transport, estuarine circulation, waves and atmospheric forcing. The resulting temporal and spatial changes in the channel and char systems in the estuary are primarily a consequence of the interaction of these factors acting all over the estuary. Interactions between these factors are complex, and mostly non-linear. Evidence of these interactions is the geomorphologic changes that occur in the estuary with the sediment transport processes. The average total annual sediment discharge of the Brahmaputra and Ganges is about 1,100 million (BWDB, 2001) tons per year. The sediment discharge of the Upper Meghna River is negligible compared to the discharge of the Brahmaputra and Ganges. It is assumed that the net deposition of sediment in the southern part of Bangladesh is related to the amount of river borne sediment discharge: during periods of high river-borne sediment discharge (monsoon), the net gain of land and intertidal areas is higher than during low periods of river borne sediment discharge. The general sedimentology of the Lower Meghna Estuary is the consequence of many conditions. One of the most important conditions is the sediment source, which may be the river, the adjacent delta and continental shelf from which sediment is transported by littoral currents and introduced into the estuary by upland flow and tidal action. Furthermore, within the estuary proper, sediment distribution is extremely variable reflecting the hydrodynamic conditions and the particular transport processes that are dominant in each portion of it. The circulation patterns, particularly in the lower portions of the Meghna Estuary Area are highly affected by river and tidal dynamics, resulting in characteristic morphological patterns. Flow friction and river flow decrease the tidal effect landwards as the river influence becomes progressively larger.

Sediment Budget

The tidal influence reaches about as far as the Bhairab Bazaar in the Upper Meghna and at Mawa in the Padma River during dry season. The velocities in the Lower Meghna River usually decrease in downstream direction as flow expands into the estuarine section of greater cross-sectional area near the river mouth. In the transition zone of the Lower Meghna Estuary area fresh water is mixed with saltwater; sediment transport capacity diminishes and sediments are deposited. The periodic rise and fall of tide results in the temporary storage of large volumes of sea water in the estuary during high tide, followed by drainage at low tide. The volume of water exchanged by tide -the tidal prism- during pre-monsoon and post-monsoon is at least an order of magnitude greater than the river discharge. Approximately overall sediment budget in the study area over the period indicates that the deposition processes exceed the erosion processes. Erosion dominates in the northern part of the river system. High rate of sediment deposition is found in the north-east of the estuary, between Noakhali mainland, Urir Char and Sandwip. Also the area between Bhola and Hatiya, and the south- west end of the estuary are accreting, with an accretion rate of 0 - 0.1 m/y. In other areas in the estuary, erosive and depositing processes are more or less in balance. Hydrographic surveys of the Meghna estuary were carried out in 1999 and 2009 by BWDB. The bathymetric maps derived from these two surveys have been compared to analyse the net sediment deposit and erosion at different places. The total Lower Meghna estuary has been divided to 7 sub-areas, which are analysed separately to examine the net deposition and erosion. The difference map showing sediment deposition and erosion patterns are presented in the Figure 5-28 and Table 5-12.

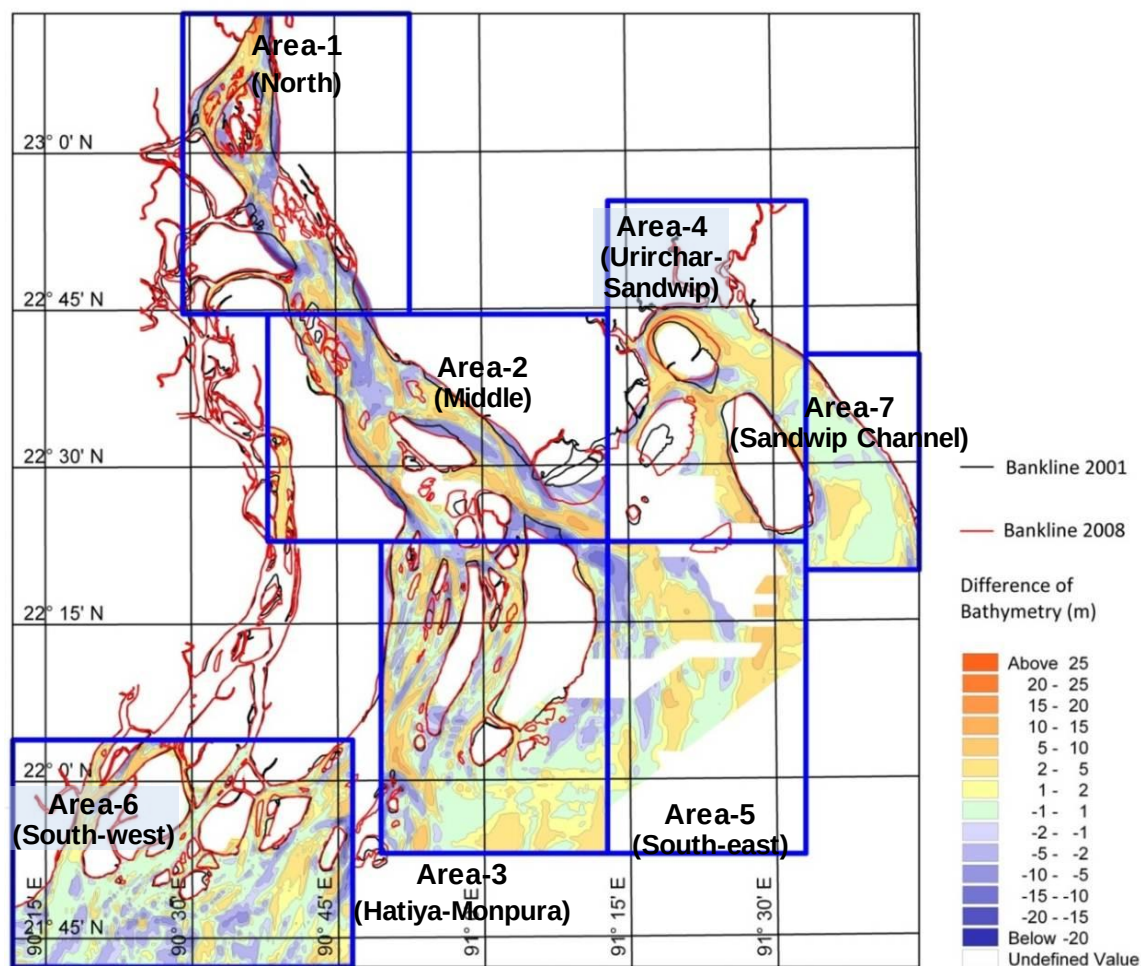


Figure 5-28: Sediment budget (1999-2009) calculations in seven sub-areas of Meghna Estuary (Source: IWM, 2009)

Table 5-12: Net change of sediment volume in the Meghna Estuary (Source: IWM, 2009)

Sub-area	Erosion		Deposition		Net Deposition			Net Change
	Volume (Mm ³)	Area (ha)	Volume (Mm ³)	Area (ha)	Volume (Mm ³)	Volume (Mm ³ /yr)	Total Area (ha)	m/yr
A1	1467	27411	892	23694	-574	-57	51105	-0.11
A2	2050	45400	1908	44707	-142	-14	90107	-0.02
A3	1408	64956	1941	93801	533	53	158756	0.03
A4	366	16838	1594	44758	1228	136**	61596	0.22
A5	547	25934	1492	60422	944	94	86356	0.11
A6	672	35516	1138	59376	465	47	94892	0.05
A7	139	13383	444	34104	305	31	47487	0.06
Total	6649	229438	9409	360860	2760	276	590298	0.05

**The yearly change has been estimated dividing the total change by 9 years because 2008 survey was used instead of 2009 survey, “+”ve sign indicates sediment deposition.

The navigation route is along the sub-area of Area 1, Area 2, Area 4, Area 5 and Area 7 of the estuary. The deposition and erosion process in each sub-area is described in the following section since the deposition of each sub-area influences the navigation depth and dredging requirement.

Area 1 (northern reach of Lower Meghna)

A large char (Char Bhairabi) has been developed in the middle stream of the river deflecting the flow. Deep channels are located very close to both riverbanks. River widens, especially on the western side. Western channel moved to the west by 2-2.5km over a distance of approximately 7 km. It is evident in the satellite image of 2015 that eastern channel has been enlarged and deepened over the years and become the main navigation channel. This may locally reduce the erosion of the west bank. At the level of Chandpur, the main channel moved to the west, causing some erosion of the river bank. This area shows net erosion of 11cm over the years.

Area 2 (middle estuary)

Largest morphological change has been occurred in this area over the years characterizing the area is morphologically very dynamic. Extensive deposition is observed on the southern side (Noakhali mainland/Bouyr Char), reducing the depth of the channel and forcing the main water flow towards the northern head of Hatiya island. This results in the migration and strong deepening of the Hatiya Channel, and large-scale erosion of the head of the island. At the upstream head of Char Gazaria some erosion is observed. Large and very shallow flats west of Char Gazaria extended to the west.

This is associated with the migration of the West Shahbazpur Channel, which moved very close to the bank of Bhola causing erosion of the riverbank. The net change is minor erosion.

Area-4 (Urir Char-Sandwip)

Vast accretion/sediment deposition is observed at the northern head of Sandwip. Also some accretion is found along eastern bank of Sandwip. Net change is sediment deposition.

Area-5 (South-east)

In this area, south of Sandwip and east of Hatiya, no large bathymetric changes are found. Shallow areas north-east of Hatiya extended to the east causing migration of the Hatiya Channel to the north at the level of island's northern head, and to the east in the southern course of the channel.

Area 7 (Sandwip Channel)

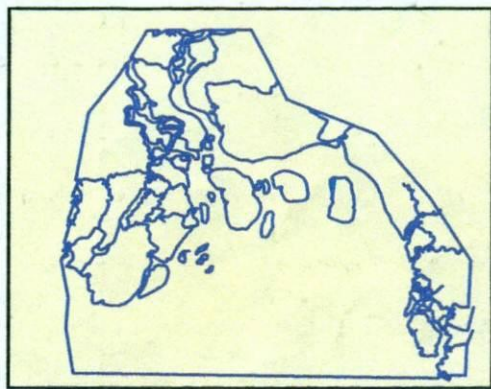
The Sandwip Channel remained quite stable during the period of 1999 to 2015. However, south and southwest of Sandwip island sediment deposition occurs causing navigation problems.

Geomorphological Evolution during the Last Century in the Meghna Estuary

Deltas and estuaries are generally known as areas of a net deposition of sediments either transported by the river from the upstream or supplied from the sea. The growth of the

delta and the accretion of land in the estuaries is a continuous and generally a very gradual natural process interfered by the dynamics of the ever- changing courses of their channels.

A comparison of the 2015 satellite image (Figure 5-29) with the 1779 map of J .Rennell (Figure 5-29) shows a completely changed system of channels and river courses but a more or less stable coastline west of the Tetulia River. East of the Tetuliariver, however, a general tendency of seaward growth of the coastline is evident, particularly in the region Bhola Island - Hatiya Island, Nijhum Dwip and in the Noakhali district. Although the overall process of accretion is dominant, areas of erosion is also visible, particularly on the river banks along the Ramgati under Laxmipur district, northeast shoreline of Bhola Island.



Rennell map 1779



Satellite Image 2015

Figure 5-29: Comparison of Rennell map with satellite image of 2015

Long Term Net Accretion Rate

Several studies have examined the rates of change for coastal Bangladesh, which is presented in Table 5-13. The extent of study area, cartographic methods, interpretation of coastline and/or land features is not precisely known for all of these studies. However, in all cases where the net changes were studied over a period of 20 years or more, there was a net increase of land. The rate of change of 9.9 km²/y computed for the period 1776-1996 by EGIS (MES, 1997) compares closely with the 7.0 km²/y computed by Allison (1998). Another, more reliable chart of 1840 prepared by Commander Lloyd was compared (Allison, 1998) against a 1984 satellite image set where the rate of 4.4 km²/y was computed. The range of net land gain over time periods ranging from 23 to 220 years varied from 4.4 km²/y to 29 km²/y (BWDB, 2001). A comparison of the rate of change for the period of 1973-2000 with the rate of change for the period 1940-1963 shows that the magnitude of natural processes has speeded up to some extent due to the construction of the two Meghna cross-dams (1957 and 1964) in the old course of the Lower Meghna Estuary. Table 5-13 shows the land accretion in different period.

Table 5-13: Comparison of erosion and accretion rates from different studies
(Source: MES II, 2001)

Length of study period (years)	Period of study	Net Change for Period (km ²)	Rate of change (km ² /y)	Reference
220	1776-1996	+2187	9.9	EGIS (1997)
192	1792-1984	+1346	7.0	Allison (1998)
144	1840-1984	+638	4.4	Allison (1998)
23	1940-1963	+279	12.1	Evsink (1983)
27	1973-2000	+508	18.8	Present Study (2001)
7	1972-1979	+213	30.4 ¹⁾	SPARRSO and ERIM (1981)

1) Area described as "mud flat" was considered as accreted; therefore rate of change is not comparable to the present study.

Long Term Trends of Accretion and Erosion over the Last Decades

In the Meghna Estuary Study (BWDB, 2001), a time series of digitized satellite images from the period 1973 to 2000 was used to examine the extent of land for each date and to assess the changes in plan-form and channel system due to accretion and erosion in the estuary. The accretion and erosion pattern as seen in the Figure 5-30 demonstrates the dynamic behavior the estuary.

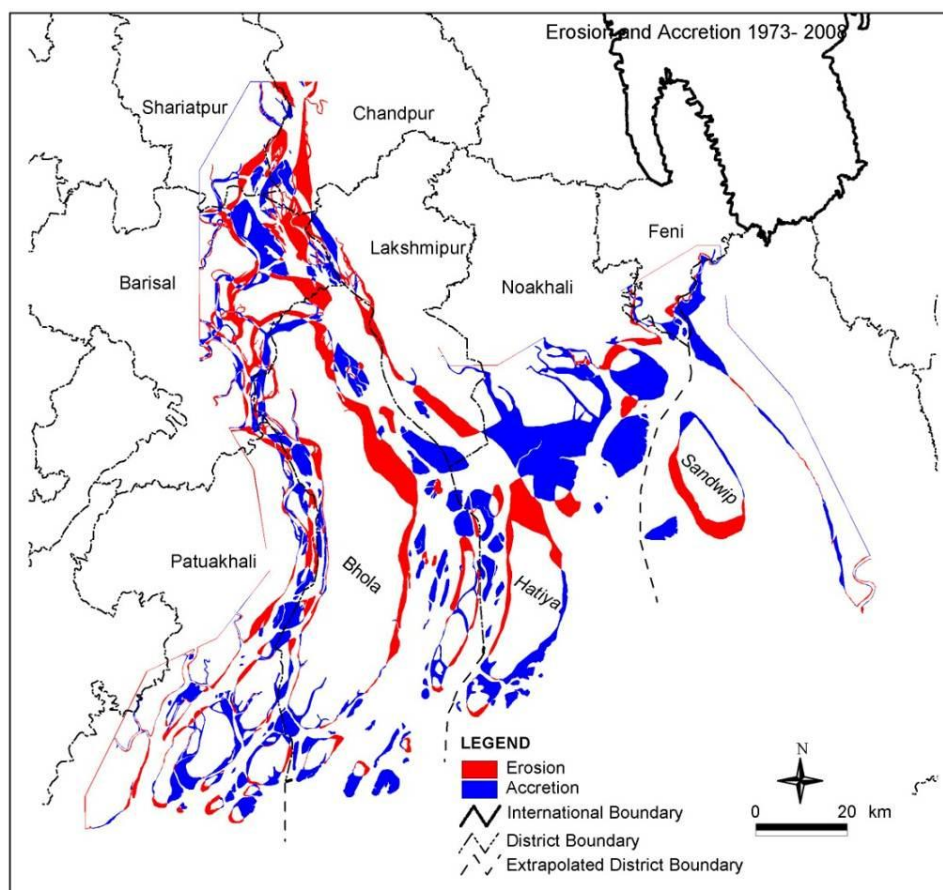


Figure 5-30: Accretion and erosion in the Meghna Estuary from 1973 to 2000.

Both accretion and erosion are evident along the navigation route. The accretion trend in the west of Sandwip channel is evident over the decades that specifies the need of frequent dredging at this location.

Under the present study use of satellite images of 2015 is also used to see the changes of Sandwip Island and Jahizzer Char, which are adjacent to the navigation route, to investigate the shifting characteristics of shoreline. Figure 5-31 shows the bank line shifting characteristics of the Jahajzer char, Sandwip and Urrichar. Continuous enlargement of Jahazer char is apparent, which poses a threat of decreasing of navigation depth in the south of this char.

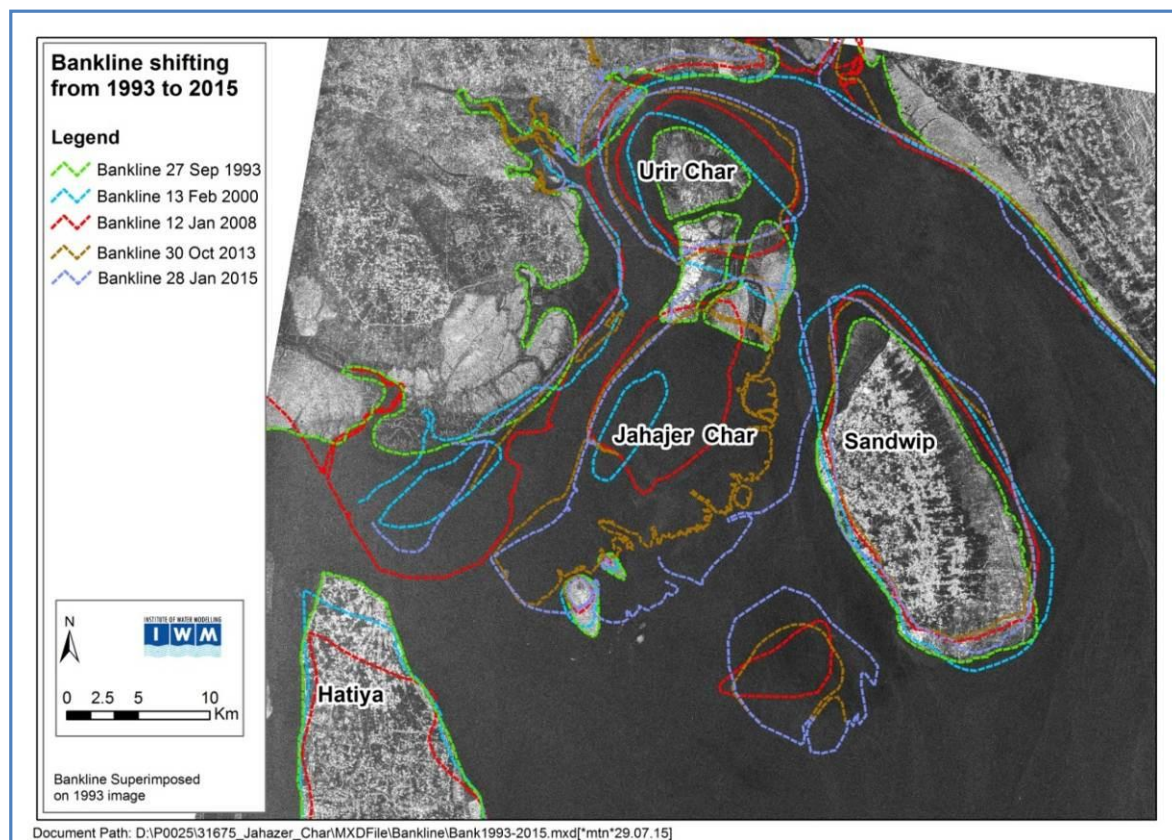


Figure 5-31: Shifting characteristics of shoreline of Jahajzer char, Sandwip island and Noakhali coast from 1993 to 2015

The net change over the considered period shows an overall land gain for the Meghna Estuary system as a whole, for the period 1973-2000 of about 50,800 ha. The net change over the considered period shows that generally gain of land took place. There is a clear relation between the magnitude of maximum discharge in the estuary and the net change of land. Periods of net loss of land coincide with occurrence of very high monsoon discharges (1986, 1988, 1996, 1998), while gain of land or deposition coincides with the periods of lower monsoon discharges in the river system (BWDB, 2001). Although the long-term trend of gain of new land is dominant in the estuary, it should be mentioned that a huge amount of fertile land (in particular old land) is exposed to erosion due to migration

and widening of the river system. Analysis of time series satellite image of recent years including 2015 clearly shows that a considerable amount is deposited in area northeast of the navigation channel and the Jahizzer Char is developing very fast.

There are new char areas and new areas of mud flats north-west of Sandwip and Urirchar islands, which continue to grow at high paste. Other large areas of accretion include the very large char in the Lower Meghna Channel that appears to be a consolidation and extension of Char Gazaria adjacent to the Dhaka-Chittagong Navigation route. Land erosion is associated with widening and migration of the main Lower Meghna and the Shahbazpur and Hatiya Channels. The northern end of Hatiya retreated very fast and there is a huge scour whole of -18mPWD. Also eastern bank of Bhola suffers from severe erosion, with its most extreme form found west of Char Gazaria. It is evident that these areas are sensitive to changes in river and sediment discharges.

Floodplain Hydrology

Geology in D-C Corridor and Associated River Routes

Geologically almost 85% of entire Bangladesh is underlain by alluvial and deltaic deposits borne by the river systems of the Ganges, the Brahmaputra and the Meghna. Coastal deposits are limited to narrow-strip zone along the western edge of Chittagong and Cox's Bazaar districts (Alam *et al.* 1990). The geological formation in the Dhaka-Chittagong river route and associated routes are mainly alluvial, deltaic and coastal deposits.

The river Buriganga flows through alluvial silt and clay of medium to dark grey silt to clay. The Dhaleswari River from its meeting point with the Buriganga down to the meeting point with the Meghna River flows through alluvial silt. This formation composed of fine sandy to clayey silt having light to medium-grey colour. The Meghna River until the confluence with the Padma River around Mohonpur (under Matlab North Upazila) flows through the formation of alluvial sand, which is the size from coarse sand to fine silty sand and brownish grey in colour. However, down to it until Chandpur it flows through alluvial silt for its Chandpur side (left bank) and deltaic sand for its Shariatpur side (right bank). The rest of the Meghna River, down from Chandpur, over a section of Shariatpur, entire Mehendiganj and Bhola district flows through estuarine deposits. These kinds of deposits show the characteristics of silty clay to clayey silt which has brownish/yellowish appearance. However, on its left bank immediately down to Chandpur a small segment of the riparian area (broadly Haimchar, Faridganj, Raipur) composed of alluvial silt and clay.

The left flood plain of the Meghna River, after this, over the districts Lakshmipur, Noakhali and Feni is entirely composed of tidal deltaic deposits, which has characteristics of light to greenish colour and silt to clayey silt with very fine to fine sand. The area is criss-crossed by numerous tidal creeks. Also this area has some brackish-water deposits. The navigation route, downwards, along the Chittagong districts passes through beach and dune sand. With respect to formation and contents, it contains well-sorted medium to fine sand that are light to whitish-grey in colour,

shell fragments, heavy minerals, and rare clasts. As to the three associated routes: all the approaching routes to Barisal passes through deltaic deposits – estuarine deposits (Mehendiganj, Bhola), and tidal deltaic deposits (the rest of the route down to Barisal, then Jhalokathi). The Ghorashal route, the Shitalakhya River, passes mainly through alluvial silt. The Ashuganj Route, the Upper Meghna River flows through a river corridor that is composed of alluvial sand.

As for the three ferry crossings: the Harina and Alu Bazaar ferry route lies on the formation of alluvial silt and clay on its east side (Harina) and estuarine deposits on its west side (Alu Bazaar). The crossing between Maju Chowdhury's Hat (under Lakshmipur Upazila) and Bhola lies on the formation of tidal deltaic deposits (Lakshmipur side) and estuarine deposits (Bhola side).

5.2 Environmental Quality

The existing environmental quality in the project influence area serves as the basis for identification, prediction and evaluation of potential environmental impacts of the proposed project interventions. The baseline environmental quality has been assessed through field studies within the impact zone and analysis the information for various components of the environment, viz. air and noise, water, and riverbed sediments. The sampling locations were in the following Figure 5.33

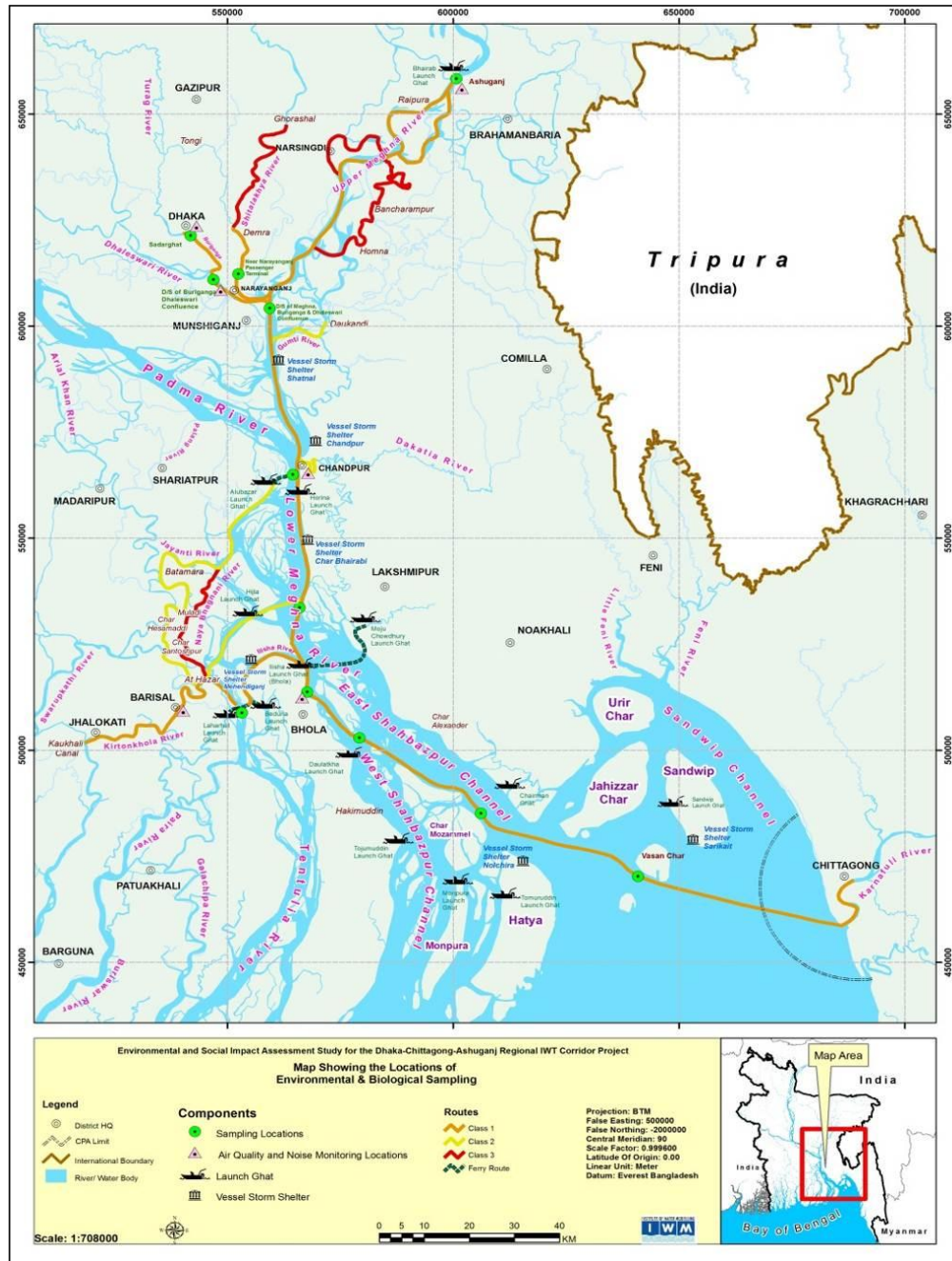


Figure 5-32: Sampling Locations along the Project Influence Area

5.2.1 Monsoon Period Data Analysis

Surface Water

The surface water quality assessment in the project influence area has been carried out for the most important parameters namely, pH, DO, BOD, TOC, TDS, TSS and ions. The locations for sampling are shown in the Figure 5.33. The tests were undertaken in the month of September and October 2015 and the detailed analyses are incorporated with the standard values set by the DoE are shown in Table 5.14 and Table 5.15 respectively.

Table 5-14: Surface Water Quality of Rivers in Project Influence Area

Parameter Unit		Sampling ID											
		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SW11	SW12
pH	-	7.10	7.30	6.99	7.12	7.02	6.95	7.60	7.48	6.94	7.42	7.36	7.55
Temp	°C	25.2	24.7	25.1	25.1	25.2	25.1	24.8	25.2	24.8	25.3	25.2	25.2
Turbidity	NTU	337.0	14.9	32.7	8.06	9.60	5.32	905.0	110.0	88.5	165.0	90.1	98.0
EC	µS/cm	171.0	68.2	148.0	54.2	57.5	150.0	1193	128	147	151	139	132
DO	mg/L	6.12	5.30	5.09	5.89	5.61	3.66	5.05	5.10	5.12	5.20	5.29	0.89
BOD ₅	mg/L	1.11	0.95	1.11	1.12	1.58	7.65	2.98	2.98	2.04	2.08	2.09	58.3
TOC	mg/L	10.0	6.54	1.28	<0.5	<0.5	0.67	8.04	7.83	7.28	14.7	7.43	1.24
TDS	mg/L	89.2	56.0	78.8	68.4	50.4	90.0	646	102	143	117	92.4	107
TSS	mg/L	391.0	9.60	91.0	153.0	53.0	22.8	953	110	202	301	327	109
Ca	mg/L	23.1	6.63	16.0	4.88	4.85	16.7	45.8	16.4	17.1	18.5	22.6	15.6
Mg	mg/L	10.6	2.30	4.42	2.08	2.26	4.46	38.7	4.66	5.47	6.60	7.44	4.47
Na	mg/L	5.90	3.06	5.23	3.19	3.33	5.90	130	4.48	4.80	4.40	4.20	4.40
K	mg/L	3.0	1.21	2.73	1.04	1.10	2.46	7.88	2.09	2.33	2.41	2.33	2.30
Cl ⁻	mg/L	1.63	6.57	1.84	1.06	1.18	1.98	459	1.93	1.58	1.41	1.33	1.35
F	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Br	mg/L	2.42	1.54	3.07	1.07	1.17	4.02	<1.0	1.81	<1.0	<1.0	1.12	<1.0
SO ₄	mg/L	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
NO ₃	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Total PO ₄	mg/L	11.4	<0.2	<0.2	<0.2	<0.2	0.58	29.7	3.15	1.33	1.32	1.17	0.77

Source: Field survey, September- October 2015, Cells in grey color shed indicate the exceedance the limit of DOE standard,

SW1- Harinaghat, Chandpur, SW2- Gozaria, Munshiganj, SW3- Boktabali Ferryghat, Narayanganj, SW4- Araihasar, Narayanganj, SW5- Ashuganj, SW6- Sadarghat, Dhaka, SW7- Near Bhasan Char (Chukkhalthighat, Sandwip), SW8- Near Chairman Ghat (Noakhali), SW9- Near Beduria Launch Ghat (Sripurdwip, Barisal), SW10- Near Hizla (Mehendiganj, Kaliganj) SW11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), SW12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat)

Table 5-15: Bangladesh Water Quality Standards

Sl No.	Best Practices Based Classification	Parameters			
		Temperature (°C)	pH	DO (mg/l)	BOD ₅ (mg/l)
1	Water usable for fisheries	25 - 30	6.5- 8.5	5 or more	6 or less
2	Water usable for irrigation	25 - 30	6.5- 8.5	5 or more	10 or less

Source: Environmental Conservation Rule (ECR) '97

Notes: In water used for pisciculture, maximum limit of presence of ammonia as Nitrogen is 1.2 mg/l. Electrical conductivity for irrigation water– 2250 mhos/cm (at a temperature of 25°C); Sodium less than 26 percent; boron less than 0.2 percent.

Table 5.14 represents the water quality measured during field investigations at the selected locations of the project influence area. Surface water quality is represented by some selected parameters, which are crucial for agricultural activities and industries and to maintain optimum aquatic environment. The standard values of these indicators set by the Department of Environment, Bangladesh are also shown for comparison purposes.

Water Temperature- The temperature of water bodies affects fish habitats and their oxygen holding capacity. The temperature of the water bodies in the project influence area ranges from 24.7 to 25.2°C in September - October 2015. Temperature of all the samples except SW2 (Gazaria), SW7 (Bhasan Char, Sandwip) and SW9 (Beduria Launch ghat, Bhola) lies within the DoE standards for both irrigation and fish habitats.



Figure 5-33: Surface water collection in the project influence area



Figure 5-34: Surface water pollution source in the project influence area

pH- The "desirable" range of pH prescribed by the DOE is between 6.5 and 8.5. This is the range, which provides adequate protection to the life of fresh water fish and bottom dwelling invertebrates. In most of the water bodies of the area, the pH range is found well within the DoE standards. The pH of water samples lies in the range of 6.95 to 7.30. However, pH value is governed largely by the carbon dioxide/carbonate/bicarbonate equilibrium. Organic substances may affect it, by change in the carbonate equilibrium due to the bioactivity of plants and in some cases by hydrolysable salts.

Turbidity- Turbidity values of the surface water samples ranges from 5.32 to 337.0 NTU. Turbidity in water is caused by suspended and colloidal matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms. Higher turbidity in September-October can be caused by high turbulence of river water due to monsoon precipitations. Lower turbidity value might be due to the calm nature of river water. The highest values of turbidity were observed in SW1 collected from Harina ghat due to high flow of monsoon precipitation.

Dissolved Oxygen (DO) - Dissolved oxygen is necessary to many forms of life including fish, invertebrates, bacteria and plants. Decrease in DO values below the critical level of 3 mg/l causes death of most fishes and other aerobic aquatic organisms. The dissolved oxygen values ranged from 5.09 to 6.12 mg/L in twelve locations; in SW6 (Sadarghat) at Buriganga River and SW12 (Dawlatkhan Launch ghat) at West Shahbazpur Channel was low value of 3.66 mg/L and 0.89 mg/L recorded respectively.

BOD₅-The BOD₅ is a measure of the amount of oxygen that bacteria will consume in five days at 20°C while decomposing organic matter under aerobic conditions. The term also refers to a chemical procedure for determining this amount. This is not a precise quantitative test, although it is widely used as an indication of the organic quality of water. In the study area BOD₅ values range from a minimum of 0.95 mg/l to a maximum of 7.65 mg/l. The highest concentration of BOD₅ is 7.65 mg/L and 58.3 mg/L recorded in SW6 and SW12 accordingly which exceed the DOE surface water standard. The higher concentration of BOD means lower the DO and more hazards for aquatic animals.

Electric Conductivity (EC) - Electrical conductivity in the aquatic ecosystem is considered to be a good indicator for evaluating total dissolved solid materials in water and nature of the purity of water. Electric Conductivity in rivers is affected primarily by the geology of the area through which the water flows. Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity. EC as a water quality indicator is useful for estimating the amount of minerals, assessing the effect of diverse ions on chemical equilibrium, physiological effects on plants or animals, and corrosion rates. In the study area EC values range from a minimum of 54.2µS/cm to a maximum of 171.0µS/cm. The water sample collected from SW1 (Harina Ghat in Chandpur) recorded the highest value of EC.

Total Dissolved Solids (TDS) Dissolved solids are also important to aquatic life by keeping cell density balanced. However water containing excessive dissolved solids adversely affects drinking water. Continuous use of such water may cause a general loss of condition, weakness, scouring, reduced production, bone degeneration and ultimately death. TDS may influence the toxicity of heavy metals and organic compounds for fish and other aquatic life. The natural range of TDS concentration in the water bodies of the project influence area are between 50.4 mg/l and 90.0 mg/l.

Total Suspended Solids (TSS) - The concentration of total suspended solids ranges from 9.60 mg/L to 391.0 mg/L. The water sample collected from Harina ghat in Chandpur (SW1) recorded the highest value of suspended solids.

Total Organic Carbon (TOC) – TOC in freshwaters arises from living material (directly from plant photosynthesis or indirectly from terrestrial organic matter) and also as a constituent of many waste materials and effluents. Consequently, the total organic matter in the water can be a useful indication of the degree of pollution. In surface waters, TOC concentrations are generally less than 10 mg/L unless the water receives municipal or industrial wastes, or are highly colored due to natural organic material, as in swamps. The concentration of TOC ranges from below 0.5 mg/L to 10.0 mg/L. In SW1 collected from Harina ghat in Chandpur recorded the highest value of total organic carbon.

Major Ions- Major ions are naturally very variable in surface water due to local geological, climatic and geographical conditions. All natural waters contain some sodium since sodium salts are highly water soluble and it is one of the most abundant elements on earth. The concentration of Na ranges from 3.06 mg/L to 5.90 mg/L. The highest value of Na is 5.90 mg/L found in SW1 and SW6 collected from Chandpur and Sadarghat which may arise due to sea water intrusion and, sewage and industrial effluents accordingly. In addition, the salts of calcium, together with those of magnesium, are responsible for the hardness of water. The concentrations of Ca and Mg are higher in SW1 and SW6 than other five samples. On the other hand, the nitrate and fluoride concentrations are generally below 3.0 mg/L and 0.5 mg/L respectively for all the locations. Bromine is observed ranges from 1.07 mg/L to 4.02 mg/L, its highest concentration i.e. 4.02 mg/L is observed in SW6 collected from Buriganga River.

From the present study it is found that the surface water becomes polluted from Industrial, municipal and agricultural sources (Figure 5.35). Industrial and municipal effluents must be discharged into the River after proper treatment. Moreover, higher values may also be due to the washing out of fertilizer from agricultural fields and detergents used in household purposes which ultimately disposed of into the Rivers water. Besides this, many industries have effluent treatment plants, but they are not using it.

Riverbed Sediment

The riverbed sediment is an integral component of the aquatic ecosystem providing habitat and a source of food for key components of the food web. The sediment often becomes a catchment for natural and anthropogenic toxic substances that bind to particles and settle from the water column to the riverbed. The toxicity from the buildup of these contaminants may threaten the sediment-dwelling benthic organisms, vegetative communities, and the aquatic food web that depend on them. Organisms and plants, particularly those living in the sediment, can acquire and accumulate toxic substances through epidermal contact, respiration, or by ingestion of toxins.

The riverbed sediment quality parameters collected in the project influence area during the month of September - October 2015 (Table 5.16). The collected samples were analyzed for metals (such as magnesium, calcium, sodium, potassium and sulphate, phosphate, nitrate and heavy metals) and the analysis results are given in Table 5.16.

Table 5-16: Analysis of Riverbed Sediment Samples Collected from Project Influence Area

Parameter	Unit	Sampling ID												OSPAR *
		RBS1	RBS2	RBS3	RBS4	RBS5	RBS6	RBS7	RBS8	RBS9	RBS10	RBS11	RBS12	
Salinity	%	0.021	0.012	0.060	0.013	0.014	0.051	0.070	0.072	0.010	0.020	0.011	0.021	-
Total Mg	%	0.295	0.423	0.852	0.719	0.379	0.163	-	-	-	-	-	-	-
Total Ca	%	0.179	0.068	0.088	0.085	0.084	0.094	-	-	-	-	-	-	-
Total Na	%	0.010	0.012	0.028	0.022	0.018	0.011	-	-	-	-	-	-	-
Total K	%	0.099	0.204	0.612	0.599	0.414	0.093	-	-	-	-	-	-	-
Total Organic Carbon (TOC)	%	0.223	0.428	0.459	0.536	1.172	0.370	0.222	0.377	0.590	0.530	0.07	0.40	-
Total PO ₄ ³⁻	%	0.232	0.246	0.482	0.474	0.321	0.205	0.307	0.076	0.051	0.015	0.035	0.026	-
Total NO ₃	ppm	8.00	37.96	36.28	33.89	10.63	34.20	8.87	6.85	6.14	4.30	1.44	4.72	-
Total As	ppm	0.34	0.31	1.32	0.70	1.65	0.38	0.79	1.24	0.67	0.75	0.30	1.81	30-80
Total Cd	ppm	0.13	0.12	0.10	0.21	0.11	0.11	0.24	0.17	0.18	0.14	0.11	0.10	1.0-2.5
Total Hg	ppm	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.6-1.0
Total Pb	ppm	0.12	4.56	10.25	8.14	8.36	14.63	0.52	0.57	0.112	0.124	0.113	0.110	100-120
Total Cr	ppm	11.38	24.87	45.02	39.35	32.90	10.56	27.36	42.04	21.25	11.45	7.49	9.73	150-200
Total Zn	ppm	12.16	34.95	85.68	72.27	64.05	39.84	28.53	59.07	24.99	12.46	6.04	16.15	250-500
Total Ni	ppm	56.19	56.84	79.66	51.86	33.83	82.26	8.48	28.54	10.27	2.89	2.55	6.62	50-100

Source: Field survey, September- October 2015, BDL- Below Detection Limit (Detection Limit: Hg = 5.0 ppb), *OSPAR Guidelines for Management of Dredged Material, RBS1- Harinaghat, Chandpur, RBS2- Gozaria, Munshiganj, RBS3- Boktabali Ferryghat, Narayanganj, RBS4- Araihasar, Narayanganj, RBS5- Ashuganj, RBS6- Sadarghat, Dhaka, RBS7- Near Bhasan Char (Chukkhallighat, Sandwip), RBS8- Near Chairman Ghat (Noakhali), RBS9- Near Beduria Launch Ghat (Sripurdwip, Barisal), RBS10- Near Hizla (Mehendiganj, Kaliganj) RBS11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), RBS12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat)

Based on the laboratory result, Hg (mercury) is the only parameter which was not detected during the test. Concentration of all the parameters in the riverbed sediment collected throughout the project influence area is below OSPAR standard limit. The highest detected concentrations of Zn and Ni are 85.68 ppm and 82.26 ppm which are found in RBS3 and RBS6 respectively. Based on the above mentioned analysis from monsoon season sampling, sediments collected from the rivers are not categorized as hazardous waste according to the OSPAR regulation. Acute toxicity level of the sediment for human health is identified as relatively harmless. The primary sources of cadmium (Cd) to the atmosphere are from municipal waste incineration and fossil fuel combustion. Non-point sources include domestic wastewater effluent, atmospheric deposition, leaching from landfills, and effluent from manufacturing processes such as pulp and paper, batteries, glass ceramics, electroplating, paints and plastics. The concentrations of Cd are below the standard limit and it ranges from 0.11 to 0.21 ppm. Total organic carbon (TOC) consists of thousands of components, including macroscopic particles (e.g. decaying leaves, grasses and plankton), colloids, particulate and low molecular weight organic and macromolecules. The organic carbon material settles on the riverbed mixing with the sands, silts and clays and contributes to the sediment composition. The TOC content of the sediment varied from 0.223% to 1.172%. The highest sediment TOC values were located in RBS5 (Ashuganj). Concentration of total organic carbon in the water gives indication of domestic wastes pollution in the rivers. The use of detergents adds chromium, arsenic etc. to the waste water. Sewage sludge if discharged into the water may be a significant source of copper, cadmium, zinc and lead. Run off from urban areas during the rainy season is rich in certain heavy metals such as copper, chromium, zinc and lead. The relative quantities depend on the factors such as road traffic conditions, land use and city planning. Lead from automobiles is released into atmosphere, which later gets deposited at surface, and finds its way in the run off. Agricultural soils are usually rich in heavy metals as a result of the use of various fungicides, herbicides, phosphatic fertilizers, organic manure and the presence of decaying plant and animal residues. The sediment deposition works as important sink for heavy metals. Most metals entering the aquatic system ultimately will find their way into sediments. The highly contaminated sediment can often be a greater source of contamination to the water column than runoff or direct discharge sources.

Groundwater

Water for human consumption should be undergone regular physico-chemical tests. Physico-chemical properties are high priorities in determining acceptability, although they may have little bearing on whether the water is safe to drink or not. Generally, the standards used to evaluate the suitability of water for drinking and domestic purposes are more restrictive than those that would be applied to water for other purposes.

The groundwater quality parameters, measured in the project area during the month of September - October 2015 (Table 5.17), were found to comply with the drinking water quality standards set by DOE. The ground water quality of the area is presented in **Table 5.17**



Figure 5-35: Groundwater sample collection in the project influence area



Figure 5-36: Riverbed sediment collection in the project influence area

Table 5-17: Groundwater Quality in the Project Influence Area

Parameter	Unit	Sampling ID												DOE Standard for Drinking Water
		GW1	GW2	GW3	GW4	GW5	GW6	GW 7	GW 8	GW 9	GW 10	GW 11	GW 12	
pH	-	6.82	6.85	4.70	6.52	6.55	6.65	7.85	6.98	7.38	7.92	7.52	7.50	6.5 – 8.5
Temp	°C	24.8	25.3	25.1	24.8	25.3	24.8	24.7	25.1	25.2	24.8	25.1	25.1	20 - 30
EC	µS/cm	425.0	802.0	907.0	1062.0	324.0	987.0	552	6500	1432	829	730	539	-
TDS	mg/L	254.0	461.0	841.0	620	198.0	622.0	339	3398	736	450	395	309	1000
Ca	mg/L	38.4	29.4	97.2	151.0	19.8	101.0	51.4	181	44.7	5.55	21.9	19.3	75
Mg	mg/L	19.5	21.2	14.6	54.9	16.5	28.8	1.34	74.9	17.9	2.00	13.0	12.7	30 – 35

Para-meter	Unit	Sampling ID												DOE Standard for Drinking Water
		GW1	GW2	GW3	GW4	GW5	GW6	GW 7	GW 8	GW 9	GW 10	GW 11	GW 12	
Na	mg/L	38.6	113.0	93.6	29.2	19.9	53.1	107	767	200	170	120	75.0	200
K	mg/L	4.26	2.46	25.7	5.76	3.71	5.49	1.36	20.9	5.42	1.66	4.21	4.37	12
Cl ⁻	mg/L	6.94	111.0	86.9	11.6	15.1	116.0	18.2	1766	169	58.6	44.4	17.5	150 – 600
F	mg/L	<0.5	<0.5	29.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1
Br	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-
SO ₄	mg/L	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	400
As	mg/L	<0.005	<0.005	0.369	0.04	0.03	<0.005	<0.005	0.02	<0.005	<0.005	<0.005	<0.005	0.05
Fe	mg/L	1.34	1.19	3.14	1.31	24.7	0.35	0.63	3.24	0.42	0.30	0.98	1.02	0.3 – 1.0
Mn	mg/L	0.07	0.07	2.57	2.60	1.73	0.50	<0.05	2.10	0.08	<0.05	0.05	<0.05	0.1

Source: Field survey, September- October 2015, Cells in grey color shed indicate the exceedance the limit of DOE drinking water standard, GW1- Harinaghat, Chandpur, GW2- Gozaria, Munshiganj, GW3- Boktabali Ferryghat, Narayanganj, GW4- Araihasar, Narayanganj, GW5- Ashuganj, GW6- Sadarghat, Dhaka, GW7- Near Bhasan Char (Chukkhallighat, Sandwip), GW8- Near Chairman Ghat (Noakhali), GW9- Near Beduria Launch Ghat (Sripurdwip, Barisal), GW10- Near Hizla (Mehendiganj, Kaliganj) GW11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), GW12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat)

Temperature: Temperature affects physical, chemical and biological processes in water bodies. As water temperature increases, the rate of chemical processes generally increases and the solubility of gases in water such as O₂, CO₂, N₂ and others decrease. The metabolic rate of aquatic organisms is also related to temperature. In project area, all collected groundwater samples have temperature within the Bangladesh standard for drinking water (20 - 30 °C) purpose.

pH: pH is a measure of the hydrogen ion concentration in water and indicates whether the water is acidic or alkaline. The measurement of alkalinity and acidity of pH is required to determine the corrosiveness of the water. From the pH value of the groundwater samples it is observed that lowest value is found in samples collected from Boktabali ferry ghat in Narayanganj, which is 4.70 far below the permissible limit.

Electrical Conductivity: Conductivity is ability of water to carry an electrical current. This ability mainly depends on presence of anion and cations in water and also depends on mobility, valence of ions and temperature. In the present study the GW4 showed higher electrical conductivity (1062.0 mg/L) when compared to other sampling locations.

Total dissolved solids (TDS): TDS values indicate the general nature of water quality and are usually related to conductivity. However, the values of TDS of all the samples collected throughout the project influence area are within the standard limit except GW8 where conductivity was recorded 3398 µS/cm.

Major Ions: The abundance of major ions largely depends upon the nature of rocks, climatic conditions and mobility. The ion distribution is also influenced by the infinite complex surface and subsurface physicochemical environments. To assess these geochemical processes the collected water samples are chemically analyzed for the major cations (Na, K, Ca and Mg) and major anions (Cl and SO₄). In addition to Fe and F which are naturally very variable due to local geological, climatic and geographical conditions. However, the higher contents of calcium and magnesium in water are due to gypsum and anhydrite dissolution in the circulating waters. The concentrations of calcium in the study area are 97.2 mg/L, 151.0 mg/L, 101.0 mg/L and 181.0 mg/L recorded in GW3, GW4, GW6 and GW8 respectively exceeds the standard limit. Likewise, magnesium (Mg) concentrations in the study area are 54.9 mg/L and 74.9 mg/L recorded in GW4 and GW8 respectively exceeds the standard limit. Moreover, Iron (Fe) content of groundwater samples along the project influence area (GW1- 1.34 mg/L, GW2- 1.19 mg/L, GW3- 3.14 mg/L, GW4- 1.31 mg/L, GW5- 24.7 mg/L, GW8- 3.24 mg/L and GW12- 1.02 mg/L) exceeds the Bangladesh standard for drinking water (0.3-1.0 mg/L). Likewise, manganese (Mn) content of groundwater samples (GW3- 2.57 mg/L, GW4- 2.60 mg/L, GW5- 1.73 mg/L, GW6- 0.50 mg/L and GW8- 2.10 mg/L) exceeds the standard for drinking water (0.1 mg/L). Sulphate is found in small quantities in all groundwater samples which lie within the permissible limits of DOE drinking water standard. Groundwater sample (GW3) of Boktabali ferry ghat, Narayanganj contained arsenic (0.369 mg/L) exceeding the DOE tolerance limit (0.05 mg/L) for drinking water.

With the growth of industry the groundwater is made susceptible for contamination due to addition of waste materials. Waste materials from the factories percolate with rain water and

reach aquifer resulting in erosion of groundwater quality. Groundwater is used for domestic, industrial, water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population, unplanned urbanization, industrialization and too much use of fertilizers and pesticides in agriculture.

Air Quality

Air quality measurements carried out during 2 to 14 October 2015 in six locations of the Project influence area (Table 5.18) and the monitoring results are given in Table 5.19. World Bank Group Environmental, Health, and Safety (EHS) Guidelines and Bangladesh national standards for ambient air quality are also presented in **Table 5.19**. The key air quality parameters (particulate matter- PM₁₀ and PM_{2.5}, oxides of sulfur - SO_x, carbon monoxide- CO, oxides of nitrogen – No_x, ground ozone O₃) were analyzed from samples collected over an eight (8) hour period at each sampling sites.

Table 5-18: Ambient Air Quality Parameters in Project Influence Area (in µg/m³)

Location →	AAQ1	AAQ2	AAQ3	AAQ4	AAQ5	AAQ6	Air Quality Standards	
Parameter ↓							DOE*	WBG EHS**
Carbon Monoxide (CO)	510.77	1016.25	254.14	319.08	802.77	421.25	10,000 (8 hour)	-
Nitric Oxide (NO)	20.61	31.84	12.51	18.22	27.76	19.07	100 (Annual)	40 (Annual)
Nitrogen dioxide (NO₂)	18.34	20.15	9.79	15.51	19.32	16.56		
Sulphur dioxide (SO₂)	16.98	23.67	11.62	15.18	20.07	16.01	365 (24 hour)	20 (24 hour)
Ozone (O₃)	11.37	15.89	8.44	10.32	14.37	12.61	157 (8 hour)	100 (8 hour)
Particulate Matter (PM₁₀)	89.21	127.18	49.67	83.11	95.83	87.22	150 (24 hour)	50 (24 hour)
Particulate Matter (PM_{2.5})	41.41	54.33	21.84	28.56	46.17	37.58	65 (24 hour)	25 (24 hour)
Temperature	32.69	30.83	26.71	27.70	26.34	30.43	-	-
Humidity	55.01	57.82	62.56	69.91	67.48	57.88	-	-

Source: Field survey, October 2015, AAQ1-Ashuganj, Brahmanbaria, AAQ2- Sadarghat Launch Terminal, Dhaka, AAQ3- Char Shreepur, Barisal, AAQ4- Dhunia, Bhola, AAQ5- Chandpur Launch Terminal, AAQ6- Gozaria Launch Terminal, Munshiganj,

*The amended Schedule-2, 2005, of (Air Quality Standard) Environmental Conservation Rules, 1997

**World Bank Group Environmental, Health, and Safety (EHS) Guidelines

The measurement results showed achievement of all air quality standards. Based on the ambient air quality standard of DOE, air quality in the project areas can be stated as in good condition. Particulate matters PM₁₀ and PM_{2.5} showed concentrations of 49.67 to 127.18µg/m³

and 21.84 to 54.33 $\mu\text{g}/\text{m}^3$ which are far below the DOE standard of 150 $\mu\text{g}/\text{m}^3$ and 65 $\mu\text{g}/\text{m}^3$ respectively. On the other hand, all the sampling locations except AAQ3 (Dhunia, Bhola) exceeded the standard of World Bank for particulate matters PM_{10} and $\text{PM}_{2.5}$. Details of air quality measurements are described below:

Carbon monoxide (CO): CO measured in sampling campaign in the month of October 2015 and the concentration of the samples was within DOE standard of ambient air quality. The highest value of 1016.25 $\mu\text{g}/\text{m}^3$ is obtained at Sadarghat launch terminal (AAQ2).

Nitric oxide (NO) and Nitrogen dioxide (NO₂): Ambient NO and NO₂ concentrations in all the sampling points showed compliance with DOE and WB standard of 100 $\mu\text{g}/\text{m}^3$ and 40 $\mu\text{g}/\text{m}^3$ accordingly. Measured concentrations for NO and NO₂ are 12.51 to 31.84 $\mu\text{g}/\text{m}^3$ and 9.79 to 20.15 $\mu\text{g}/\text{m}^3$ accordingly.

Sulphur dioxide (SO₂): Ambient SO₂ concentrations in six sampling locations showed compliance with the DOE standard of 365 $\mu\text{g}/\text{m}^3$ but Sadarghat (AAQ2) and Chandpur (AAQ5) cannot meet the WB standard of 20 $\mu\text{g}/\text{m}^3$ for SO₂ concentrations. Measured concentrations are ranges from 11.62 to 23.67 $\mu\text{g}/\text{m}^3$.

Ozone (O₃): The results indicated that ozone (O₃) in the six study areas are within the air quality standards of DOE and the concentration ranges from 8.44 to 15.89 $\mu\text{g}/\text{m}^3$.

Air Pollution Sources- Most of the sampling points located in the commercial area in nature except char Shreepur in Barisal and Dhunia in Bhola district which are in rural area. The main sources of pollution in Ashuganj, Chandpur and Gozaria are the boat traffics, local vehicles especially auto-rickshaws, trucks, locally manufactured small three-wheelers. Cooking and other fires in the area cause some pollution. In addition, various types of motor boats and launches were also sailing in the river– causing air quality deterioration. In Sadarghat, the location of air quality measurement is at the terminal area. Surrounding area of the sampling location is overcrowded which induced extensive dust emission. The measurement was done at morning and ended in the evening when launches started their journey and people began to gather at the terminal. To sum up, the air quality in the vicinity of the waterways is good as there is little industry and only a few roads. This is partly due to the effect of the biomass of project area and also partly due to the absence of emission sources.



Figure 5-37: Air quality and noise level measurement in the project influence area

Noise Level

Noise level data were collected in the same locations as air quality samples, in eight locations from 2-14 October 2015 are shown in Figure 5.38 and the test results are given in the Table 5.19. The measured noise values are within the prevailing standards set by DoE and WB (Table 5.20 and Table 5.21). The technical terms and units of noise measurements employed by these standards are defined as follows:

L_{eq} = the sound level equivalent, i.e., an energy-averaged sound level that includes both steady background sounds and transient short-term sounds. The L_{eq} represents the level of steady sound which, when averaged over the sampling period, is equivalent in energy to the fluctuating sound level over the same period. The L_{eq} is commonly used to describe traffic noise levels that tend to experience hourly peaks.

dBA = A weighted measurement of sound. Since the range of sound pressure levels varies considerably, sound levels are expressed on a logarithmic scale, which compresses the range. The standard measurement unit of sound is the decibel (dB), which represents a ratio of pressure levels referenced to the 0.0002 microbar, which is considered to be the threshold audible range, of human hearing. The threshold of pain, which is of the order end of the audible range, occurs at approximately 140 decibels. Using the decibel scale, an increase of three decibels is barely perceptible and an increase or decrease of ten decibels is perceived as a doubling or halving of the sound level. Humans are capable of hearing only a limited frequency range of sound and the human ear is not equally sensitive to all frequencies. The human ear is more tolerant to higher noise levels at lower frequencies and can hear frequencies ranging from 20 hertz (Hz) to 20,000 Hz. In order to take this characteristic into account in noise measurements, a frequency weighting known as A-weighting is commonly applied to the sound pressure levels which approximate the frequency response of the human ear by placing most emphasis on the frequency range of 1,000 to 5,000 hertz. Because the A-weighted scale closely describes the subjective response of the human ear, it is most commonly used in noise measurements. Sound level measurement using A-weighting are expressed as dBA.

Table 5-19: Noise Levels in Project Influence Area

Location	Category of the area	Date	Noise (L_{eq}) in dBA
NM1	Commercial	02/10/2015	49.86
NM2	Commercial	03/10/2015	65.06
NM3	Residential and Rural	10/10/2015	55.72
NM4	Residential and Rural	11/10/2015	60.66
NM5	Commercial	13/10/2015	63.52
NM6	Commercial and Mixed	14/10/2015	53.52

Source: Field survey, October 2015

Source: Field survey, October 2015, NM1-Ashuganj, Brahmanbaria, NM2- Sadarghat Launch Terminal, NM3- Char Shreepur, Barisal, NM4- Dhunia, Bhola, NM5- Chandpur Launch Terminal, NM6- Gozaria Launch Terminal, Munshiganj

Table 5-20: Noise Quality Standards of Bangladesh

Sl. No.	Area Category	Noise Quality Standard in dBA
A	Silent Zone	50
B	Residential Area	55
C	Mixed Area (basically residential and together used)	60
D	Commercial Area	70
E	Industrial Area	75

Source: The amended schedule-4, 2006, of (Noise Measurement Standard) Environmental Conservation Rules, 1997

Notes:

1. Silent zones are areas up to a radius of 100 m around hospitals, educational institutes, and Government-declared special establishments. Use of vehicular horns, other signals, and loudspeakers are prohibited in silent zones.

Table 5-21: World Bank Group EHS Standards for Noise

Area Category	Standard Values in dBA
Residential, institutional, educational area	55
Commercial and industrial area	70

Source: World Bank Group Environmental, Health, and Safety (EHS) Guidelines

All the locations are generally within the limits prescribed by the ambient noise quality standards by DOE and WB. Minimum noise levels vary from 49.86 dB (A) at Ashuganj to 65.06 dB (A) at Sadarghat launch terminal. The value at Dhunia in Bhola is higher than the permissible limit for residential areas (55 dBA) due to passing launches and engine boats during noise measurement.

Noise Sources- Noise levels are generally low in the vicinity of the waterways as there are few sources of loud noise such as little factories, boat traffics and road traffics. Boat traffics in the river such as launch, ferry, engine boat, twallers etc. are the key sources of noise in the project influence area.

5.2.2 Dry Period Data Analysis

Surface Water

In case of dry season monitoring, the surface water samples were collected from the month of January to February 2016 and the detailed analyses are incorporated in Table 5.22

Table 5-22: Dry Season Surface Water Quality of Rivers in Project Influence Area

Parameter Unit		Sampling ID											
		SW1_D	SW2_D	SW3_D	SW4_D	SW5_D	SW6_D	SW7_D	SW8_D	SW9_D	SW10_D	SW11_D	SW12_D
pH	-	8.47	7.31	6.95	7.77	7.54	7.02	7.65	7.80	7.10	7.29	7.42	7.45
Temp	°C	23	25	22.5	23	24.5	22	24.5	23	22.5	22.5	23	21.5
Turbidity	NTU	8.2	3.34	22.5	48.6	6.97	14.2	47.8	9.06	36.9	19.8	8.22	12.5
EC	µS/cm	264	278	560	786	129.1	1073	22450	13975	271	245	607	275
DO	mg/L	3.18	0.83	4.00	1.02	7.74	2.40	0.55	4.05	4.58	5.33	2.00	5.50
BOD ₅	mg/L	<MDL	1.00	2.24	14.4	3.2	15.7	67.3	2.12	15.3	2.83	18.9	2.87
TOC	mg/L	3.56	4.89	3.17	11.48	-	10.8	3.09	1.92	7.29	8.04	<0.5	6.34
TDS	mg/L	155	191	300	492	64.5	537	14738	6583	159	136	375	147
TSS	mg/L	26	35	18.4	19	117	33.6	40.2	356	89.4	33.8	36.0	141
Ca	mg/L	-	-	35.5	-	13.89	50.6	279	162	40.2	26.2	20.3	29.5
Mg	mg/L	6.69	5.73	11.7	8.86	6.85	15.2	468	244	11.3	7.30	13.8	9.88
Na	mg/L	25	44.7	30.0	187.1	8.21	107	1071	893	7.98	7.46	86.7	10.8
K	mg/L	17.9	5.8	6.89	22.8	2.14	10.9	49.2	47.2	2.76	2.81	4.38	3.67
Cl ⁻	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
F	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Br	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
SO ₄	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
NO ₃	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Total PO ₄	mg/L	0.19	0.69	2.38	3.84	3.43	7.24	1.50	-	-	-	-	-

Source: Field survey January-February 2016 D-Dry Season,, Cells in grey color shed indicate the exceedance the limit of DOE standard, SW1- Harinaghat, Chandpur, SW2- Gozaria, Munshiganj, SW3- Boktabali Ferryghat, Narayanganj, SW4- Araihasar, Narayanganj, SW5- Ashuganj, SW6- Sadarghat, Dhaka, SW7- Near Bhasan Char (Chukhalighat, Sandwip), SW8- Near Chairman Ghat (Noakhali), SW9- Near Beduria Launch Ghat (Sripurwip, Barisal), SW10- Near Hizla (Mehendiganj, Kaliganj) SW11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), SW12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat)

Water Temperature- The temperature of the water bodies in the project influence area ranged from 21.5 to 25°C in January - February 2016. Temperatures of all the samples are below the DoE standards for both irrigation and fish habitats.

pH- In case of dry season, for all the samples, the pH range is found well within the DoE standards like wet season. The pH of water samples lies in the range of 6.95 to 8.47.

Turbidity- Turbidity values of the surface water samples ranges from 3.34 to 48.6 NTU. Lower turbidity value might be due to the calm nature of river water. The highest values of turbidity were observed in SW4 collected from Araihasar, Narayanganj.

Dissolved Oxygen (DO) - The dissolved oxygen values ranged from 0.55 to 7.74 mg/L in twelve locations. The concentration of DO exceeded in all the surface water samples except SW4 at Araihasar, SW10 near Hizla ghat at Mehendiganj and SW12 near Dawlatkhan Launch ghat, Bhola. However, the worst condition is observed in SW7 near Bhasan Char, Sandwip which was 0.55 mg/L where the DOE standard limit for irrigation is 5 mg/L or more.

BOD₅- In the study area BOD₅ values range from below detection limit to a maximum of 67.3 mg/L. The concentration of BOD₅ is far more than DOE standard limit in SW4, SW6, SW7, SW9 and SW11 which are 14.4 mg/L, 15.7 mg/L, 67.3 mg/L, 15.3 mg/L and 58.3 mg/L accordingly. The best scenario in terms of low value of BOD₅ is recorded in SW1 which is below detection limit.

Electric Conductivity (EC) - In dry season monitoring EC values range from a minimum of 129.1µS/cm to a maximum of 22450.0µS/cm. The entire water samples collected from the study area are within the standard limit except SW7 (Bhasan Char, Sandwip) and SW8 (Chairman Ghat, Noakhali) recorded the higher value of EC.

Total Dissolved Solids (TDS) - TDS may influence the toxicity of heavy metals and organic compounds for fish and other aquatic life. The natural range of TDS concentration in the water bodies of the project influence area are between 64.5 mg/L and 14738.0 mg/L. The higher value of TDS is recorded in SW7 (Bhasan Char, Sandwip) and SW8 (Chairman Ghat, Noakhali).

Total Suspended Solids (TSS) - The concentration of total suspended solids ranges from 18.4 mg/L to 356.0 mg/L. The water sample collected from Chairman Ghat, Noakhali (SW8) recorded the highest value of suspended solids.

Total Organic Carbon (TOC) -The concentration of TOC ranges from below 0.5 mg/L to 11.48 mg/L. In SW4 collected from Araihasar in Narayanganj recorded the highest value of total organic carbon and the opposite value observed in SW11 near Ilisha Ghat in Bhola.

Major Ions- The concentration of Na ranges from 7.46 mg/L to 1071.0 mg/L. The higher values of Na are 1071.0 mg/L and 893 mg/L found in SW7 and SW8 collected from Bhasan Char, Sandwip

and Chairman Ghat, Noakhali which may arise due to sea water intrusion. In addition, the salts of calcium, together with those of magnesium, are responsible for the hardness of water. The concentrations of Ca and Mg are higher in SW7 and SW8 than rest of the samples. On the other hand, the nitrate concentration is generally below 3.0 mg/L for all the locations. Phosphate is observed ranges from 0.19 mg/L to 7.24 mg/L, its highest concentration i.e., 7.24 mg/L is observed in SW6 collected from Buriganga River.

The test result of both seasons reveals that the surface water quality shows some seasonal variation. The results from data analysis show that the surface water quality is not acceptable from aquaculture and irrigation perspectives for the parameters such as DO, BOD5, EC during dry season. The data depicts that during the wet season, the DO level increases from 0.89 to 6.12 mg/L in twelve locations, while during dry season, the DO level drops from 7.74 to 0.55 mg/L at those locations. However, the EC measures the salinity of water and depends on the ions present in water. The values for EC in the surface water during the wet season at all the sampling locations were found within the DOE standard, which is 54.2µS/cm to 171.0µS/cm. However, during dry season the EC values varied from 129.1µS/cm to 22450.0µS/cm and at SW7 (Bhasan Char, Sandwip) and SW8 (Chairman Ghat, Noakhali) recorded the higher value of EC. Moreover, the values of major ions were recorded higher in the dry season in twelve locations than the wet season. In the wet season, as the flow of the river increases which may cause the dilution of the salinity of the water, while in the dry season, the flow of the river decreases, as a result the EC and the concentration of major ions increase.

Riverbed Sediment

For dry season sampling, the riverbed sediment collected from the same location as wet season sampling during the month of January - February 2016 (Table 5.23). Also one additional sample was analysed which was taken from the branch of upper meghna river (Route-9) at the probable dredging location.

Table 5-23: Dry Season Riverbed Sediment Samples Collected from Project Influence Area

Parameter	Unit	Sampling ID												OSPAR*
		RBS1	RBS2	RBS3	RBS4	RBS5	RBS6	RBS7	RBS8	RBS9	RBS10	RBS11	RBS12	
Salinity	%	-	-	0.04	-	0.06	0.06	0.88	0.59	0.02	0.021	0.019	0.040	-
Total Mg	%	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Ca	%	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Na	%	-	-	-	-	-	-	-	-	-	-	-	-	-
Total K	%	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Organic Carbon (TOC)	%	0.32	0.67	0.45	0.17	0.666	0.32	0.44	0.38	0.22	0.45	0.26	0.64	-
Total PO ₄ ³⁻	%	0.188	0.245	0.220	0.104	0.217	0.248	0.0152	0.0154	0.160	0.148	0.176	0.127	-
Total NO ₃	ppm	5.67	2.23	0.71	102.46	6.675	0.61	1.280	0.524	0.113	0.106	0.117	0.103	-
Total As	ppm	15.04	1.34	2.352	9.7	0.051	4.227	4.324	4.967	2.395	4.326	2.871	5.134	30-80
Total Cd	ppm	0.00	0.00	BDL	0.00	0.140	BDL	0.035	0.054	BDL	BDL	BDL	BDL	1.0-2.5
Total Hg	ppm	0.041	0.041	0.005	0.055	BDL	0.020	7.26	3.17	BDL	BDL	BDL	BDL	0.6-1.0
Total Pb	ppm	16.0	12.6	6.70	23.1	10.525	204.63	13.404	11.353	4.264	11.487	5.922	15.080	100-120
Total Cr	ppm	18.9	17.5	27.73	20.2	23.797	66.01	31.727	34.512	26.647	32.126	21.470	33.483	150-200
Total Zn	ppm	59.2	62.4	46.13	112.8	51.658	251.22	51.176	57.331	30.443	54.468	35.306	59.746	250-500
Total Ni	ppm	21.0	21.1	32.969	21.3	35.261	18.015	40.918	45.682	20.711	42.851	21.405	35.318	50-100

Source: Field survey, January- February 2016, BDL- Below Detection Limit (Detection Limit: Hg = 1.0 ppb, Cd= 0.03 ppm), *OSPAR Guidelines for Management of Dredged Material, RBS1- Harinaghat, Chandpur, RBS2- Gozaria, Munshiganj, RBS3- Boktabali Ferryghat, Narayanganj, RBS4- Araihasar, Narayanganj, RBS5- Ashuganj, RBS6- Sadarghat, Dhaka, RBS7- Near Bhasan Char (Chukkhali, Sandwip), RBS8- Near Chairman Ghat (Noakhali), RBS9- Near Beduria Launch Ghat (Sripurdwip, Barisal), RBS10- Near Hizla (Mehendiganj, Kaliganj) RBS11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), RBS12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat)

In case of dry season sampling, concentration of two parameters- Hg (mercury) and Pb (lead) were exceeded the OSPAR standard limit. The highest exceeded concentration of Hg was 204.63 ppm which detected in RBS6 collected from Sadarghat. On the other hand, concentrations of Pb were above the OSPAR guideline which were 7.26 and 3.17 ppm collected from Bhasan char, Sandwip (RBS7) and near Chairman Ghat, Noakhali (RBS8) respectively.

The test result revealed that the values of most of the ions were within the OSPAR standard limit for twelve locations during wet and dry season. In the wet season, as the flow of the river increases which may cause the dilution of the riverbed sediments, while in the dry season, the flow of the river decreases, as a result the concentration of Hg and Pb increase in the sediment collected from the estuarine rivers at Bhasan Char, Sandwip (RBS7) and near Chairman Ghat, Noakhali (RBS8). Sediment quality is a matter of concern at the downstream of Chandpur, Upper Meghna, Lower Meghna, Shitalakhya and Buriganga.

Groundwater

The groundwater samples for dry season monitoring were collected from the same locations as wet season sampling during the month of January- February 2016 (Table 5.24).

Table 5-24: Groundwater Quality in the Project Influence Area for Dry Season

Parameter	Unit	Sampling ID												DOE Standard for Drinking Water
		GW1_D	GW2_D	GW3_D	GW4_D	GW5_D	GW6_D	GW 7_D	GW 8_D	GW 9_D	GW 10_D	GW 11_D	GW 12_D	
pH	-	7.90	7.72	6.90	7.54	6.76	6.85	7.66	7.88	7.08	7.85	7.58	7.20	6.5 – 8.5
Temp	°C	27	26.2	27	25.5	26	29	28	26.3	29	25.5	30	26	20 - 30
EC	µS/cm	411	763	861	712	462.1	986	29900	5950	11700	931	240	742	-
TDS	mg/L	284	469	540	430	231.1	562	17380	2905	5747	520	142	444	1000
Ca	mg/L	18.78	23.62	123	52.78	42.96	94.3	320	172	534	116	27.5	44.8	75
Mg	mg/L	7.74	10.68	23.2	23.01	26.71	31.3	558	136	308	2.05	7.5	26.2	30 – 35

Parameter	Unit	Sampling ID												DOE Standard for Drinking Water
		GW1_D	GW2_D	GW3_D	GW4_D	GW5_D	GW6_D	GW7_D	GW8_D	GW9_D	GW10_D	GW11_D	GW12_D	
Na	mg/L	48.7	200	11.4	148.2	1.19	31.4	1357	500	1145	186	99.8	63.8	200
K	mg/L	8.2	4.4	5.48	4.2	4.01	4.04	61.4	21.3	19.1	2.67	4.38	4.19	12
Cl ⁻	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	150 – 600
F	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	1
Br	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
SO ₄	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	400
As	mg/L	<0.005	<0.005	<0.005	0.006	0.011	<0.005	<0.005	0.029	<0.005	<0.005	<0.005	<0.005	0.05
Fe	mg/L	1.7	0.9	1.57	22	1.75	0.36	19.3	2.43	2.89	<0.2	1.04	2.20	0.3 – 1.0
Mn	mg/L	<MDL	<MDL	2.58	0.26	5.67	0.38	0.41	2.04	0.32	<0.05	<0.05	0.06	0.1

Source: Field survey, January-February 2016, Cells in grey color shed indicate the exceedance the limit of DOE drinking water standard, GW1- Harinaghat, Chandpur, GW2- Gozaria, Munshiganj, GW3- Boktabali Ferryghat, Narayanganj, GW4- Araihasar, Narayanganj, GW5- Ashuganj, GW6- Sadarghat, Dhaka, GW7- Near Bhasan Char (Chukhalighat, Sandwip), GW8- Near Chairman Ghat (Noakhali), GW9- Near Beduria Launch Ghat (Sripurdwip, Barisal), GW10- Near Hizla (Mehendiganj, Kaliganj) GW11- Near Ilisha Ghat (Tulatali Bazaar, Bhola), GW12- Near Dawlatkhan Launchghat (Vabanipur Lanchghat).

Temperature: In project area, all collected groundwater samples have temperature within the Bangladesh standard for drinking water (20 - 30 °C) purpose.

pH: From the pH value of the groundwater samples is found within the Bangladesh standard for drinking water (6.5 – 8.5) purpose.

Electrical Conductivity: In the present study the GW7, GW8 and GW9 showed the higher electrical conductivity of 29900 mg/L, 5950mg/L and 11700 mg/L respectively when compared to other sampling locations.

Total dissolved solids (TDS): The values of TDS of all the samples collected throughout the project influence area are within the standard limit except GW7, GW8 and GW9 which were 17380 mg/L, 2905 mg/L and 5747 mg/L accordingly where the DOE permissible limit for drinking purpose is 1000 mg/L.

Major Ions: The concentrations of calcium, magnesium, sodium and potassium in the study area are recorded higher in GW7 (Bhasan Char, Sandwip), GW8 (Chairman Ghat, Noakhali) and GW9 (Beduria Launch Ghat, Barisal) respectively exceeds the standard limit. It is noted that, the same results are also recorded for the surface water samples which collected from the same locations. However, five of the locations (GW2, GW6, GW10, GW11 and GW12) failed to meet the Bangladesh drinking water standard (0.3-1.0 mg/L) for Iron (Fe) content. The highest value was recorded in GW4 and GW7 are 22 mg/L and 19.3 mg/L accordingly. Likewise, seven of the tube-wells (GW3, GW4, GW5, GW6, GW7, GW8 and GW9) failed to meet the DOE standard (0.1 mg/L) for manganese (Mn) content in drinking water.

The test result shows that, only 8% of TDS value exceeds DOE standards for wet season whereas 25% of samples exceeds standard of allowable limits, which reveals that water is unsuitable for drinking. In case of iron, 66% and 58% samples exceed DOE recommended values during dry and wet season accordingly. Higher concentration of manganese noticed in 58% of the samples in dry season and 33% of the samples in wet season, which lead to unsuitability of drinking. The samples exceeding DOE recommended Calcium values is 58% in dry season but in case of wet season 33% samples exceeds DOE recommended value. However, about 25% samples are exceeding the recommended Mg, Na and K value by DOE guidelines in dry season but only 8% samples exceed in wet season. The study area is good for pH as all the water samples within the recommended value throughout the study period. Therefore, it can be concluded that the project influence area is highly associated with the iron problem, especially in dry season.

Air Quality

Air quality measurements carried out for dry season during January to February 2016 in six locations of the Project influence area and the monitoring results are given in Table 5.25.

Table 5-25: Ambient Air Quality Parameters in Project Influence Area (in $\mu\text{g}/\text{m}^3$)

Location	AAQ1_D	AAQ2_D	AAQ3_D	AAQ4_D	AAQ5_D	AAQ6_D	Air Quality Standards	
Parameter							DOE*	WBG EHS**
Carbon Monoxide (CO)	859.17	1543.50	376.72	568.12	937.42	755.98	10,000 (8 hour)	-
Nitric Oxide (NO)	37.90	56.53	29.98	40.30	50.47	40.01	100 (Annual)	40 (Annual)
Nitrogen dioxide (NO ₂)	26.14	27.16	12.90	22.71	28.64	21.97		
Sulphur dioxide (SO ₂)	32.08	42.88	26.09	31.46	39.33	31.45	365 (24 hour)	20 (24 hour)
Ozone (O ₃)	18.53	20.07	10.57	15.77	21.11	17.54	157 (8 hour)	100 (8 hour)
Particulate Matter	131.55	144.76	91.51	103.85	139.75	126.58	150 (24 hour)	50 (24 hour)

Location	AAQ1_D	AAQ2_D	AAQ3_D	AAQ4_D	AAQ5_D	AAQ6_D	Air Quality Standards	
Parameter							DOE*	WBG EHS**
(PM ₁₀)								
Particulate Matter (PM _{2.5})	56.73	61.84	30.24	36.96	58.27	49.14	65 (24 hour)	25 (24 hour)
Temperature	23.24	26.04	22.47	22.88	22.21	22.63	-	-
Humidity	76.00	72.46	55.51	61.18	74.71	66.06	-	-

Source: Field survey, January-February 2016, AAQ1-Ashuganj, Brahmanbaria, AAQ2- Sadarghat Launch Terminal, Dhaka, AAQ3- Char Shreepur, Barisal, AAQ4- Dhunia, Bhola, AAQ5- Chandpur Launch Terminal, AAQ6- Gozaria Launch Terminal, Munshiganj,

*The amended Schedule-2, 2005, of (Air Quality Standard) Environmental Conservation Rules, 1997,

**World Bank Group Environmental, Health, and Safety (EHS) Guidelines

Particulate matters- PM₁₀ and PM_{2.5} showed concentrations of 91.51µg/m³ to 144.76µg/m³ and 30.24µg/m³ to 61.84µg/m³ which are below the DOE standard of 150µg/m³ and 65µg/m³ respectively. On the other hand, all the sampling locations exceeded the standard of World Bank for Particulate matters PM₁₀ and PM_{2.5}.

Carbon monoxide (CO): CO measured in sampling campaign for dry season and the concentration of the samples was within DOE standard of ambient air quality. The highest value of 1543.50µg/m³ is obtained at Sadarghat launch terminal (AAQ2).

Nitric oxide (NO) and Nitrogen dioxide (NO₂): Ambient NO and NO₂ concentrations in all the sampling points showed compliance with DOE standard of 100µg/m³. On the other hand, all the sampling locations exceeded the standard of World Bank for NO except AAQ1 and AAQ3. On the contrary, all the samples were within the WB standard for NO₂ (40µg/m³). Measured concentrations for NO and NO₂ are 29.98 to 56.53µg/m³ and 12.90 to 28.64µg/m³ accordingly.

Sulphur dioxide (SO₂): Ambient SO₂ concentrations in six sampling locations showed compliance with the DOE standard of 365µg/m³ but none of them cannot meet the WB standard of 20µg/m³ for SO₂ concentrations. Measured concentrations are ranges from 26.09 to 42.88µg/m³.

Ozone (O₃): The results indicated that ozone (O₃) in the six study areas are within the air quality standards of DOE and WB. The concentration ranges from 10.57 to 21.11µg/m³.

Based on the ambient air quality standard of DOE, air quality in the project areas can be stated as in good condition all year round. The results of the air quality monitoring in dry season revealed relatively higher pollution level than wet season. Particulate matter PM₁₀ and PM_{2.5} exceeded the standard set by WB for both of the seasons. This could be due to frequent movement of water vessels run by diesel engine and silted up the water bodies located close to the sampling points.

Noise Level

Noise level data were collected in the same locations as air quality samples, in eight locations from January-February 2016 for dry season monitoring are shown in the Table 5.26

Table 5-26: Dry Season Noise Levels in Project Influence Area

Location	Category of the area	Date	Noise (L _{eq}) in dBA
NM1	Commercial	31/01/2016	53.25
NM2	Commercial	12/02/2016	62.55
NM3	Residential and Rural	06/02/2016	56.42
NM4	Residential and Rural	07/02/2016	53.69
NM5	Commercial	29/01/2016	68.5
NM6	Commercial and Mixed	30/01/2016	60.91

Source: Field survey, January-February 2016, NM1- Ashuganj, Brahmanbaria, NM2- Sadarghat Launch Terminal, NM3- Char Shreepur, Barisal, NM4- Dhunia, Bhola, NM5- Chandpur Launch Terminal, NM6- Gozaria Launch Terminal, Munshiganj

All the locations except NM3 (Char Shreepur, Barisal) are generally within the limits prescribed by the ambient noise quality standards by DOE and WB. The value at Char Shreepur, Barisal is higher than the permissible limit for residential areas (55 dBA) due to passing launches and engine boats during noise measurement. Minimum noise levels vary from 53.25 dB (A) at Ashuganj to 68.50 dB (A) at Chandpur Launch Terminal.

The noise measurement results indicated that noise level was above the environmental standards for residential areas at one sampling point in Bhola and Barisal in wet and dry season respectively. These two sites are, as cited above, not an industrial area and therefore boat traffics in the river such as launch, ferry, engine boat, twallers etc. are the key sources of noise.

Soil sample collected from potential on land disposal sites within Project Influence area:

According to the United States Department of Agriculture (USDA) Natural Resources Conservation Service, soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. The soil in the project area is highly productive and suitable to support different ecosystems in balance. During the dredging period, dredged materials will be stored at some designated places in the project influence area. Hence, there is the chance of the native soil to be disturbed by the dredged material. Soil samples collected in the month of January to February 2016 from 0.5 m depth of the surface and were analyzed in the environmental laboratory of BCSIR to assess the current soil quality of the project area. Table 5.27 reflects the test results of the soil sample collected from five locations. Test report of soil analysis proved that soil collected from the project area was acidic in nature and contained acceptable amount of some major ions.

Table 5-27: Analysis of Soil Samples Collected from Project Influence Area

Parameter	Unit	Sampling ID				
		Soil 1	Soil 2	Soil 3	Soil 4	Soil 5
pH	-	6.17	6.12	6.18	5.27	7.45
EC	µS/cm	441	350	1877	735	444
Magnesium (Mg)	%	0.206	0.016	0.369	0.110	0.111
Calcium (Ca)	%	0.145	0.234	0.539	0.024	0.033
Sodium (Na)	%	0.045	0.046	0.072	0.017	0.015
Potassium (K)	%	0.123	0.113	0.287	0.150	0.215
Total Organic Carbon (TOC)	%	0.248	0.074	1.518	1.13	1.27
Total PO ₄ ³⁻	%	0.134	0.069	0.460	0.218	0.278
Total NO ₃	ppm	10.108	3.750	98.796	0.76	95.48

Source: Field survey, January- February 2016, BDL- Below Detection Limit (Detection Limit: Hg = 1.0 ppb, Cd= 0.03 ppm), Soil 1- Char Sonarampur, Ashuganj, Soil 2- Char Chartola, Ashuganj, Soil 3- Boro Char, Munshiganj, Soil4- Selimabad, Bancharampur, Brahmanbaria, Soil5- Homna, Comilla .

5.3 Biological Environment

5.3.1 General Ecosystem and Biodiversity

Overview of general ecosystem and biodiversity in the project area

Bangladesh is situated in the “oriental region”, between the Indo-Himalayas and Indo-Chinese subregions. The country has a total area of 147,570 km, of which about 80 percent comprises one of the largest deltaic plains in the world, formed in the confluence of the Ganges, the Brahmaputra (Jamuna), and the Meghna rivers. The remaining 20 percent of the land area is comprised of the undulating hillocks, forested Hill Tracts. Distinct physiographic characteristics, variations in hydrological and climatological conditions, and difference in the soil properties in Bangladesh contribute in developing diverse forms of ecosystems enriched with great diversity of flora and fauna.

Rivers, floodplains, wetlands and estuaries of Bangladesh support a myriad of species comprising biological diversity. Aquatic biodiversity of the country are also a basis of renewable resources-based economic growth and millions of people enjoy their day-to day livelihoods from these important resources. Biodiversity has a very close relationship between ecosystem services and livelihoods when allocating land and natural resources. Healthy ecosystems ensure human well-being by providing food, materials (e.g., wood, crops, fibre, fruits and vegetables) and clean water, and also by breaking down waste materials.

Diversity of ecosystems and its rich floral and faunal resources have made Bangladesh and its ecosystems resilient to natural calamities. The rich biodiversity of this land with moderate

tropical climate makes it soothing for the human habitation. As an agrarian society, Bangladesh and its population heavily depend on the genetic resources of crop varieties. The history of its rich agricultural practices goes back to many centuries and farmers were highly innovative to create many cultivars using wild genetic resources. Presence of 10,000 plus rice varieties is a clear example of our vast wealth of genetic resources. Bangladesh is also one of the oldest producers of cotton and its rich and diverse collection of medicinal plants attracts attentions throughout the history. Nevertheless, the richness of species diversity, health of ecosystems and habitats has been degraded and become threatened in recent decades for a number of reasons.

Being a low-lying deltaic country, seasonal variation in water availability is the major factor, which generates different ecological scenarios of Bangladesh. Temperature, rainfall, physiographic variations in soil and different hydrological conditions play vital roles in the country's diverse ecosystems.

The ecosystems of Bangladesh could be categorised into two major groups, i.e. (i) land based and (ii) aquatic. The land-based ecosystems include forest and hill ecosystems, agro-ecosystems and homestead ecosystems; while seasonal and perennial wetlands, rivers, lakes, coastal mangroves, coastal mudflats and chars, and marine ecosystems fall into the aquatic category.

Protected Areas

A sound and lasting protected area program requires careful, realistic deliberation to ensure the existence of adequate legal strategies and institutional arrangements. The Constitution of the People's Republic of Bangladesh did not have any expressed provisions for the protection of wildlife and environment until 30 June 2011 when in the Fifteenth Amendment of the Constitution a new clause (18A) was introduced by the Jatiya Sangsad (National Parliament) for safeguarding and developing the environment and wildlife, under which the State will protect natural resources, biodiversity, water bodies, forest, and wildlife, and preserve and develop the environment for the present and future generations.

The project area includes the rivers Buriganga, Dhaleswari, Sitalakhya, Upper Meghna, Lower Meghna, and Meghna Estuary including the Sandwip Island and Bashan Char. Additional extensions include Upper Meghna to Ashuganj and from Chandpur to Barisal including Tetulia River. The river stretches from Sadar Ghat located on the banks of the river Buriganga in the south of the metropolitan Dhaka to Chittagong excluding the 10 km radius of the Chittagong Port Authority. This aquatic habitat represented by the above mentioned rivers and estuary consist areas that vary in their characteristics (freshwater, brackish, tidal affected, etc) and are rich in biodiversity and favour the existence of a myriad of species. The rivers either as a whole or some sections of the rivers are declared as protected under the Bangladesh Environment Conservation Act (BECA) 1995, Fish Conservation Act 1983 (updated 2010).

The rivers surrounding the capital Dhaka including the Buriganga, Turag, Balu and Sitalakhya are declared as Ecologically Critical Areas (ECA) in 2009 under the BECA 1995.

Under Article 5 of the Environment Act, so far 17 ECAs have been declared in Bangladesh with the wetlands dominating the list and the Buriganga and Sitalakhya Rivers were declared as ECA in 2009.

Under Article 5 (2) of the Environment Act 1995, the following specifications for ECAs were included in the ECA gazette notification. The specification includes the following activities that are prohibited in ECAs:

- Cutting natural forests and trees or harvest
- All kinds of hunting and killing of wildlife
- All kinds of activities harmful for habitats of fauna and flora
- Activities those can damage/alter natural characteristics of land and water
- Establishment of industries those pollute soil, water and air
- Any other activities harmful for fishes and other aquatic fauna

Despite the rivers being declared as ECAs, they face tremendous pressure and threats due to the developmental activities, mostly industries and many of the restrictions imposed under the ECA Rules are not followed due to the lack of monitoring and enforcement. : List of ECAs declared under the Bangladesh Environment Conservation Act 1995 is mentioned in Table 5.28.

Table 5-28: List of ECAs declared under the Bangladesh Environment Conservation Act 1995.

S.No.	Name of the ECA	Year of Declaration	Within Project Area
1.	Sundarban Reserve Forest (10 km periphery on all sides)	1999	-
2.	Cox's Bazaar – Teknaf Peninsula sea beach	1999	-
3.	St. Martin's Island, Cox's Bazaar	1999	-
4.	Sonadia Island, Cox's Bazaar	1999	-
5.	Hakaluki Haor, Sylhet-Maulavibazaar	1999	-
6.	Tanguar Haor, Sunamganj	1999	-
7.	Marjat Baor, Jenaidah-Jessore	1999	-
8.	Gulshan – Baridhara Lake, Dhaka Metropolitan	2001	-
9.	Buriganga River	2009	-
10.	Turag River	2009	-
11.	Balu River	2009	-
12.	Sitalakhya River	2009	✓
13.	Jaflong-Dauki River, Sylhet	2015	-

Bangladesh had always been predominantly an agricultural based country and in early days pollution was never even felt in this region. Since early sixties, of necessity, industries of various kinds started to spring up slowly. It appears that ecological imbalance is being caused

continuously due to discharge of various industrial wastes into air and water bodies. It has also been found that the intensity of pollution caused by the factories and industrial units depend on their type, location, raw materials, chemical effects, production process and discharge of gaseous, liquid and solid pollutants to the natural environment.

A survey in 1999 revealed that the water of Buriganga, Turag, Dhaleshwari, Balu, and Narai flowing around the greater Dhaka city had been completely polluted. The report concluded that the water of these rivers posed a serious threat to public life and was unfit for human use. The water of the Buriganga, which in dry season between October and April becomes almost stagnant with upstream drying up, is so polluted and the water, mixed with filth and human waste, looks like a black gel in places, emitting a strong stench and devoid of any life. However the following fish species (Table 5.29) were recorded for the Buriganga River (Ahmed *et al.* 2010) which were considered not fit for human consumption and Sitalakhya River (baseline survey, November 2015).

The Sitalakhya River also suffered from similar conditions except that the Sitalakhya received untreated industrial wastes from urea fertilizer plants, textile mills and other industries. The principal polluting agent being higher concentration of dissolved ammonia from the Urea Fertilizer Factory of Ghorasal. Though ammonia is toxic for most of the aquatic species some fish can tolerate high concentrations of NH_4 by detoxification. Higher concentration of NH_4 caused incidents of water borne and skin diseases and rendered the habitat not livable for aquatic species like freshwater fish, turtles, etc. Considering this the government declared the Buriganga and Sitalakhya Rivers as Ecologically Critical Areas to arrest further deterioration of the ecosystem in 2009. However, declaring the river as an ECA made little difference due to lack of enforcement and the situation is at the mercy of the polluters.

The recent hydrographic survey indicates that no section of the Buriganga River will be dredged. However, a small section (3,300 m^3) of the Sitalakhya River (near Kathpatti, Narayanganj) has been proposed for dredging. Common fishes of the Buriganga and Sitalakhya Rivers and their breeding period is presented in Table 5.29.

Table 5-29: Common fishes of the Buriganga and Sitalakhya Rivers and their breeding period.

Scientific name	Local name	Buriganga	Sitalakhya	Breeding Period
<i>Gudusia chapra</i>	Chapila	√		May - Oct
<i>Glossogobius giuris</i>	Bele	√		May - Oct
<i>Cirrhinus reba</i>	Tatkeni	√		Apr - Jul
<i>Channa punctatus</i>	Taki	√	√	Jun - Oct
<i>Mystus vittatus</i>	Tengra	√		Apr - Aug
<i>Pseudeutropius atherinoides</i>	Batashi	√		May
<i>Notopterus notopterus</i>	Foli/Foloi		√	Jul - Oct
<i>Rhinomugil corsula</i>	Kholla/Bata		√	Jul - Oct
<i>Clarias batrachus</i>	Magur		√	Jul - Aug

Samples analyzed during the baseline establishment of D-C project it was found that Pb was 14.63 ppm and 10.25 ppm in two sampling stations of Buriganga whereas Ahmed et al., 2010 mentioned the Pb concentration was 69.75 ± 4.13 mg/kg in three other different sampling points of Buriganga River and they varied on the basis of seasonal variation. Project team recorded that 0.10 and 0.11 ppm Cd were evident in the Buriganga River. On the other hand, 3.33 ± 0.77 mg/kg Cd, Ni - 200.45 ± 29.21 mg/kg. Zn, As, Cr, Hg was recorded in diverse concentration as well.

Dredging may cause changes in the benthic environment and may also pose threat and disturbance to the benthic and other aquatic animals through physical changes in the habitat, aquatic environment and species composition. Certain activities harmful for habitats of flora and fauna are prohibited in the ECAs. For example, dredging may change the physical characteristics of some section of the river bed affecting the benthic fauna and the aquatic biodiversity. However it is assumed that dredging activity may be allowed in the ECAs provided adequate mitigation measures are taken. Moreover, appropriate dredged material management will minimize any damage or harm to the environment or the habitats.

It may be noted that the Buriganga and the Sitalakhya are already under tremendous environmental stress from the industrial effluents, illegal encroachment, land use changes and dredging may not cause any harm provided the guidelines of the EMP are followed. This may possibly assist in getting the environmental clearance from the Department of Environment (pers. comm. with the DOE).

Hilsa and other fish sanctuaries

Hilsa is a major cash crop of Bangladesh and the hilsa fishery contributes to about 1% of the national GDP. In order to protect the hilsa fishery the government under the Protection and Conservation of Fish Rules 1985 (SRO No. 301 Law/2011 dated 29 September 2011) declared the following areas as hilsa fish sanctuary areas. The project area south of Shatnal fall within the areas demarcated as protected for hilsa fishery and spawning ground. Later in 2018 the government under the same Protection and Conservation of Fish Rules 1985 declared the sixth hilsa fish sanctuary (SRO No. 268-Law/2018 dated 10 September 2018). List of Hilsa fish sanctuaries and fishing ban period as notified by the government under the Protection and Conservation of Fish Rules 1985 is mentioned below in Table 5.30 and shown in Fig. 5.39.

Table 5-30: Hilsa fish sanctuaries and fishing ban period as notified by the government under the Protection and Conservation of Fish Rules 1985.

SN	Hilsha Fish Sanctuary Area	Boundary Point	Period Fishing banned
01	From Shatnol of Chandpur to Char Alexander of Laxmipur (100km stretch of Lower Meghna)	Shatnol Point (90°37.12'E and 23° 28.19'N); Char Alexander Point (90°49.30'E and 22° 40.92'N)	From March to April of each year
02	Char Ilisha to Char Pial of Bhola District (90km stretch of Shahbazpur Channel, a tributary of Meghna River)	Char Ilisha Mosque Point (90°38.85'E and 22° 47.30'N); Char Pial Point (90°44.81'E and 22° 05.10'N)	From March to April each year
03	Bheduria of Bhola district to Char Rustam of Patuakhali (100km stretch of Tentulia River)	Bheduria Ferry Ghat Mosque Point (90° 33.89'E and 22° 42.31'N) Mandol Bazaar (Char Rustam) (90° 31.40'E and 21° 56.32'N)	From March to April each year
04	Whole 40km stretch of Andermanik River in Kalapara Upazila of Patuakhali District	Golbunia Point (90° 19.20'E and 21° 57.68'N) Confluence of Bay of Bengal and Andermanik River (90° 3.91'E and 21° 49.43'N)	From November to January each year
05	20 km stretch of Lower Padma between Naria-Bhedorganj Upazila of Shariatpur in the north and Matlab Upazilla of Chandpur and Bhedorganj Upazilla of Shariatpur in the south	Kachikata Point of Bhedorganj UZ of Shariatpur district in the northeast (90°32.60'E and 23° 19.80'N) Bhomkara Point of Naria UZ of Shariatpur District in the northwest (90°28.80'E and 23° 18.40'N) Beparipara Point of Matlab UZ of Chandpur District in the southeast (90°37.70'E and 23° 15.90'N) Tarabunia Point of Bhedorganj UZ of Shariatpur District in the southwest (90°35.10'E and 23° 13.50'N)	From March to April each year
06	Total length of 82 km between three different river points of Barisal District. Three points are: a. Total 13.70 km stretch of the Kalabadar River between Habinagar point, Barisal Sadar Upazila and Bamnar Char Point, Mehediganj Upazila of Barisal	i) Habinagar point: (22°45'1.08"N and 90°25'10.20"E) ii) Bamnar Char point: (22°49'22.44"N and 90°28'5.16"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)
	b. Total 8.81 km stretch of the Gajaria River between Bamnar Char Point of Mehediganj Upazila and Hizla Launch Ghat point, Hizla Upazila of Barisal District	i) Bamnar Char point: (22°82'29"N and 90°46'81"E) ii) Hizla Launch Ghat: (22°90'67"N and 90°53'08"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)

SN	Hilsha Fish Sanctuary Area	Boundary Point	Period Fishing banned
	c. Total 59.51 km stretch of the Meghna River between Hizla Launch Ghat point of Hizla Upazila and Daskhin-Paschim Jangalia point, Mehediganj Upazila of Barisal District	i) Hizla Launch Ghat: (22°90'67"N and 90°53'08"E) ii) Daskhin-Paschim Jangalia point: (22°73'33"N and 90°49'17"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)

According to amended Rule 13 of the Protection and Conservation of Fish Rules 1985 catching of all kinds of fishes is prohibited in the hilsa sanctuary during the period mentioned. Further under the same Rule hilsa spawning ground has been identified and fishing is banned during the peak spawning period mentioned in Table 5.31.

Table 5-31: Fishing ban period due to Peak Spawning Period of hilsa fish

Hilsa Spawning Ground Boundary Point	Peak Spawning Period
1	2
Mayani Point, Mirsarai, Chittagong in the northeast (91° 32.15'E and 22° 42.59'N) Paschim Syed Awlia Point, Tajmuddin, Bhola in the northwest (90° 40.58'E and 22° 31.16'N) North Kutubdia Point, Kutubdia, Cox's Bazaar in the southeast (90° 52.51'E and 21° 55.19'N) Lata Chapali Point, Kalapara, Patuakhali in the southwest (91°12.59'E and 21° 47.56'N)	Five (5) days before and five (5) days after the fullmoon, including the day of fullmoon, that is total eleven (11) days of the moon which will first appear in the Bangla month of Ashwin each year

Additionally, the government from time to time imposes ban on fishing activities for the protection and conservation of fishes particularly hilsa (<http://www.thedailystar.net/backpage/2-month-ban-fishing-five-rivers-784831>).

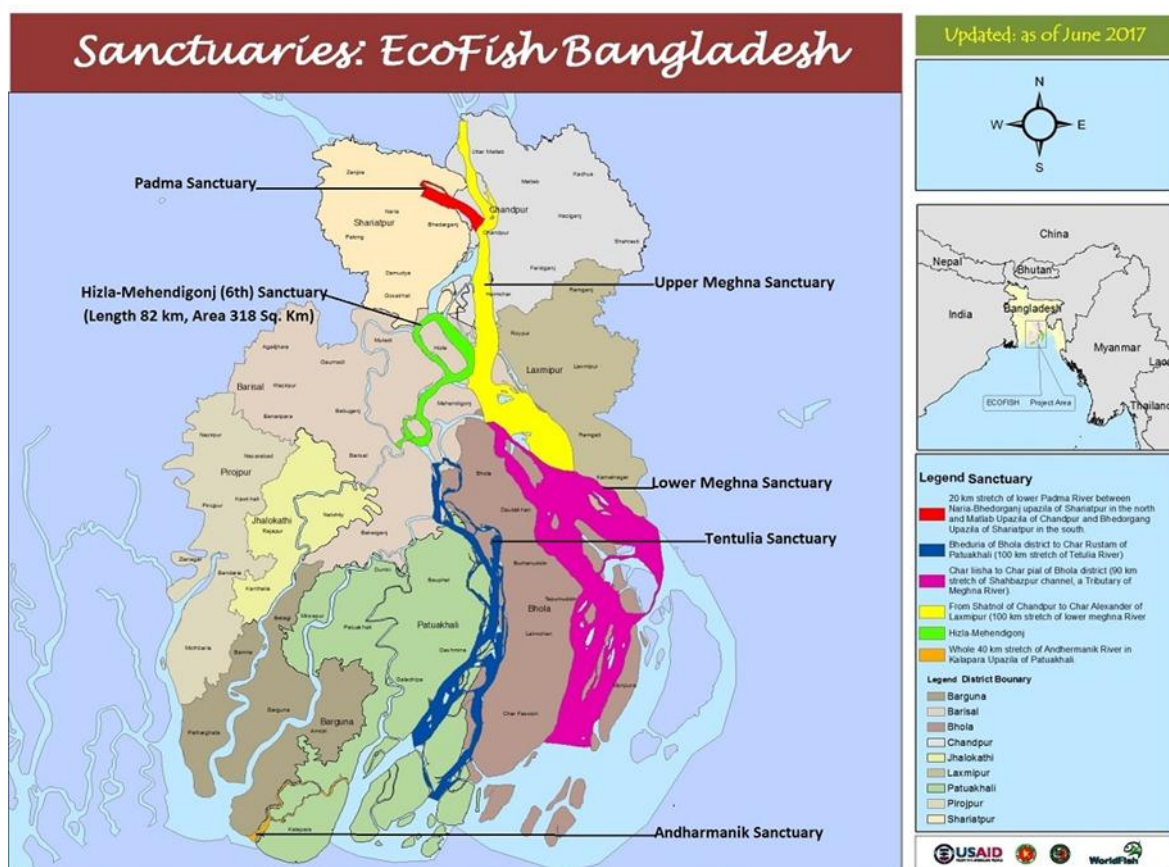


Figure 5-38: Hilsa sanctuaries and spawning area (in color) declared by the government.

Table 5.32. Other fish sanctuaries declared in the Lower Meghna River
(Source: Fish Sanctuaries of Bangladesh. DOF/MOFL 2015).

Sanctuary Name	Location
1. Name of sanctuary	Hurakhali Jalmahal Fish Sanctuary, (Meghna River)
Area/ Location of	4.86 ha; Zilla: Lakshmipur, Upazilla: Komolnagar, Union:
Extent of the sanctuary	Southest corner: Char Falcon; Northeast corner: Lakhsmipur;
Important species	Bata, Rita, Powa, Lotiya, Prawn
2. Name of sanctuary	Mulgaon Fish Sanctuary
Area/ Location of	0.75 ha; Zilla: Shariatpur; Upazilla: Goshairhat; Village:
Extent of the sanctuary	Meghna River-bend
Important species	Chital, Boal, Aire
3. Name of Sanctuary	Haturia-Shailatala Meghna River Bend Sanctuary
Area/ Location of	1.0 ha; Zilla: Shariatpur, Upazilla: Gosairhat, Union: Idilpur,
Extent of the sanctuary	Meghna River-bend
Important species	Chital, Boal, Aire

Critical and natural habitats

The ecosystems of Bangladesh could be categorized into two major groups, *i.e.* (i) terrestrial, and (ii) aquatic. The land-based terrestrial ecosystems include forest and hill ecosystems, agro-ecosystems and homestead ecosystems; while seasonal and perennial wetlands, rivers, lakes, coastal mangroves, coastal mudflats and chars, and marine ecosystems fall into the

aquatic category. Each of the ecosystems has many sub-units with distinct characteristics as well. Bangladesh is classified into twenty five bio-ecological zones Figure 5.40 some of which are constituted of one or more than one type of ecosystems. The Project Influence Area (PIA) consists of bio-ecological zone categories 4b, 4c, 4e, 8b, 8d, 11, and 12 which are briefly described below.

Each of the bio-ecological categories contains a unique set of characteristics based on which the species composition varies. Some of the categories share the same species whereby the species have to adapt themselves to that particular niche.

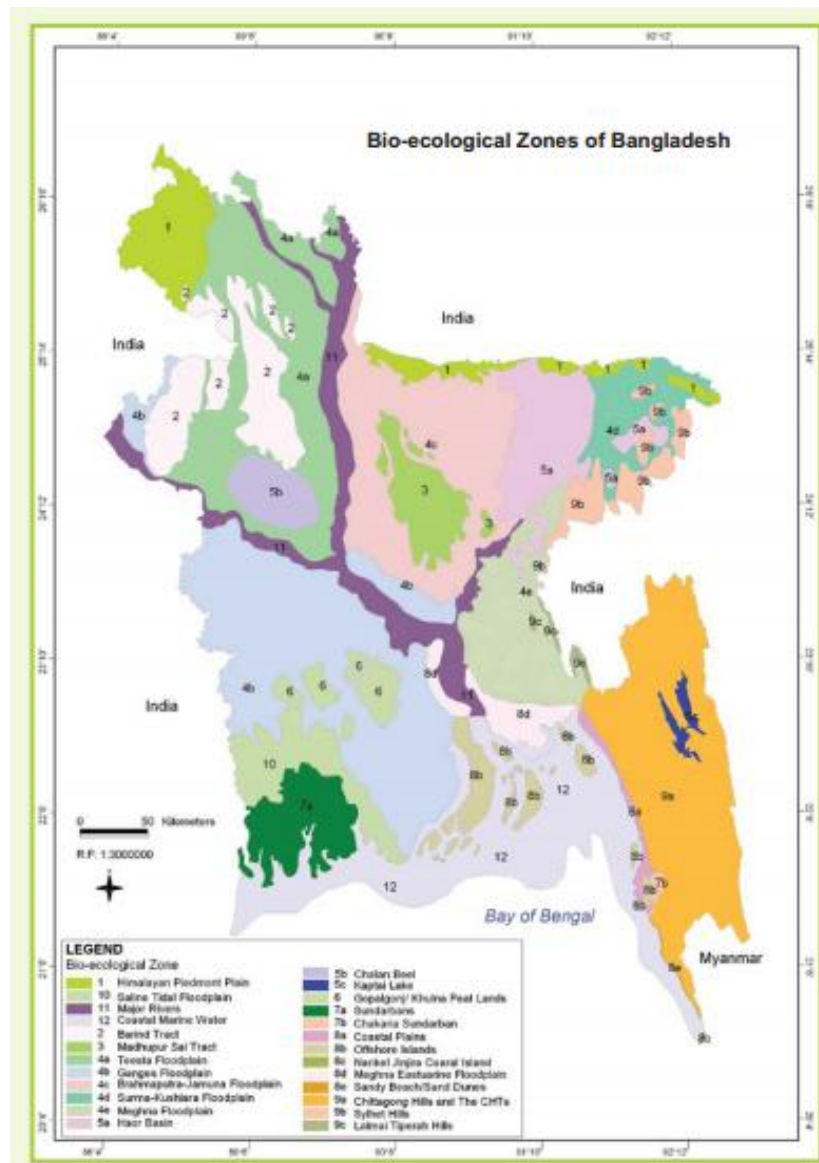


Figure 5-39: Bio-ecological zones of Bangladesh (Source: IUCN 2002)

Zone 4b. Ganges Floodplain

The Ganges floodplain is basically consists of the active floodplain of the Ganges River and the adjoining meandering floodplains. The adjoining meander floodplains mainly comprise a smooth landscape of ridges, basins and old channels. Gangetic alluvium is readily distinguishable from the Old Brahmaputra, Jamuna and Meghna sediments by its high lime content. The Ganges channel is constantly shifting within its active floodplain, eroding and

depositing large areas of new char lands in each flooding season but is less braided than the Brahmaputra-Jamuna. Interestingly both plant and animals move and adapt with the pattern of flooding (Brammer 1996). The floodplain is characterized by mixed vegetation, presence of a lot of stagnant waterbodies, and channel, rivers and tributaries in this zone and support habitats favourable to a rich biodiversity. The areas covering Buriganga River ECA and Dhaleshwari River up to the confluence with the Meghna River fall within this zone.

Zone 4c. Brahmaputra-Jamuna Floodplain

The mighty Brahmaputra (=Jamuna) is comparatively new and its course is clearly distinguishable from the older Brahmaputra. Brahmaputra-Jamuna Floodplain comprises the active channel of the Brahmaputra River and the adjoining areas of the young floodplain lands formed with the shifting to its present course – the Jamuna River. The main river course is strongly braided, consisting of several interconnected channels which erode to form new lands during each flooding season. Some portion of the Sitalakhya River falls within this zone.

Zone 4e. Meghna Floodplain

Created mainly by the deposition of sediments brought by the Old Brahmaputra River. Added depositions come from the Meghna River itself and by some minor rivers flowing down from the Tiperrah Hills. The floodplain occupies a low-lying landscape of chars and many broad meandering channels. The Meghna sediments are mainly silty and clays and sandy Brahmaputra sediments occur at the surface on some ridges in the north. Seasonal flooding from the Meghna is mainly deep. Basin sites are submerged early and drain late. This floodplain area has a slightly irregular ridge and basin relief, but also has large mounds used for settlement and cultivation. Seasonal flooding was formerly moderately deep, fluctuating in depth twice daily with the tides in the south, but flooding is mainly shallow and by rainwater within the area protected and drained by the Chandpur irrigation project.

The estuarine landscape is quite different from that on river and tidal floodplains. This sub-unit occupies almost the level land within and adjoining the Meghna estuary. It includes both island and mainland areas. New deposition and erosion are constantly taking place on the margins, continuously altering the shape of the land areas. The sediments are deep silts, which are finally stratified and are slightly calcareous. In many, but not all parts, the soil surface becomes saline to varying degrees in the dry season. Seasonal flooding is mainly shallow, but fluctuates tidally, and is caused mainly by rainwater or non-saline river water. Flooding by salt water occurs mainly on the lamed margins and during exceptional high tides during the monsoon; also when storm surges associated with tropical cyclones occur.

Southern portion of the floodplains lie within the hilsa sanctuary and spawning area as well as in an Important Bird Area declared by the BirdLife International.

Zone 8b. Offshore Islands

The zone covers the islands in the estuary – Bhola, Hatiya, Sandwip, Bashan Char, etc. Shapes of the island are continuously changing as a result of erosion and tidal insurgence. The islands have extensive intertidal mudflats rich in alluvium and benthic fauna that constitute the major staging area for the migratory waders. The islands lie within the hilsa spawning area and in an Important Bird Area declared by the BirdLife International.

Zone 8d. Meghna Estuarine Floodplain

The newly accreted mudflat is the main physiographic feature. Erosion and deposition is constantly taking place on the land margins, thereby altering the shape of the land. The soil surface in certain areas becomes saline to varying degrees due to the tides. Seasonal flooding is usually by rain or exceptionally high tides when storm surges associated with cyclones occur. The accreted intertidal lands are important wintering grounds for the migratory birds. The area falls within the hilsa sanctuary and hilsa spawning area.

Zone 11. Major Rivers

Bangladesh – a delta - is a land of rivers drained by four major rivers: the Ganges-Padma, Brahmaputra-Jamuna, Meghna and Teesta. Together they cover 7% of the country's area and support a myriad of species. A diverse range of species are dependent on these river systems. Some portion of the Padma and most of the Lower Meghna comprise the hilsa sanctuary.

Zone 12. Coastal & Marine Waters

The coastal zone has its own dynamics and a very distinct terrain. The coastal zone comprised by the complex delta of the Ganges-Brahmaputra-Meghna river system has immense biological resources. It carries an estimated annual sediment load of 2 billion tons subjected to the coastal dynamic processes leading to land accretion and erosion. The northern section of the Zone 12 comprises the hilsa spawning area.

The WB Policy (OP 4.04) describes the conservation of natural habitats, like other measures that protect and enhance the environment, to be essential for long-term sustainable development. The Bank therefore supports the protection, maintenance, and rehabilitation of natural habitats and their functions in its economic and sector work, project financing, and policy dialogue. The Bank also supports, and expects borrowers to apply a precautionary approach to natural resource management to ensure opportunities for environmentally sustainable development. The Bank promotes and supports natural habitat conservation and improved land use by financing projects designed to integrate into national and regional development the conservation of natural habitats and the maintenance of ecological functions. Furthermore, the Bank promotes the rehabilitation of degraded natural habitats. The Bank does not support projects that involve the significant conversion or degradation of critical natural habitats.

Meghna River is one of the major rivers in Bangladesh, especially famous for its great estuary that discharges the flows of the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna itself. The Meghna has two distinct parts. The Upper Meghna from Kuliarchar to Shatnal is a comparatively small river. The Lower Meghna below Shatnal is one of the largest rivers in the world because of its wide estuary mouth. The Lower Meghna is at times treated as a separate river.

The Upper Meghna Flood Plain is a dominant freshwater environment inhabited by freshwater plant and animal species. The floodplain comprises a nutrient rich freshwater ecosystem supporting high fish production, and many aquatic species some of which are now endangered. Native waterfowl and migratory birds, freshwater turtles and other reptiles and amphibians depended on this system, and the area was rich in biodiversity. The construction of embankments along some sections of the Upper Meghna, effluents from the industries entirely changed the ecosystem. The free migration patterns of fish from the floodplain to the Meghna River and vice versa was disrupted, and fish production. Intensive agriculture and reduction in wetland areas have affected the habitat of migratory birds, freshwater turtles. The pressure from the increasing human population on the natural resources has affected the ecosystem. However the water quality is still favourable for many of the aquatic species like the turtles, otters, Gangetic dolphins, etc.

The Lower Meghna River conveys the combined flows of the Brahmaputra, the Ganges and the Upper Meghna rivers and the discharge into the Meghna estuary is dominated by these three major rivers reinforced by the Dhaleshwari. All the three rivers are large. The Dhaleshwari-Meghna and the Padma are each 5 km wide at the confluence. The Lower Meghna has several small chars (braid-bars) in it, which create two main channels, of which the large eastern one is 5 to 8 km wide. The western channel is about 2 km in width. Near Muladi the 1.5 km wide Safipur River is an offshoot from the right-bank. Further south, the Lower Meghna shifts into three channels: west to east flowing Tentulia (Ilisha) River, the Shahbazpur and the Bamni (now nonexistent). The Ilisha is a 5 to 6.5 km wide channel separating Bhola Island from the Barisal mainland. Shahbazpur Channel, 5 to 8 km wide, separates Bhola from Ramgati and Hatiya Islands and at its mouth are the Manpura Islands.

One of the obvious features of the Lower Meghna is the braid bars exposed during periods of low flow and/or dry season, which are responsible for the multi-channel cross-section. Studies of the river have shown two distinct braid bar levels, those with elevations which are very close to bank top level and lower bars which are submerged during the majority of high in-bank flows. The upper sand bars, known as either islands or attached chars, are relatively stable and vegetated and are often inhabited. They can be considered as parts of the flood plain contained within the braid belt, only submerged during over bank flows. The lower braid bars are unstable and are being continually re-worked by the river.

Among the critical natural habitats within the project influence area some of the important ones like the reed lands, coastal mudflats have been described as the VECs.

Threatened and important species (as per national and IUCN designations)

Each of the bio-ecological categories contains a unique set of characteristics based on which the species distribution and composition varies. Some of the categories share the same species whereby the species have to adapt themselves to that particular niche.

All wildlife species including butterflies are protected under the Bangladesh Wildlife (Conservation & Security) Act 2012. The Protection and Conservation of Fish (Amendment) Act, 1995 mentions about the prohibition of killing fishes in destructive ways (like poisoning, polluting fish habitat, etc), prohibition of catching, carrying or selling of fries, fingerlings and brood of rui (*Labeo rohita*), kalbaus (*L. calbasu*) and gonia (*L. gonius*), catla (*Catla catla*), mrigel (*Cirrhinus mrigala*), hilsa jatka (*Tenualosa ilisha*) <23 cm during November to May;

pangas (*Pangasius pangasius*) <23 cm during Nov-April; and shilong (*Silonia silondia*); shol (*Channa striata*); and Ayre (*Mystus aur*) <30cm during Feb-Jun; and prohibition of catching fries, fingerlings and post larvae throughout the year in the coastal region.

About 267 species of freshwater fish inhabit the water bodies of Bangladesh (Rahman 2005, Mustafa 2013) of which about 200 species are small indigenous fishes (SIS). According to the IUCN Bangladesh (2000) fifty four (54) species (=20%) are endangered. The IUCN Redlist is currently being updated and the numbers and categories of fish species may change. Table 5.32 will describe threatened vertebrate animal species found in the Project Influence Area. Photograph of some endangered and vulnerable species are given shown in Figure 5.41.

Table 5-32: List of some of the threatened fish species found in the Project Influence Area

Sl. No	Local Name	Common Name/English Name	Scientific Name	Status (IUCN Bangladesh 2000)	Presence in study area
1	Rita, Ritha	Rita	<i>Rita rita</i>	Critically endangered	✓
2	Pabda	Pabdah Catfish	<i>Ompok pabda</i>	Endangered	✓
3	Bagair/ Garua	Dwarf Goonch	<i>Bagarius bagarius</i>	Critically	
4	Gajar/ Gajal	Great snakehead	<i>Channa marulius</i>	Endangered	✓
5	Gachua/Gaira/ Telo	Walking snakehead	<i>Channa orientalis</i>	Vulnerable	✓
6	Kuchia	Gangetic mud eel/ Cuchia	<i>Monopterusuchia</i>	Vulnerable	✓
7	Chenua/Sisir/ Cheuna	Sisor catfish	<i>Sisor rhabdophorus</i>	Critically endangered	
8	Ek thota	Wrestling half-beak	<i>Dermogenys pusilla</i>	Threatened	✓
9	Napit Koi/ Kala/ Koi/Bot	Dwarf Chameleon Fish	<i>Badis badis</i>	Endangered	✓
10	Bhol/Bol/ Buggua	Trout Barb/ Indian Trout	<i>Raiamas bola</i>	Endangered	
11	Laubuka/Chap Chela/ Kash	Indian Glass barb/ Indian Hatchet fish	<i>Laubuca laubuca</i>	Endangered	
12	Along/ Etang/ Sephalia	Bengala Barb/ Bengal Barb	<i>Megarasbora elanga</i>	Endangered	
13	Darkina/ Leuzza Darkina	Gangetic Scissortail Rasbora	<i>Rasbora rasbora</i>	Endangered	✓
14	Pipla/ Pipla Shol/ Tila Shol	Barca Snakehead	<i>Channa barca</i>	Critically endangered	✓
15	Boa mach/ Boa baim/ Telkoma/	Indian Mottled Eel	<i>Anguilla bengalensis</i>	Vulnerable	✓

Sl. No	Local Name	Common Name/English Name	Scientific Name	Status (IUCN Bangladesh 2000)	Presence in study area
16	Kumirer Khi/ Kota Kumirer	Deocata Pipefish	<i>Microphis deocata</i>	Endangered	
17	Joia/ Hiralu/ Tila/ Koksa/	Hamilton's Barila	<i>Barilius bendelisis</i>	Endangered	
18	Khoksa	Vagra Barila	<i>Barilius vagra</i>	Endangered	
19	Pabda	Pabo catfish	<i>Ompok pabo</i>	Endangered	✓
20	Gonia/Ghainna/ Goni	Kuria labeo	<i>Labeo gonius</i>	Endangered	✓
21	Gang magur/ Kan Magur	Grey Eel catfish	<i>Plotosus canius</i>	Vulnerable	✓
22	Tengra	Assame Batasio	<i>Batasio tengana</i>	Endangered	✓
23	Shilong	Silond catfish	<i>Silonia silondia</i>	Endangered	✓
24	Kajuli/ Baspata	Jamuna Ailia	<i>Ailiichthys punctata</i>	Vulnerable	
25	Ghora mach/ Ghora muikha	Pangusia labeo	<i>Labeo pangusia</i>	Critically endangered	
26	Napte Khoira/ Madhumala	Frail gourami	<i>Ctenops nobilis</i>	Endangered	
27	Bacha	Batchwa Vacha	<i>Eutropiichthys vacha</i>	Critically Endangered	✓
28	Guizza/ Guizza Ayre	Giant river catfish	<i>Sperata seenghala</i>	Endangered	✓
29	Sarpunti/ Deshi Sar Punt	Olive barb	<i>Puntius sarana</i>	Critically Endangered	✓
30	Raikhor/ Tatkini/ Aikhor	Reba Carp	<i>Cirrhina reba</i>	Vulnerable	✓



Figure 5-40: Threatened fish within the Project Influence Area (Photo © BFRF)

Seasonal differences may yield different composition of fishes like for example the species diversity and abundance based on the water quality, water depth, etc. As an example some of the differences in the fish species for the Buriganga and Sitalakhya Rivers observed during the dry season field visit are given in the Table 5.33 below. During wet season species

diversity was more compared to the dry season. Species found during the dry season were more ‘hardy’, can tolerate higher degree of environmental stress and had additional ‘lungs’ other than the gills.

Table 5-33 Seasonal variation of some of the common fish species found in the Buriganga and Sitalakhya Rivers

River Name	Wet Season	Dry Season
Buriganga (Sadar Ghat)	Mola, Taki, Bailla, Puti	Singh, Taki
Sitalakhya	Mola, Keski, Tengra, Bailla	Singh, Taki



Figure 5-41. Common fish species from the Buriganga River during the wet and dry seasons (Photos © CARINAM).

Table 5-34: List of some amphibians in the project area [PD - Ponds; AG - Agri land; HS - Homesteads; GL - Grassland; FL - Fallow land; TS – Trees; VC – Very Common, C – Common, UC – Uncommon, R – Rare; VC – Very Common, C – Common, UC – Uncommon, R – Rare]

S.No.	Scientific Name	English/Local Name	Habitat	Status
1	<i>Duttaphyrnus melanostictus</i>	Common Asian Toad	FL	VC
2	<i>Euphlyctis hexadactylus</i>	Green Frog	PD, GL	R
3	<i>Hoplobatrachus tigerinus</i>	Indian Bull Frog	PD, GL, AG	C
4	<i>Uperodon globulosus</i>	Balloon Frog	FL, AG	UC
5	<i>Kaloula pulchra</i>	Painted Bull Frog	HS, GL	UC
6	<i>Euphlyctis cyanophlyctis</i>	Skippping Frog	PD	VC
7	<i>Fejervarya spp</i>	Cricket Frog	PD, GL, FL	C
8	<i>Microhyla ornata</i>	Ornate Narrow-mouthed Frog	FL, GL	UC
9	<i>Hylarana tytleri</i>	Leaping Frog	GL, AG, FL	UC
10	<i>Polypedates leucomystax</i>	Four-lined Tree Frog	TS, HS	UC



Figure 5-42: Some amphibians within the project area: Top left- Green Frog; Top right: Bull frog; Bottom left: Jerdon's Bull Frog; Bottom right: Common Toad (Photos © CARINAM)

During the dry season survey young and juvenile toads, skipping and cricket frogs were mostly observed in the fallow lands, along the river banks and ponds/ditches.

The project influence area contains both the threatened and endangered species. Threatened species are those species which are likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range or locally within a country like Bengal Skimmer, Smooth-coated Otter. Endangered species is species which is in danger of extinction throughout all or a significant portion of its range or locally within a country like Gangetic Dolphin, Northern River Terrapin.

Table 5-35: List of some endangered and threatened reptiles (mainly turtles) in the project area (Reference for breeding period of turtles see Rashid & Swingland 1997)

Scientific Name	English Name	Status	Comment
<i>Batagur baska</i>	Four-toed Terrapin, Northern River Terrapin	CR	Sundarban RF, Lower Meghna, Estuary; breeding period Feb-April
<i>Batagur dhongoka</i>	Three-striped Turtle	EN	Lower Meghna; breeding period Feb - April
<i>Hardella thurjii</i>	Crowned River Turtle	VU	Widespread but rapidly declining, Upper & Lower Meghna adjoining areas; breeding period Nov-Jan
<i>Chitra indica</i>	Narrow-headed Softshell Turtle	EN	Rivers; Padma, Jamuna, Meghna, Brahmaputra, Dhaleswari rivers and their major tributaries. The nesting season extends from February to May,

Scientific Name	English Name	Status	Comment
			September – November during which <i>C. indica</i> lays multiple clutches.
<i>Pelochelys cantorii</i>	Giant Asian Softshell Turtle	EN	River mouths & estuary. Nesting sites include riverbanks as well as seacoasts; breeding period Feb-April
<i>Nilssonia gangeticus</i>	Ganges Softshell Turtle	VU	Rivers, estuary; mates from August to January and lays multiple clutches. The first clutch of eggs is laid between mid-August and late-September, the second between mid-October and late-November, and the third between mid-December and January.
<i>Lepidochelys olivacea</i>	Olive Ridley Turtle	EN	Nests on sandy beaches of the St. Martin's Island and Meghna estuary chars & Sundarban RF; breeds round the year peak Nov - Jan
<i>Chelonia mydas</i>	Green Turtle	EN	Nests on sandy beaches of the St. Martin's Island and Meghna estuary chars & Sundarban RF; breeding peak Aug - Oct
<i>Eretmochelys imbricata</i>	Hawksbill Turtle	EN	Rarely nests on sandy beaches of the St. Martin's Island and Meghna estuary chars, forages in the estuary; breeding peak Nov - Jan

Table 5-36: List of endangered and threatened birds in the project area

Scientific Name	English Name	Status	Comment
<i>Aythya baeri</i>	Baer's Pochard	EN	World's main wintering area but major decline
<i>Aythya nyroca</i>	Ferruginous Duck	NT	Winter visitor; declining population
<i>Pelargopsis amauroptera</i>	Brown-winged Kingfisher	NT	Off-shore islands, Sundarban RF holds main population in world
<i>Calidris pygmaea</i>	Spoonbill Sandpiper	CR	Perhaps as few as 100 breeding pairs remaining.
<i>Tringa guttifer</i>	Nordmann's Greenshank	EN	Very small population which is declining as a result of the development of coastal wetlands throughout its range
<i>Limosa lapponica</i>	Bar-tailed Godwit	VU	Rapidly declining population, primarily to destruction of its wintering grounds
<i>Limnodromus semipalmatus</i>	Asian Dowitcher	EN	Moderately small population overall, rapid decline, owing primarily to destruction of its wintering grounds (BirdLife International 2001)
<i>Rynchops albicollis</i>	Bengal Skimmer	VU	Vulnerable because its population is undergoing a rapid decline as a result

Scientific Name	English Name	Status	Comment
			of widespread degradation and disturbance of lowland rivers and lakes
<i>Haliaeetus leucogaster</i>	White-bellied Sea Eagle	VU	Vulnerable because its population is undergoing a rapid decline as a result of widespread habitat degradation

Table 5-37: List of threatened mammals in the project area

Scientific Name	English Name	Status	Comment
<i>Prionailurus viverrinus</i>	Fishing Cat	EN	Steady declining population
<i>Vulpes bengalensis</i>	Bengal Fox	VU	Population declining steadily
<i>Lutrogale perspicillata</i>	Smooth-coated Otter	VU	Drastic decline in most of the rivers, wetlands
<i>Platanista gangetica</i>	South Asian River/ Gangetic Dolphin	EN	Population declining, threats from increasing navigation, pollution and intentional captures
<i>Orcaella brevirostris</i>	Irrawady Dolphin	EN	Mostly in the estuary and upstream depending on the salinity gradient



Figure 5-43: Critically Endangered Northern River Terrapin (*Batagur baska*) (left), and endangered Crowned River Turtle (*Hardella thurjii*) (right) occur within the project influence area. (Photos © CARINAM)

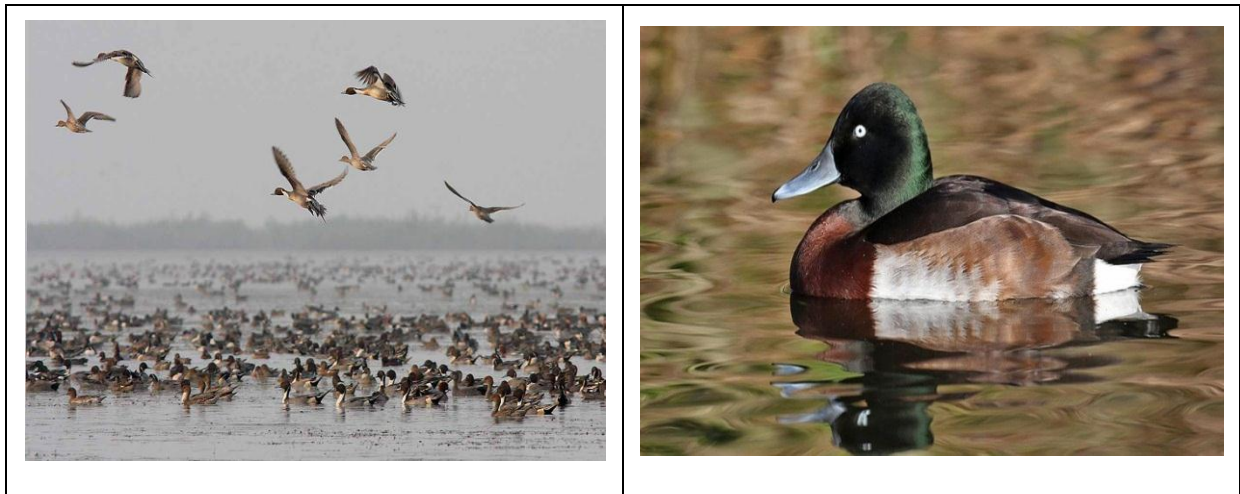


Figure 5-44: Wetlands including rivers host migratory ducks during winter (left), the endangered Baer's Pochard (right) (Photos © CARINAM)

Identification of Valued Environmental Components

Valued Environmental Components (VECs) are defined as fundamental elements of the physical, ecological, biological or socio-economic environment, including the ecosystem, ecosystem services, air, water, soil, terrain, vegetation, wildlife, fish and land use that may be affected by a proposed project. VECs may vary by project, industry, and geographic region, to reflect the nature of the potential project effects and the environmental, economic, social, heritage, and health context within which the project is implemented.

One other term that needs to be understood is 'effect pathway'. Effect pathway refers to the cause-effect linkage between a project activity and a VEC. In some cases, the project-VEC interaction comprises a direct impact, while in others the project may affect the VEC indirectly, by causing changes in the natural or human environment on which the VEC depends. For example, a project may affect local economic activity by altering water quality, which may in turn adversely affect a fish population, which may in turn reduce the fishing success of commercial or subsistence fishing activity. In this example, water quality and fish are intermediate components along an effect pathway between the project and the ultimate receptor VEC - economic activity.

VECs are at the heart of impact prediction, knowing more about how and why they are chosen and if they adequately represent cumulative effects (CEs) it may fulfill the purpose of Environmental Impact Assessment (EIA).

Upper Meghna: Wetland Biodiversity/Dolphins/Otters

Meghna River is one of the major rivers in Bangladesh, especially famous for its great estuary that discharges the flows of the Ganges-Padma, the Brahmaputra-Jamuna and the Meghna itself. The Meghna has two distinct parts. The Upper Meghna from Kuliarchar to Shatnal is a comparatively small river. The Lower Meghna below Shatnal is one of the largest rivers in the world because of its wide estuary mouth. The Lower Meghna is at times treated as a separate river.

The Meghna receives the Old Brahmaputra on its right at Bhairab Bazaar. A little above the confluence, the Meghna has a railway bridge-'Bhairab Bridge'-and a road bridge-'Bangladesh-

UK-Friendship Bridge' over it. The width of the river there is three-quarters of a kilometre. Several small channels branching off from the Meghna and meandering through the lowland bordering the Tippera Surface receive the flow of a number of hilly streams and rejoin the main river downstream. The most important of these offshoots is the Titas, which takes off south of Ghatalpar and after meandering through two long-bends extending over 240 km rejoins the Meghna through two channels in Nabinagar Upazila. Other offshoots of the Meghna are the Pagli, Kathalia, Dhonagoda, Matlab and Udhamdi. The Meghna and these offshoots receive water of a number of hilly streams from the Tripura Hills. The important hill streams are the Gumti, Kakrai, Kagni, Dakatia, Hawrah, Sonaiburi, Harimangal, Pagli, Kurulia, Balujuri, Sonaichhari, Handachora, Jangalia and all of these are liable to flash floods (Banglapaedia 2015).

The Upper Meghna Flood Plain is a dominant freshwater environment inhabited by freshwater plant and animal species. The floodplain comprises a nutrient rich freshwater ecosystem supporting high fish production, and many aquatic species some of which are now endangered. Native waterfowl and migratory birds, freshwater turtles and other reptiles and amphibians depended on this system, and the area was rich in biodiversity. The construction of embankments along some sections of the Upper Meghna, effluents from the industries entirely changed the ecosystem. The free migration patterns of fish from the floodplain to the Meghna River and vice versa was disrupted, and fish production. Intensive agriculture and reduction in wetland areas have affected the habitat of migratory birds, freshwater turtles. The pressure from the increasing human population on the natural resources has affected the ecosystem. However the water quality is still favourable for many of the aquatic species like the otters, Gangetic dolphins, etc.

The Gangetic Dolphin (*Platanista gangetica*) or 'shishu/shushuk' (in Bangla) is found in most of the areas of the Ganges-Brahmaputra-Meghna river system including Nepal, India and Bangladesh. This species is rated as 'Endangered' by the International Union for Conservation of Nature (IUCN) Red List (2010) with the wild populations decreasing drastically within the range countries. These dolphins share the same ranks as the tigers and great apes that are listed as a species endangered by trade on Appendix I of Convention on International Trade of Endangered Species of Flora & Fauna (CITES). The species is listed as a 'flagship species' by World Wide Fund for Nature (WWF).

Water abstraction upstream decrease river depth and the appearance of sand bars during winter season cause danger to the dolphins as the river is divided into small segments, causing a segregation of populations in deeper pools, narrowing of the gene pool, increase in the intensity of fishing, increase in river traffic, pollution due to release of untreated effluents from industries, incidental and/or intentional capturing for oil extraction for use as fish attractant, liniment and aphrodisiac, etc., have become the major threats for its survival.

The freshwater dolphins being an iconic species for the river ecosystem serve as a link between people and freshwater and a symbol of a healthy ecosystem. The positive side for the conservation by the presence and increase in the population of dolphins will mean that rivers are clean enough to draw water supplies, there is more and diverse assemblage of fish to support people and dolphins, effluents will need to be adequately treated before release, enough water in the rivers to reduce saltwater intrusion, restoration of floodplains, etc.

Seasonality, food availability and environmental conditions of the water are the main factors of the Ganges River dolphin for its habitat use/preference (Hussain *et al.* 2011). Water depth increases during the monsoon months and decreases during the winter and summer months. During the winter and summer months, dolphins usually remain concentrated in the deeper sections (*kums*) of the rivers. This was reflected in the higher number of sightings during the winter and summer months and lower number of dolphin sightings during the monsoon months in the rivers (Rashid *et al.* 2015). Optimum water depth preferred by the Ganges River dolphin throughout the year is mostly available in sections where scours in the river exist. Secondly, most river fishes occur or should have occurred in the scours of the rivers during the winter and summer months (Hussain 2010). The dolphins feed on fishes hence distribution, composition and abundance of their prey may also play an important role in the distribution and abundance of dolphins and consequently habitat utilization. Kasuya and Haque (1972) mentioned that the area from Upper Meghna to south of Gualanda is a goldmine for the dolphins and the numbers are considerably less upstream in the north.

Table 5-38: Gangetic dolphin density in different rivers of Bangladesh and neighbouring India.

Author/Year	Location	Dolphin Density
Kasuya and Haque, 1972	Lower Meghna	0.22/km
Kasuya and Haque, 1972	Upper Meghna& Upstream of Bhairab Bazaar	1.43/km
Smith et al. 2006	Sunderbans, Bangladesh	0.47/km
Smith et al. 2001	Lower Sangu River, Bangladesh	1.36/km
Smith et al. 2001	Karnaphuli River, Bangladesh	0.47/km
Sharma et al. 1995	Chambal River, India	0.27/km
Sinha, 1997	Bhagirati River, India	0.37/km
Sinha et al. 2000	Downstream between Kahalgaon and Manihari [near Katihar], India	3.40/km
Sinha et al. 2000	Ganges mainstem, between Maniharighat and Buxar, India	1.50/km
Choudhary et al. 2006	Vikramshila Gangetic Dolphin Sanctuary, Bihar, India	1.80/km
Wakid, 2009	Brahmaputra [856 km], Assam, India	0.23/km
Rashid et al. 2015	Padma River: Shangram – Dhalar Char, Pabna, Bangladesh	0.53/km
Rashid et al. 2015	Jamuna River: Dhalar Char – Nagdemra, Pabna, Bangladesh	1.45/km

Accidental killing of dolphin in the form of by-catch in net fishing is a major threat for dolphins in the rivers of the project area. It was reported that accidental killing of dolphins through getting trapped or entangled in fishing nets were higher than the past. Other threats for dolphins in the rivers included oil spill from boats and ships, river erosion, low water depth during winter, use of harmful fishing gears (especially current net) and making cross dam of bamboos across rivers for fishing. As reported by local people, the practice of

intentionally trapping and/or killing of dolphins in the rivers for commercial reasons are gradually gaining momentum for oil extraction. Remains of the dolphin body, particularly the head, are used in the brush pile fishery – certain sections of the river close to the banks is fenced using bamboos and piles of tree branches are used to provide a temporary refuge for the fish during the dry season when water level gets low. During dry season the fenced area is netted and fishes are caught. By putting the remains of the dolphin body and head together with the tree branches fishes are attracted by the smell as they decompose.

The Lower Meghna supports both the Ganges Dolphin and Irrawaddy Dolphin (Fig. 5.46). However their distribution is marked by the salinity depending on seasonal freshwater discharge. The ecological boundary follows salinity and turbidity gradients, and implies that long-term monitoring of dolphin distribution patterns may prove insightful into the impacts of declining freshwater flows on other aquatic biota (Smith et al. 2006). The narrow geographic band between the coastline and the Swatch of No Ground (southwest of the Meghna estuary) is unique habitat for the seasonally mobile population of the Irrawaddy dolphin (*Orcaella brevirostris*). Farther offshore but still occurring in habitat influenced by freshwater inputs is the Indo-Pacific humpback dolphin (*Sousa chinensis*) and finless porpoise (*Neophocaena phocaenoides*). Then, a relatively short distance from the fluvial habitat is the Swatch-of-No-Ground where a burst of biological productivity created by upwelling currents supports large groups of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), Pantropical spotted dolphins (*Stenella attenuata*) and Spinner dolphins (*Stenella longirostris*), as well as a possible resident population of Bryde's whales (*Balaenoptera edeni*). The Meghna estuary is occasionally visited by Whale Shark (*Rhincodon typus*).



Figure 5-45. Gangetic Dolphin (left, © BCDP) and Irrawaddy Dolphin (right, © BTT) found in the project influence area.

There are three species of otters in Bangladesh. One of these is the smooth-coated otter (*Lutra perspicillata*). Smooth-Coated Otters like large rivers, lakes, peat swamp forests, coastal mangroves, estuaries and rice fields, provided there is ample bankside vegetation for cover and escape, and deep soil for digging natal holes. The area occupied by these animals has reduced significantly in the last 10 years as development; alteration of their habitat is taking a toll. It is considered that their decline may be occurring faster than generally thought. Increasing human population across its range is putting this species under pressure through habitat destruction (wetland reclamation), pollution (pesticide and agricultural run-off leading to eutrophication of waterways and reduction in prey biomass), and serious, widespread

conflict with aquaculturalists and fishermen who kill them as pests and competitors, and deliberate trapping for fur. Although technically legally protected throughout the country under the Wildlife (Security & Protection) Act 2012, this is laxly enforced.



Figure 5-46. The fast declining threatened smooth-coated otter (*Lutrogale perspicillata*), a key species of the wetlands (Photo: © CARINAM).

Lower Meghna: Hilsa sanctuaries/Irrawady dolphins/ Important Bird Areas/Sea turtle mating & nesting/ Northern River Terrapin

The Lower Meghna River conveys the combined flows of the Brahmaputra, the Ganges and the upper Meghna rivers and the discharge into the Meghna estuary is dominated by these three major rivers reinforced by the Dhaleshwari. All the three rivers are large. The Dhaleshwari-Meghna and the Padma are each 5 km wide at the confluence. The Lower Meghna has several small chars (braid-bars) in it, which create two main channels, of which the large eastern one is 5 to 8 km wide. The western channel is about 2 km in width. Near Muladi the 1.5 km wide Safipur River is an offshoot from the right-bank. Further south, the Lower Meghna shifts into three channels: west to east flowing Tentulia (Ilisha) River, the Shahbazzpur and the Bamni. The Ilisha is a 5 to 6.5 km wide channel separating Bhola Island from the Barisal mainland. Shahbazzpur Channel, 5 to 8 km wide, separates Bhola from Ramgati and Hatiya Islands and at its mouth are the Manpura Islands. Bamni now is said to be nonexistent.

One of the obvious features of the Lower Meghna is the braid bars exposed during periods of low flow and/or dry season, which are responsible for the multi-channel cross-section. Studies of the river have shown two distinct braid bar levels, those with elevations which are very close to bank top level and lower bars which are submerged during the majority of high in-bank flows. The upper sand bars, known as either islands or attached chars, are relatively stable and vegetated and are often inhabited. They can be considered as parts of the flood plain contained within the braid belt, only submerged during over bank flows. The lower braid bars are unstable and are being continually re-worked by the river.

The biological profile of plankton from the Padma, Meghna and Tetulia reference river sites during 2011 spawning season of hilsa showed that in total of 58 taxa of plankton were

present. Of which, 19 taxa (32.76%) were of phytoplankton and 39 taxa (67.24%) of zooplankton. Phytoplankton group belonged to Cyanophyceae (6 taxa), Chlorophyceae (7 taxa) and Bacillariophyceae (6 taxa) while zooplankton including Protozoa (10 taxa), Rotifera (19 taxa), Copepoda (4 taxa), Cladocera (5 taxa) and Ostracoda (1 taxon). The average abundance of plankton was recorded as 194.05 ± 82.58 indiv/l.

Gangetic Dolphin/Irrawady Dolphin

The Lower Meghna supports both the Ganges Dolphin and Irrawady Dolphin and has been described above. However their distribution is marked by the salinity depending on seasonal freshwater discharge. The ecological boundary follows salinity and turbidity gradients, and implies that long-term monitoring of dolphin distribution patterns may prove insightful into the impacts of declining freshwater flows on other aquatic biota (Smith *et al.* 2006).

Sea Turtles

The coastal waters and the Bay of Bengal support five species of sea turtles – Olive Ridley turtle (*Lepidochelys olivacea*), Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*), Loggerhead Turtle (*Caretta caretta*) and leatherback (*Dermichelys coraicea*). Among the five species female turtles of three species - Olive Ridley, Green and Hawksbill – have been recorded to nest (Rashid 1997, Rashid & Islam 2006). Female turtles have often been netted by the fishermen in the Lower Meghna River. Mating has been observed in areas south of the Sandwip Island in the Lower Meghna estuary and in the Bay near the Swatch of No Ground (SoNG). The males usually stay in off-shore areas for mating with the females and do not come near-shore while the females use the favourable sandy beaches of the islands and the coastline for nesting.



Figure 5-47: Left: Hawksbill Turtle (©MLA); Right: mating Olive Ridley Turtles (©NATHAB)

Freshwater Turtles

Some of the freshwater turtle species have also been recorded in the Lower Meghna estuary. One of the top three critically endangered turtle species – Northern River Terrapin *Batagur baska* forages in the Lower Meghna Estuary and the Sundarban. Bangladesh is the last stronghold for this species as natural population of this species has been extirpated from the other range countries – Myanmar and India. A few other endangered species like Narrow-headed Freshwater Turtle (*Chitra indica*), Asian Giant Turtle (*Pelochelys cantorii*) (Fig. 5.49) also share the same habitat.

The Upper Meghna and the other river network support several other species like Crowned River Turtle (*Hardella thurjii*), Three-striped Turtle (*Batagur dhongoka*), Tent River Turtle (*Pangshura tentoria*), Gangetic Softshell Turtle (*Nilssonia gangeticus*) and some of the common species like Peacock Softshell (*Nilssonia hurum*), Roofed Turtle (*Pangshura tecta*), Yellow Turtle (*Morenia petersi*) and Spotted Flapshell (*Lissemys punctata*). These freshwater turtles are in great demand locally for consumption as food by people of a particular religious faith and are collected / hunted illegally by the fishermen and some professional hunters/collectors.

The newly accreted sand dunes/bars at Lower Meghna estuary are important breeding ground of turtles which required to be kept undisturbed during nesting period).



Figure 5-48. Critically endangered turtle - *Pelochelys cantorii* (left) (Photo © CARINAM) and endangered *Nilssonia gangeticus* (right) (Photo © CARINAM). These species are also soughtafter for human consumption.

Important Bird Area

The Asian Waterbird Census (AWC) is the only ongoing flyway level collation of annual waterbird count data that covers East, Southeast and South Asia and Australasia; has data that was collected by Government agencies, NGO's and individuals; often stored in national databases and shared with the Asian Waterbird Census; is regionally coordinated by Wetlands International (WI) and implemented through a network of national partners - government and/or NGOs, including WI & BirdLife International national partners and is coordinated jointly by the WI-South Asia office and the WI-Netherlands offices.



Figure 5-49: Critically endangered birds within the project influence area. Top: Spoonbill Sandpiper (©Sayam) with its migration route; Middle: Bengal Skimmer (©Indraneil); Bottom left: Asian Dowitcher (©Yui), and Bottom right: Nordmann's Greenshank (©LPB).

The Padma-Jamuna-Meghna Rivers as well as the Lower Meghna estuary are also key habitats for some of the migratory and local resident waterbirds, including some globally critically endangered birds (Fig. 5.50). Considering the importance of the riverine and estuary ecosystems and as the staging and refuelling areas for migratory birds the BirdLife International has declared some areas as Important Bird Areas (IBA) (Fig. 5.51). The globally critically endangered species in the Lower Meghna estuary include Spoonbill Sandpiper, Asian Dowitcher, Nordmann's Greenshank, Bengal Skimmer, Black-bellied Tern, Oystercatcher, Bar-headed Geese, Graylag Geese, etc. The rivers support ducks like Ruddy Shelduck, Widgeon, Pintail, etc.

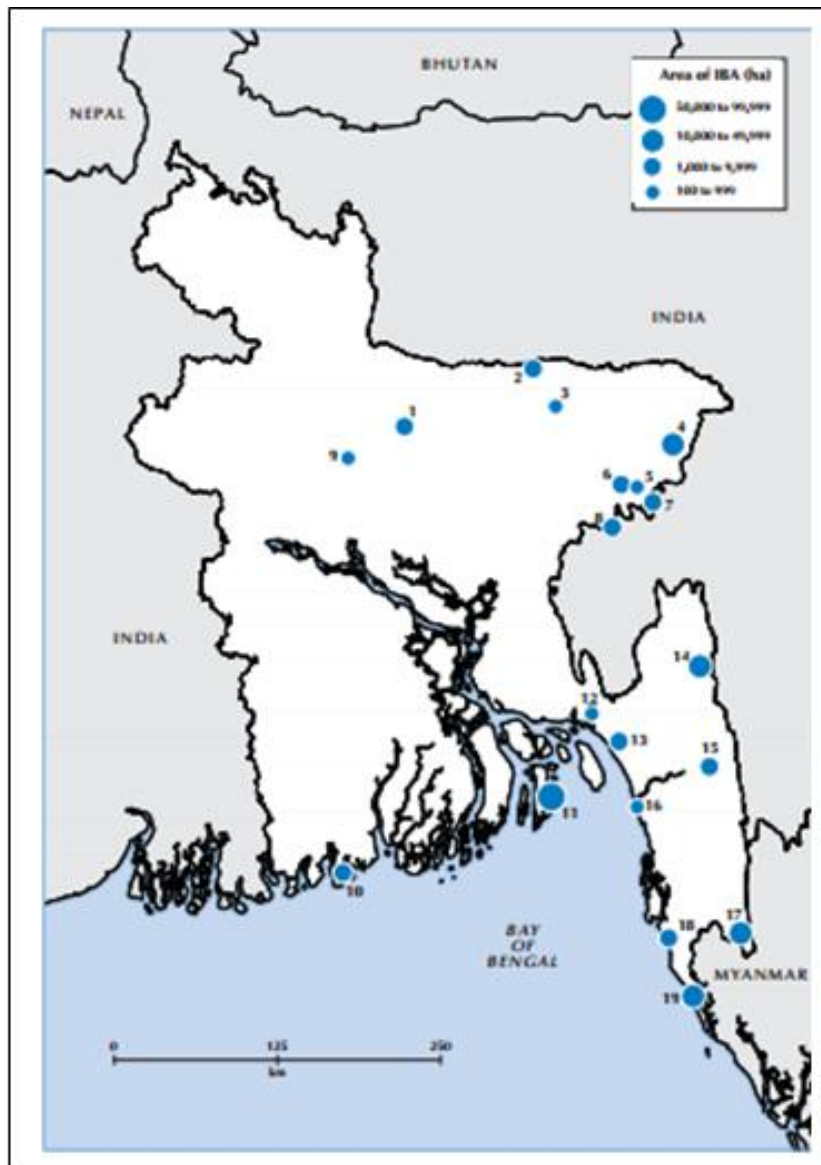


Figure 5-50: Important Bird Areas of Bangladesh (Source: BirdLife International)

Duars/Kums: Large fish & Dolphin Conservation.

Scour holes (locally known as duars/kums) or the deep subaqueous holes are the deepest points of the river system usually formed at the river bends and/or at the junctions of tidal creeks. They may form in tidal environments where the flow direction alternates over the tidal cycle and scoured by turbulence. This primarily takes place during the flood tide when the flow divides into branch channels and excessive macro-scale turbulence exists, which tends to suppress normal boundary layer development. Such scours feature in tidal creeks, at the confluence of rivers and at the river bends. These scours act as a refuge for some mammals (dolphins, turtles) and some large fishes (chital, pangas, baghaire, etc.) during the dry season when water levels are low.

River bathymetric data may reveal the location of such scours and those with depth less than 5m should be avoided for in-river disposal of dredged materials. If filled up by disposing the

dredged materials these unique niches for some of the species may be altered and the species may either migrate to some other suitable site or leave the area once for all.

Coastal Mudflats: Migratory birds roost/wintering/ staging grounds

Waterbirds are one of the most remarkable components of global biodiversity. Their long migrations and tendency to concentrate in large numbers on wetlands makes them visible and charismatic. Their management hinges on collection of reliable long-term information and the International Waterbird Census (IWC) implemented over the last five decades through the efforts of thousands of experts (many of them volunteers) around the world and coordinated by Wetlands International provides a basis for counting and assessing the status of many waterbird species and populations.

Waterbirds cover thousands or even tens of thousands of kilometres every year during their annual migratory cycle between their breeding and non-breeding areas. Thus many countries share the responsibility. Bangladesh has shared the responsibility for monitoring and management of waterbird populations since 1987 when important wetlands were identified and documented in the Asian Wetland Directory. The Bangladesh Forest Department, Department of Environment collaborate with the NGOs to jointly support the efforts and the Asian Waterbird Census aggregate counts from national monitoring schemes into the International Waterbird Census. These counts are used to monitor the status and trends of waterbird species. The analyses allow us to support major international and national policies to conserve and manage waterbird populations and key wetland sites. Bangladesh shares both the Central Asian Flyway and the East Asian - Australasian flyway (Figure 5.52).



Figure 5-51: The Asian Migratory Bird Flyways: Bangladesh shares both the Central Asian-Indian and East Asian-Australian Flyways.

Bangladesh is participating in the Asian Waterbird Census since 1987 where several sites (chars and off-shore islands) in the Lower Meghna Estuary are regularly monitored for migratory birds on an annual basis. The surveys are conducted on a voluntary basis involving NGOs, and occasionally the government entities in the month of January (between 7th and 25th) every year as this is the period when the migratory birds are most active. However in the last few years due to delayed setting in of winter season the migration pattern is changing so the survey periods are extended into the month of February.

The annual monitoring information generated through the AWC provides a major data source for the Waterbird Population Estimate (WPE) reviews. The WPE is the official reference for countries to designate Ramsar Sites based on the 1% criterion.

It was during these annual censuses that some of the critically endangered waterbirds like Spoonbill Sandpiper, Nordmann's Greenshank, Asian Dowitcher, Bengal Skimmer, Bartailed Godwits, etc., were known to winter in the Bangladesh coasts. For example, the spoonbill sandpiper flies all the way from Camchatka, Siberia to spend the winter in the coastal islands of Bangladesh. It is worthy to know that the world population is known to be around 1200 birds and Bangladesh hosts more than 10% of the global population which makes the coasts, estuary and off-shore island an important area for migratory bird conservation.

Hilsa Fishery

Hilsa (*Tenualosa ilisha*) is one of the flagship diadromous fish species of Bangladesh that migrate only through the Ganges-Meghna river system route. The biological profile of plankton from the Padma, Meghna and Tetulia reference river sites during 2011 spawning season of hilsa showed that a total of 58 taxa of plankton were present. Of which, 19 taxa (32.76%) were of phytoplankton and 39 taxa (67.24%) of zooplankton. Phytoplankton group belonged to Cyanophyceae (6 taxa), Chlorophyceae (7 taxa) and Bacillariophyceae (6 taxa) while zooplankton including Protozoa (10 taxa), Rotifera (19 taxa), Copepoda (4 taxa), Cladocera (5 taxa) and Ostracoda (1 taxon). The average abundance of plankton was recorded as 194.05 ± 82.58 indiv/l. The highest abundance of total plankton (692 indiv/l) was observed in Godagari, Rajshahi and was lowest (4.00 indiv/l) in Charghat, Rajshahi. The highest abundance (49 indiv/l) of total zooplankton was observed in Godagari and lowest (1 indiv/l) in Charghat with mean value of 19.46 ± 4.12 indiv/l. The highest species richness (SR = 45) was observed in Daulatkhan, Bhola and the lowest (SR = 3) in Charghat, with mean value of 17.10 ± 4.408 . Shannon-Weiner species diversity index (H') ranged from 3.334 in Daulatkhan to 1.5 in Charghat, with mean value of 2.717 ± 0.147 . Based on the plankton profile it may be concluded that the biological quality of hilsa migratory river was not alike throughout the route which may restrict the migration upstream and spontaneous spawning of hilsa (Ahsan *et al.* 2012).

The confluences of Padma-Meghna and Tetulia River are very significant habitat. It plays an important role as the major nursery and breeding ground of national fish, hilsa (*Tenualosa ilisha*) and many other commercially important riverine fishes. Hilsa is primarily a plankton feeder and its food includes blue green algae, diatoms, desmids, copepods, cladocera, rotifer, etc. Hence, the Department of Fisheries (DOF) has earmarked sanctuaries for hilsa in the Lower Meghna and associated rivers.

Species diversity is a measure of the diversity within an ecological community that incorporates both species richness and the evenness of species abundances. Diversity indices are good indicator of pollution in aquatic ecosystem. Ahsan *et al.* 2012 found that diversity index of the hilsa migratory route ranged from 1.500 to 3.334 with mean value of 2.717 ± 0.147 . Lower Meghna, particularly areas adjoining Daulat Khan contained the highest diversity index – 3.334. Diversity Index value greater than 3.00 indicate clean water. Values in the range of 1.00 to 3.00 are characteristics of moderately healthy conditions and values less than 1.00 characterize heavily deteriorated condition. Based on diversity index, the abundance of plankton was not found alike throughout the migratory route of Hilsa during the spawning period which might be one of the major restrictions for the easy migration of Hilsa as plankton is the major food for this flagship migratory fish.

Mangroves: Nursery for fisheries resources, natural barrier against storm/tidal surges, carbon sink

The coastal islands in the Meghna Estuary have been planted with mangrove species by the Forest Department. Bangladesh is one of the first countries to start mangrove plantation in the newly accreted land/chars along the coast/estuary since 1960s (Fig. 5.53). This plantation program has created opportunities for the local people with natural resources, protected the coastal dwellers from tidal surges and facilitated land accretion. So far more than 200,000 hectares of land has been planted with mangroves (*Avicennia* sp., *Sonneratia* sp.) and mangrove-associated species. The Forest Department is also coordinating with other organizations like BWDB by planting trees to protect the coastal embankments.

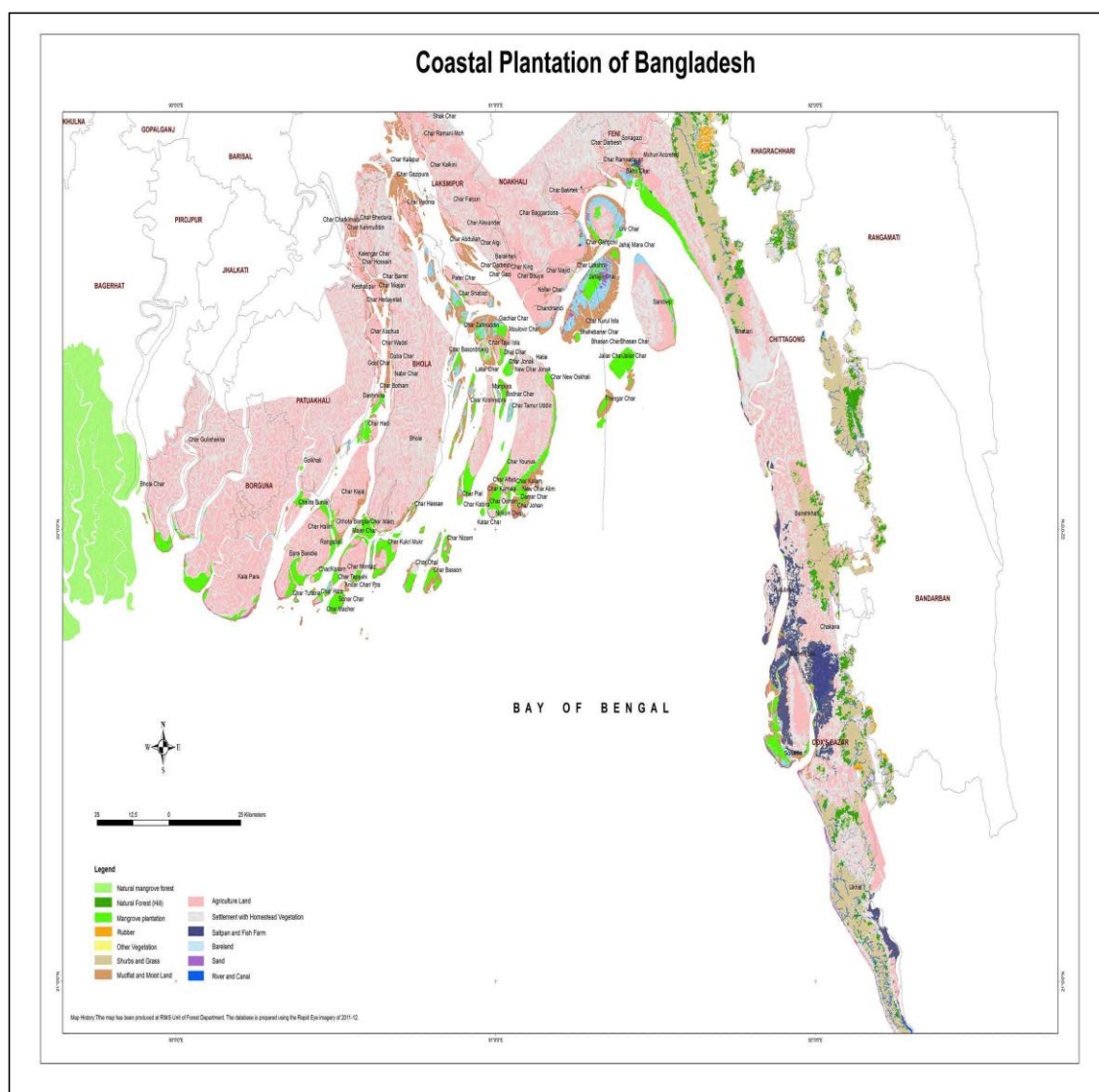


Figure 5-52. Coastal plantation (in bright green) by the Bangladesh Forest Department. (Source: RIMS, Forest Department)

Char lands/Lower Meghna Islands: Bashanchar, Sandwip

The west coast of the Sandwip Island was severely eroded in the past and for the last 5-7 years sediment accumulation has started and several kilometres of sandy beach/mudflat is observed during low tide. Similar is the case with Bashan Char. The east coast of Sandwip Island and Bashan Char has mangrove plantations done by the Forest Department (Fig. 5.54). However, the shallow waters due to sedimentation make it difficult to approach the west coast of Sandwip and the west and south coasts of Bashan Char (Fig. 5.55).



Figure 5-53 Mangrove plantation and eroded river bank of the Sandwip east coast



Figure 5-54 Bashan Char at a distance - shallow water makes it difficult to approach



Figure 5-55 A glimpse of the different habitat types of Sandwip Island



Figure 5-56. Fish landing at the river bank, Sandwip and the early morning wholesale fish auction

Water Quality: Aquatic resources conservation

It is necessary to monitor the water quality on a regular basis (see section on physical environment) as water quality acts as:

- ecological indicators: to characterize and monitor change in the state of various physical, chemical, and biological aspects of the environment relative to defined quality targets with thresholds for management action
- socio-economic indicators: to measure whether environmental quality is sufficient to maintain human health, human uses of resources, and favourable public perception
- governance indicators: to monitor the progress and effectiveness of management and enforcement practices towards meeting environmental policy targets

5.3.2 Riverine Biodiversity

Rivers tend to have longitudinal profiles which are concave open to the sky. This means that within any one river, there is typically a succession of types of water course with steep slopes near the source to minimal slope near the mouth. This succession is by no means always adhered to, and many major rivers, through accidents of terrain, alternate between fast-flowing, rocky and slow-flowing, muddy stretches. Thus, after torrential upper courses, rivers show several successive reaches of floodplain and rapids along their length. The different types of water course plainly support different communities of living organisms and this has formed the basis for several systems of geographical and ecological zoning. Ecologically, such distinctions have value as they generally correspond to many differing conditions including flow, slope or bottom type, which determine the types of plant and animal community living in them. This classification divides the river course into two main classes - the rhithron and the potamon.

The rhithron is defined as the region extending from the source to the point where mean monthly temperatures rise to 20°C, where oxygen concentrations are always high, flow is fast and turbulent and the bed is composed of rocks, stones or gravel with occasional sandy or silty patches. The potamon is the region where monthly mean temperatures rise to over 20°C, oxygen deficits may occur, flow is slow and the bed is mainly sand or mud. Three sub-zones are distinguished - the epipotamon, the metapotamon and finally, the hypopotamon, which is that brackishwater zone affected by marine waters. The rivers in the Project Influenced Area are mainly of the potamon type.

The potamon regulated rivers consists only of the channel which may be meandrine or braided in form. In flood rivers, however, there are two major components to the potamon: (i) the channel, and (ii) the floodplain. The floodplains typically include the following features:

- (a) The river channel;
- (b) Oxbows or oxbow lakes representing the cut-off portion of meander bends;
- (c) Point bars - loci of deposition on the convex side of curves in the river channel;
- (d) Meander scrolls - depressions and rises on the convex side of bends formed as the channel migrates laterally down valley by the erosion of the concave bank;

- (e) Sloughs - areas of dead water formed both in meander-scroll depressions and along the valley walls as flood flows move directly down valley scouring adjacent to the valley walls;
- (f) Natural levees - raised berms or crests above the floodplain surface adjacent to the channel, usually containing coarser materials deposited as floods flow over the top of the channel banks. They are most frequently found at the concave bank. Where most of the silt load in transit is fine-grained, natural levees may be absent or nearly imperceptible;
- (g) Backswamp deposits - overbank deposits of finer sediments deposited in slack water ponded between the natural levees and the wall or terrace riser;
- (h) Sand splay - deposits of flood debris usually of coarser and sand particles in the form of splays or scattered debris.

The main channel or channels of the river and its anabranches usually retain water, but not necessarily flowing water, at all times of the year. As the river enters its alluvial plain it starts to meander forming wide convoluted channels whose curves are proportional to river width. In some larger rivers, the Lower Meghna, for example, braided channels occur in which the islands form levees with depression lakes at their centre. Where such braided channels occur the lateral floodplain is sometimes limited in width and its whole extent may come to be contained within the main channel. The floodplain is itself divided into two components: (i) the plain itself which is seasonally inundated, but remains dry for at least part of the year, and (ii) the standing waters which remain in the plain during the dry season. These variations provide ecological niches supporting a myriad of species.

Description of the biodiversity particularly the fishes and wildlife (amphibian, reptiles, birds and mammals) has been given.

Key species (e.g. species that require migration between Indian Ocean, Bay of Bengal and Meghna estuary such as hilsa and barramundi; endangered species such as dolphins and turtles; economically important species)

Notable among the species that concerns the project are anadromous (migrate from saline to freshwater for breeding) or catadromous (opposite of anadromous) are listed below:

Table 5-39 : Notable among the species that concerns the project

Species	Behaviour
Hilsa	Adults migrate to freshwater/brackish water for spawning; later migrate to the sea and after getting bigger and becoming adult returns to the rivers/estuary for laying eggs.
Pangas	Pangasius is a highly migratory riverine fish species that makes long-distance migrations over several hundred kilometers between upstream refuge and spawning habitats and downstream feeding and nursery habitats. Pangasius is omnivorous, feeding on algae, higher plants, zooplankton, and insects, while larger specimens also take fruit, crustaceans and fish.
Prawn/Shrimp	Some species live near the shore, hiding in mud or sand, or in crevices of the stones; some others swim about in groups in deep, cold water. Bangladesh has very rich source of prawns in the Bay of Bengal, estuaries and freshwater. A total of 56 species is reported, of which 37 are salt water, 12 are brackish

Species	Behaviour
	water, and 7 are freshwater in habitats. Some species migrate in between lower and higher saline zones.
Northern River Turtle - <i>Batagur baska</i>	A critically endangered turtle, anadromous in habit, moves upstream from the estuary to lay eggs on the river banks and beaches as well.
Ganges Dolphin	A freshwater species, sometimes seen in the estuary but clear habitat boundary based on the salinity. Ganges River dolphins are not generally known to occur in salinities greater than 10 ppt, rarely up to 23ppt. Migrates to deeper sections (scour holes) of the rivers during dry season when the water levels are low.

Aquatic & River Bank (Terrestrial) flora

Aquatic plants are plants that have adapted to living in aquatic environments (saltwater or freshwater). They are also referred to as hydrophytes or macrophytes. These plants require special adaptations for living submerged in water, or at the water's surface. The most common adaptation is aerenchyma, but floating leaves and finely dissected leaves are also common. Aquatic plants can only grow in water or in soil that is permanently saturated with water. They are therefore a common component of wetlands. The principal factor controlling the distribution of aquatic plants is the depth and duration of flooding. However, other factors may also control their distribution, abundance, and growth form, including nutrients, disturbance from waves, grazing, and salinity.

Aquatic vegetation can be broken down into a number of communities or types. Each type is an aggregated assemblage of particular plant species, and is characteristic of a particular set of environmental conditions (hydroperiod, flow regime, water quality, soil, etc.) and likewise the distribution of wetland species is influenced by the fluctuating hydrological regime. Different plant communities occupy different habitats along the gradient of flooding and moisture.

Elements of the sequence of plant communities, or sometimes the entire sequence, may be absent from particular landscapes due to disruption from human activities. In the Project Influence Area, eight communities of aquatic vegetation were identified:

1. Submerged plants
2. Free floating plants
3. Rooted floating plants
4. Sedges and meadows
5. Floodplain grassland (transitional; includes sedge/meadow and reed swamp species, and grass species)
6. Reed swamp
7. Crop field vegetation
8. Homestead vegetation

Submerged plants remain fully submerged for their entire life cycle, except for the flower which occurs above the water surface. Some are rooted to the bottom and some are freely

suspended. All of these plants are monocotyledons, from ten pretty closely related families including Aponogetonaceae, Hydrocharitaceae, and Potamogetonaceae.

These plants are, for obvious reasons, highly susceptible to seasonal water level fluctuations and can be found in the floodplains the community expands in area during the monsoon and contracts with the coming of the dry season. The plants start growing when water levels start rising at the very beginning of the monsoon, persisting throughout the wet season for as long as ample water is present. When the water starts receding, most of these plants flower and fruit very quickly, thereby assuring offspring in the next year; though most of these species have rhizomes and can also reproduce vegetatively. Where the water recedes further, the plants become desiccated and decompose; in permanent water bodies, they can survive for a much longer period.

The composition and prevalence of this community varied with the river bank landscape. In the shallow areas of the river banks, particularly Dakatia River and flood plains *Hydrilla* (kureli, jhanggi), *Chara*, *Sagittaria* (chhotokul) and *Aponogeton* (ghechu) were the most abundant species (Figure 5-57).



Figure 5-57: Submerged plants (Photo © CARINAM)

Free floating vegetation consists of plants that are most commonly found floating freely on and collecting nutrients from the water; most of them can also survive for a certain period with their roots on or in moist soil. This community is common but not dominant and comprised plant species from the classes Angiosperm and Pteridophytes. The most dominant family in this community is Lemnaceae. Other common families are Salviniaceae, Lentibulariaceae and Pontederiaceae. At the species level *Eichhornia* (kochuripana), and *Salvinia* (kuripana, indurkan, tetulapana), *Lemna* (khudey pana), *Pistia* (topa pana) were found.

This community is also affected by water level fluctuations, though they are in general less dependent on water and more adaptable than the submerged plants. Before the monsoon begins, they are found growing luxuriantly in the stagnant water. They persist as the water rises, but as flooding becomes general they tend to move out into the rivers. Their main mode of propagation is vegetative, though many members of this community can produce seed.

Rooted floating plants root deeply in the soil and float leaves and flower on the water surface. To accomplish this, most plants have very long stalks for both leaf and flower, and a stem that remains under water, sometimes beneath the soil; a few plants have long stems rather than long stalks. The most dominant families in this community are Nymphaeaceae and Menyanthaceae. At the species level *Nymphaea stellata* (nilshapla), *N. nouchali* (sada, raktoshapla), *Nymphoides cristatum* (chandmala), *N. indicum* (panchuli), are common (Figure 5-58).



Figure 5-58: Free floating (top) and rooted floating (below) (Photos © CARINAM)

These plants are also susceptible to seasonal water level fluctuations. In the permanent beels they can survive and regenerate for the whole year. But in seasonally flooded areas, the rhizomes or seeds remain buried under the soil during the dry season and then start sprouting with the arrival of water. As water levels increase, they then elongate their stems or leaf and floral stalks. They typically start flowering on a large scale when the water starts receding just after the peak flood. Almost all the plants of this community can propagate vegetatively as well as sexually.

Sedges and meadows comprise the ecotone (transition area between two communities, such as floodplain and grassland, and as such usually exhibiting competition between species common to both) consisting of amphibian plants (plants that can tolerate wet or dry conditions). Usually, the leaves of these plants are exposed to the air and the roots remain under water, though inundation and desiccation are tolerated to some degree (Figure 5-59). This community has the highest species diversity of all.



Figure 5-59: Sedges, meadows and grasslands (Photos © CARINAM)

The most dominant families in this community are Cyperaceae and Polygonaceae, followed by Gramineae and others. At the species level *Polygonum* (kukra, bishkatakali, and others), and various species of *Cyperus* (mutha), *Phragmites* (nol khagra) are more or less common. Some other species like *Ipomoea fistulosa* (dhol kalmi), *Monochoria hastate* (baranukha, kechur) and *Typha* (hogla) are common. Most of the plants of this type are rhizomatous and can propagate vegetatively, but all of them produce seed as well. Generally this vegetation type occupies the water margin and is also dominant in the charlands.

Floodplain grassland prefers reasonably well-drained land affected by flooding of fairly short duration, typically found in plain lands between river banks and homesteads. The community

consists of various medium to high grasses. Species like *Vetiveria zizanioides* (binna) and other associated species like *Phragmites karka* (khagra, nol), *Saccharum spontaneum* (khag), *Sclerostachya fusca* (khuri), and *Arundo donax* (baranol). Small annual grasses, herbs, *Polygonum* and *Cyperus* are common in the dry season. In the newly formed chars there is a presence of a mixture of plant species, grasses, tree seedlings that suggest that the grassland community may not be a climax type, though the succession process seems to be very slow. Waterbirds, particularly the waders may fully utilize such grasslands.

Reedlands were found mostly in the chars and in some cases river banks that were low and affected by tide and dominated by *Typha* sp. The peripheral areas of the chars are fairly deeply flooded during the flood season and dry out during the dry season. The grasses *Phragmites karka* (khagra, nol) and *Saccharum spontaneum* (khag, aisha) predominate. Some sedge/meadow grasses are also found here, in lesser amounts, such as *Vetiveria zizanioides* (binna, gandhabena), *Sclerostachya fusca* (khuri), and *Arundo donax* (baranal, gobanal). Other than the grasses, woody shrubs like *Ficus heterophylla* (bonolat, baladumur), and *Lippia javanica* (bhuiokra) are also found. Another prominent species is *Asclepias* sp., a climber from Asclepiadiaceae family. Mature reeds attain heights of three to four meters. (Fig. 5.61)

The community is composed principally of perennials, making it particularly vulnerable to utilization pressure. The reed lands are under threat and sustainable harvesting is possible if a rotation of at least three years is allowed, but indiscriminate reed cutting for converting to agricultural land, industrial raw material, and fuel.

River bank and homestead vegetation is a very important plant community, though a synthetic one. The community includes two types of plant: those cultivated for their economic value, and those that are self-propagating. Plants of the first category can be found all along the river banks and adjacent rivers, and composition within this type is more or less uniform. The composition within the second type is more interesting, in that it reflects the composition of nearby natural communities, including communities and species that have otherwise vanished locally, and contains some strong clues as to local vegetation composition in times past. The dominant homestead trees comprise rain tree (*Samanea saman*), koroï (*Albizia procera*), some *A. richardiana*, few Hizal (*Barringtonia racemosa*), koroch (*Pongamia pinnata*), and Borun (*Trewia nudflora*). Other than these were the fruit trees like mango (*Mangifera indica*), Custard Apple (*Annona reticulata*), Guava (*Psidium guajava*), jackfruit (*Artocarpus heterophyllus*). Among the odd species were *Dillenia indica* (elephant apple; chalta), *Alstonia scholaris* (Indian Blackboard Tree, chatim). The backyards comprised herbs and shrubs of various species and saplings of fruit trees and other naturally grown species providing a refuge for some of the wildlife like monitor lizards, fishing cats, etc.

The homestead cultivated plants are the dominant floristic composition of the river bank. The trees which are most common and occupied the major canopy of the area are *Albizia odoratissima*, *Albizia saman*, *Artocarpus heterophyllus*, *Cocos nucifera*, *Litsea monopetala*, *Mangifera indica*, *Phoenix sylvestris*, *Pongamia pinnata*, *Thespesia populnea* and *Terminalia catappa*. Dominant herbaceous plants of the area are *Cynodon dactylon*, *Oenanthë javanica*,

Phyla nodiflora and *Scoparia dulcis* respectively. Most commonly cultivated crops are *Arachis hypogaea*, *Citrullus lanatus*, *Solanum tuberosum*, *Solanum melongena*, *Solanum lycopersicum*, *Oryza sativa*, *Piper betle*, *Cucurbita maxima*, *Ipomoea batatus* and *Lathyrus sativus*. (Fig. 5.61)



Figure 5-60: Reedland (above) and homestead vegetation (below). (Photos © CARINAM)

The plant diversity in some of the off-shore islands and chars in the Lower Meghna estuary include mangrove plants like *Acanthus illicifolius*, *Excoecaria agallocha*, *Sonneratia apetala*, *Derris scandens* and *Tamarix indica*. Mangrove plantation started during 1967-68 in newly accreted land in the Meghna estuary. Under the Green Belt Social Forestry Programme (funded by the World Bank), the Noakhali Coastal Forest Division planted both indigenous and exotic species like *Phyllanthus emblica*, *Dalbergia sissoo*, *Casuarina equisetifolia*, *Acacia auriculiformis*, *Azadirachta indica* and *Acacia mangium*, etc., from 1981-82. The characteristic vegetation along the river bank homestead is evergreen in nature. Few plants like *Terminalia* spp, *Albizia* spp, *Zizyphus mauritiana*, *Erythrina fusca*, *Bombax ceiba*, *Cassia fistula* and *Crateva magna* are deciduous, seasonally changing the landscape colour.

A list of homestead trees species observed along the river banks within the Project Impact Area is presented as an Annex.

People depend much for their livelihood on the cultivated plants around the homestead area for the high population density in the area. Where possible they always clear the lands for the cash crop cultivation, degrading plant diversity in the area. Grazing by domestic animals also alter the vegetation. Destruction of homestead vegetation, agricultural extension, introduction of exotic species and drought are threats to the flora of the area.

Birds (especially migratory)

The wetlands are the important habitat of migratory waterbird population. There are more than 650 bird species in Bangladesh, out of which more than 250 are Migratory. The wetlands are the abode of about 70 species of resident waterbirds including ducks, grebe, cormorants, bitterns, herons, egrets, storks, rails, jacanas, finfoot, waders, gulls, turns, skimmers etc. and many other water dependant birds. As mentioned in the IUCN Red Book, about 100 species of migratory birds regularly or occasionally visit the country.

"The Asia-Pacific Migratory Waterbird Conservation Strategy" 2001-2005, identified 50 species of migratory waterbirds as threatened, out of which 14 species occur in Bangladesh. In addition to that eleven species of resident waterbirds are also identified as threatened (The Red Book of Threatened Birds of Bangladesh, 2000).

The project influence area comprises areas that cover two important flyways of migratory birds. In fact, Central Coast of Bangladesh is the cross-road of East Asia -Australasian and Central Asian - Indian Flyways. Central Coast of Bangladesh particularly the offshore islands are possibly the best place for the wintering of shore birds in Bangladesh. These sites support more than 200,000 migratory birds either as their wintering ground or as staging ground during winter quarter. This is mainly because of its pristine habitat and a huge foraging and roosting ground. A total of about 98 species of shorebirds has so far been recorded from the coasts. Important sites at the central coasts are NijhumDweep, Char Bahauddin, Dhal Char, Char Jonak, Char Nogila, Patar Char and Kalkeniy Char and many more. Highest number of birds arrived in the central coasts are belongs to wetlands birdswaders (50000) gulls, terns and egrets (80,000), ducks and geese (50000).

The important threatened species are Masked Finfoot (*Heliopais personata*; not in the project area), Indian Skimmer (*Rhynchops albicollis*), Black-headed Ibis (*Treskeornis melanocephala*), Greater Adjutant (*Leptoptilos dubius*), Lesser Adjutant (*L. javanicus*), Baikal Teal (*Anas formosa*), Baer's Pochard (*Aythya baeri*), Ferruginous Pochard (*Aythya ferina*), Wood snipe (*Gallinago nemoricola*), Nordmann's Greenshank (*Tringa guttifer*), Spoon-billed Sandpiper (*Eurynorynchus pygmeus*).

Some of the rare species of birds those who visit regularly: Bar-headed Geese, Grey Lag Geese, Eurasian Spoonbill, Black-headed Ibis, Goliath Heron, Asian Dowitcher, Spotted Green Shank, Spotted Red Shank, Spoon-billed Sand Piper and Indian Skimmer. These birds start visiting the site from October and return in the month of April. The early migrants are Common Sandpiper, Wagtail, Lesser Sandplover, Whimbrel, Brown-headed gull, etc. The list of migratory birds is presented in Annex.

Migration Routes, Staging Sites, and Non-breeding Areas

Migratory routes for waterbirds are yet to be identified; however, basic data are available that can be used in delineating the same.

Table 5-40: Key breeding areas, key staging areas and non-breeding areas of the country's water birds

Key breeding areas	Key staging areas	Non-breeding areas
-Haor areas such as Tanguar, Hail, Hakaluki etc. -Sundarbans - Coastal mangroves apart from Sundarbans like Hatiya, Nijhum Dweep etc.	-Haor areas of the North west -Off shore Islands like -Nijhum Dweep etc.	All aquatic bodies of the country

Existing threats to riverine ecosystem

- The river water degrades continuously due to industrial effluent. There is a stinky smell of decomposed river water when there is heavy discharge of effluent.
- Household and human wastages are directly dumped to river water.
- Presence of large infrastructural construction in several spot.
- Different types of non degradable materials were found here.
- On the river there are huge amount of water vehicles like, boat, trawler, launch etc.
- There are many rice mills on the bank of *Dakatiar* river which produce a huge black smoke and pollute air.
- Brick fields, sand & stone storages were seen on the bank of many rivers.

5.3.3 Estuarine and Coastal Ecology

Bangladesh is endowed with vast marine and coastal waters having an area of about 1.5 times more than that of her total land mass. The environment is under the dynamic interface between terrestrial systems and marine systems dominated by wave actions and tidal currents from the Bay of Bengal. The land territory of Bangladesh is linked to the seabed and subsoil in the Bay by a singular process of erosion and deposition that has (a) lifted much of Bangladesh's landmass out of the sea, and (b) shaped the highly unusual seabed throughout the Bay (ITLOS, 2010). The countries exclusive economic zone (EEZ) spans 166,000 sq. km and the shelf area covers roughly 66,440 sq. km. Bangladesh sits in a broad and deep concavity at the northern limit of the Bay of Bengal, with Myanmar to its east and India to its west (ITLOS, 2010).

Fish and other estuarine/coastal fauna diversity and key species

Meghna river estuary is the largest estuarine ecosystem of Bangladesh which is still unknown, unmanaged and unmonitored. Cage culture of tilapia in Meghna River is presently a dominant water use pattern in this area. Down to Chandpur, this area is hydrographically referred to as the Upper Meghna. After the Padma joins, it is referred to as the Lower Meghna which falls to the Bay of Bengal. The Meghna empties into the Bay of Bengal via four principal mouths, named Tetulia, Shahbazpur, Hatiya, and Bamni. During lunar periodicity (full moon and New moon) higher abundance of fishes were reported by the fishermen.

Migration Patterns of *Hilsa*

Hilsa shad (*Tenualosa ilisha*) is anadromous in nature, i.e., capable of enduring in a wide range of salinity and migrating long distance from marine habitat to up-stream freshwater. *Hilsa* lives in the sea for most of its life but migrates to inland freshwater through rivers in Indian sub-continent for spawning (Ahsan, *et al.*, 2014).

The fish migrate from the sea to the freshwater for spawning. The maximum takes place during full moon of the Bengali month of Asween (October) of each year (Rahman *et al.* 2012). The larva hatch and within one to two months convert into Juvenile called Jatka. The Jatka explore in to the fresh water rivers in schools and visits diverse parts the river top up to the river Padma (Ganges). After six to eight months due to the anadromous nature they migrate back towards the Bay of Bengal. After maturation, the fish again migrate back to the same spawning ground i.e., Padma (Ganges)-Meghna.

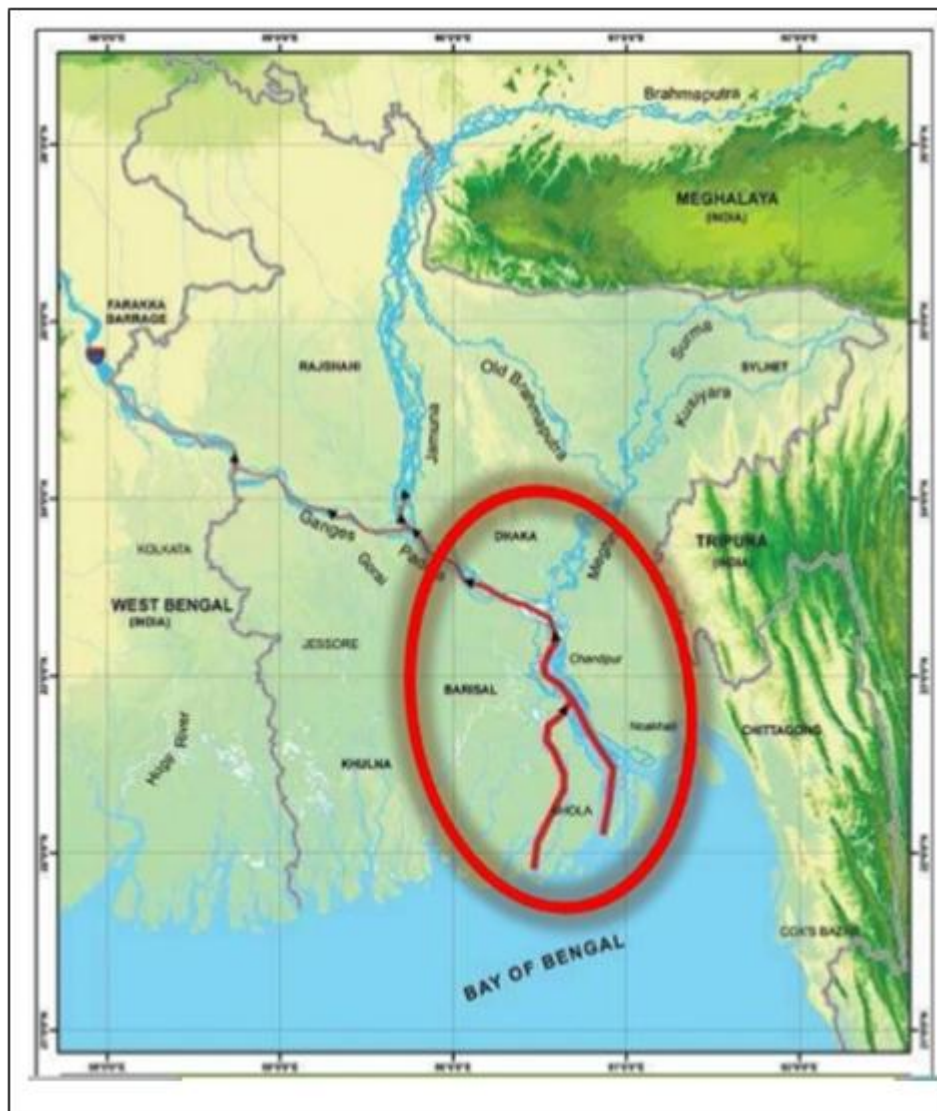
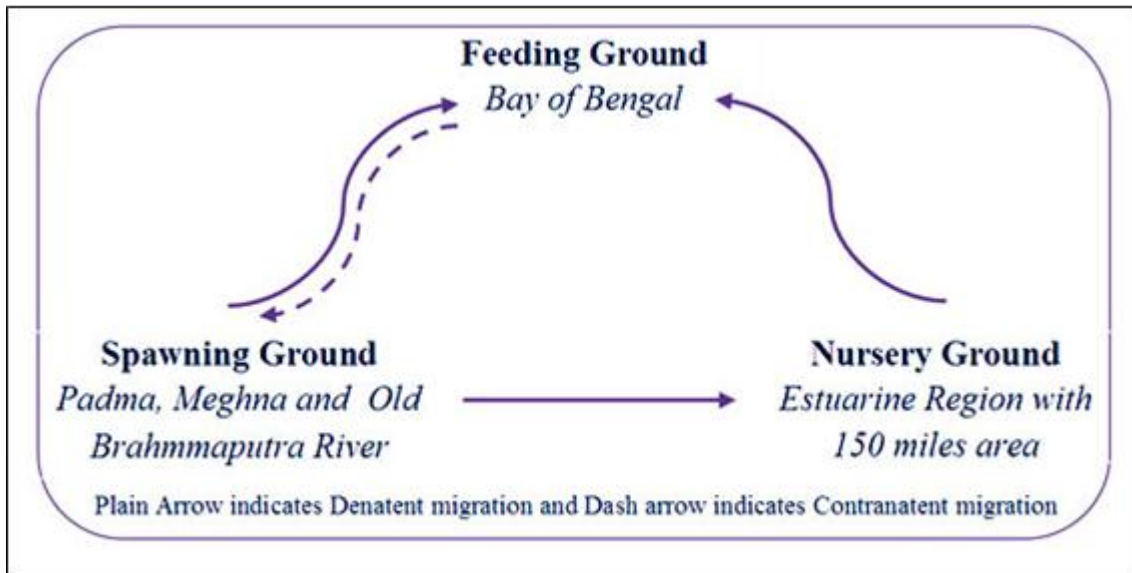


Figure 5-61: Migratory route of hilsa.

River system to breed (Rahman *et al.* 2012; Ahsan *et al.* 2014). As said by some authors, some stocks of Hilsa are permanent residents of the rivers and do not migrate into the sea (Islam, 1986). Qureshi (1968) has suggested that the breeding grounds are mostly located in the Meghna and its tributaries. The main *Hilsa* fishing season starts with the commencement of the monsoon when adult fish migrates up the rivers for spawning. The main peak season is September and October in all environments (Islam, 1986).

Table 5-41: Threshold Values of Physico-Chemical Parameters for *Hilsa* Migration, Breeding and Rearing in Bangladesh:

	Breeding Activities	Nursery Activities
Depth	20 m and above for migration and pre-breeding congregation	Comparatively shallower depth near river-estuarine margins above the congregation grounds
Turbidity (NTU)	100-140	Comparatively low turbid areas (70-80 NTU)
Temperature (°C)	29.3-30.2	29.8-30.8
Salinity (ppt)	<0.1	<0.1
DO (ppm)	5.0-6.8	4.8-6.8
pH	7.70-8.30	7.9-8.40
Chlorophyll (µg/l)	0.114-0.180	0.140-0.180

Source: Ahsan, *et al.*, 2014

Here, NTU=Nephelometric Turbidity Unit, ppt= parts per thousand, ppm= parts per million, µg/l= micrograms per liter

Hydrological features:

Sediment concentration:

Meghna Estuary region of the Northern Bay of Bengal experiences the most dynamic morphological changes like formation of new islands and erosion of coastal areas under significant sediment supply from the rivers. Nearly a billion tons of sediment enters into the northern Bay of Bengal through the Brahmaputra/Jamuna, Ganges and Upper Meghna rivers. Compared to other two rivers sediment input in the estuary through the Upper Meghna River is relatively small. A part of the sediment forms new land in the estuary, another sets off lateral and vertical accretion of the shelf area, and the rest is lost forever through the canyons in the ocean floor (Goodbred and Kuehl, 1999). Concentration of materials held in water in suspension by turbulence (suspended sediment) is measured with a view to computing the amount of sediment present in water column at a particular moment. Sediment is eroded, transported, and deposited by water. This erosion, transportation, and deposition of sediment by flowing water is important on both long and short term time scale in terms of land form development and also on shorter engineering time scale because of its impact on, e.g., navigation channels, on hydraulic structures and, on agricultural resources (Ahmed and Louters, 1997).

Tide and current:

For bays and estuaries which are open to the outer ocean like the Bay of Bengal and the Meghna Estuary residual currents can be strongly influenced by the tidal currents primarily due to the asymmetry created by the Coriolis effect as well as bathymetric configurations. At the same time, residual currents may differ under barotropic and baroclinic conditions and also the effect of asymmetry between spring and neap tide may generate residual currents at the inner bay.

The 'fluvial' and the 'fluvio-tidal' sub-units as described above act as a **tidal river** with very high river discharges in the monsoon whereas the 'tidal' unit behaves as a **tidal** estuary without significant fresh water discharge from the Feni river. The tide is semidiurnal in nature with two tidal cycles per lunar day of 24 hours 50 minutes duration - each cycle having a period of 12 hours 25 minutes. The interaction between the tidal river and the tidal estuary is induced by the open sea connection with the Bay of Bengal south of the Sandwip Island and by the two channels between the north of Sandwip island and the Noakhali main land (Ahmed and Louters, 1997).

Fresh Water Inflow:

Although several large and tiny rivers discharge into the Bay of Bengal, discharge from the lower Meghna River dominates all other rivers by its enormous volume as well as its large influence on the hydrological and morphological processes of the northern Bay of Bengal. Lower Meghna conveys the rainwater from the enormous catchments of the Ganges and Brahmaputra, combined in the Padma River, and from the Upper Meghna catchment. The river flow in the Lower Meghna has a distinct seasonal characteristic, and varies between approximately 10,000 m³/s during the dry period and 100,000 m³/s during the monsoon months (June – September) (Sokolewics and Louters, 2007).

Physico-chemical features:

Salinity distribution in the northern part of the Bay of Bengal is strongly influenced by the seasonal changes in the fresh water discharge from the Lower Meghna River. During monsoon, the salinity drops considerably and the water becomes almost completely fresh. After the monsoon, the salinity rises again and the seawater intrudes into the estuary. However, even during the period with low river discharges the salinity in the area never approaches normal seawater salinity (34 g/l) but always remains distinctly lower (Sokolewics and Louters, 2007).

According to Hossain *et al.*, (1986) the seasonal variations in surface water temperature and catch rate (kg/boat/day) of hilsa fishery is evident in Chandpur and there seems to be a direct relationship between temperature and the landings -the rise and fall in temperature coinciding with the rise and fall in the landings. At Cox's Bazaar and Chittagong, the peak value of temperature in October coincides with the peak catch rate in that month but such a situation does not obtain for the other temperature peak in May. The same study also detected that in Chittagong a significant inverse relationship was observed between salinity and catch rate. During winter high salinity was recorded when the catches were low. However, Cox's Bazaar data do not illustrate such a tendency.

Morphological features:

Meghna Estuary region of the Northern Bay of Bengal experiences the most dynamic morphological changes like development of new islands and erosion of coastal areas under significant sediment supply from the rivers. Nearly a billion tons of sediment enters into the northern Bay of Bengal through the Brahmaputra/Jamuna, Ganges and Upper Meghna rivers. Compared to other two rivers sediment input in the estuary through the Upper Meghna River is relatively small. A part of the sediment forms new land in the estuary, another sets off lateral and vertical accretion of the shelf area, and the rest is lost forever through the canyons in the ocean floor (Goodbred and Kuehl, 1999).

The availability of suitable freshwater spawning habitat is considered to be a major factor limiting the natural recruitment of anadromous Hilsa shad (*Tenualosa ilisha*) in the coastal waters of Bangladesh (Hossain, M.S., *et al.*, 2014). The broods of Hilsa migrate from saline water to estuaries and rivers for spawning where the eggs hatch to larvae. Their spawning phase is closely synchronized with the lunar cycle and a spontaneous spawning is noticed during the new and full moon (Rahman and Cox, 2006) at monsoon wet season (March–September) characterized with high turbidity, strong freshwater flow, low salinity (0–5‰) and large tidal variation (Blaber *et al.*, 1997, 2003a; Haroon, 1998; Milton and Chenery, 2003). However, the rivers, estuaries and coastal waters of Bangladesh are reported to be favorable for brood Hilsa (Shafi *et al.*, 1978; Quddus *et al.*, 1984).

Existing threats to coastal ecosystem

Estuaries are the meeting place of freshwater from rivers and saltwater from the sea and, as such, are dynamic environments characterized by large fluctuations in environmental conditions (James *et al.*, 2007). Importance of estuaries is well understood in many parts of the world as breeding and nursery grounds for a wide variety of fishes. Meghna river estuary is the largest estuarine ecosystem of Bangladesh and support diverse fisheries communities compared to others. Coastal regions of Bangladesh are considered to be the most vulnerable areas in the world due to upcoming climate change scenario, especially due to possible sea level rise and recurrent storm surges. The management of coastal and marine biodiversity in Bangladesh is its responsibility and also an exclusive task of the whole neighboring nations of Bay of Bengal and Indian Ocean rim countries (Quader, 2010). Meghna river estuary is the largest estuarine ecosystem of Bangladesh which is still unknown, unmanaged and unmonitored. The main reason behind this is the complexity and high variability at different temporal and spatial scales with lack of reference on previous conditions of ecosystem (Hossain, *et al.*, 2012). Some identified threats of coastal ecosystem are:

1. Frequent river bank erosion (RBE)
2. Indiscriminate and over fishing
3. Shrinkage of open water fish habitats
4. Obstruction to feeding and spawning migration due to inadequate migration routes
5. Use of agrochemicals and pesticides in riverside agriculture fields
6. Open water dumping in rivers causes acute harm to pelagic and benthic organisms of river
7. Spilled oil from heavy water vessels

The threats to global freshwater biodiversity can be grouped under five interacting categories: overexploitation, water pollution, flow modification, destruction or degradation of habitat and invasion by exotic species (Dudgeon, D. *et al.*, 2006).

Estuaries are areas of physical and biological transition between the land, freshwaters, and the sea (Chowdhury *et al.*, 2009). Almost 25% of the global vertebrate diversity is accounted by fish and fish species threatened in Bangladesh was last measured at 18 in 2013 by the World Bank. IUCN (2004) listed 13 threatened fish species in our coast including Sundarbans. Moreover, the Swatch of No Ground has now been identified as a cetacean hotspot for globally endangered Ganges River and Irrawaddy dolphins, and very recently government has declared its first marine protected area in the Bay of Bengal. Despite the country has number of strong policies and plans to protect environmental and biological resources, it is continuously losing its biodiversity because of their poor implementation and also due to human ignorance. We failed to recognize biodiversity as a rich and essential source of our nutrition and livelihood (Hoq, 2014).

It is believed that out of 61,259 species of vertebrates recognized world over, 32,300 are fish species; of which 16,764 are marine (William *et al.* 2010). A number of coastal areas and ecosystems in Bangladesh are under stress due to growing aquaculture, agriculture activities and other anthropological activities. Natural causes affecting coastal biodiversity have also been of concern in recent years.

Benthic habitat quality (nutrients, organic carbon, micro invertebrates) The primary result of the dredging is the change in bottom topography (deepening of the channel bed) and the temporary suspension of large clouds of sedimentary material (increased turbidity). There are a number of related impacts affecting chemical and physical conditions, and biological parameters. The extent of the impacts depends partially on the equipment used, the quantities dredged per time unit and the quality of the dredged material.

Dredging causes increased turbidity in water. This reduces light penetration, thereby interfering with the photosynthetic process. Dredging disturbs the thin layer of oxidised sediments at the channel bottom; it will expose and disturb the deeper un-oxidised layers. The removal of this material may result in high values for chemical and biological oxygen demand in the surrounding waters. Nutrients (nitrogen and phosphorous compounds) present in the bed material will be released. This in itself can be considered as a positive impact, rendering nutrients from the bottom sediment available for aquatic biota.

Benthos is among the most important components of an estuarine ecosystem and may represent the largest standing stock of organic carbon in the system (Rao and Misra, 1988). Many benthic organisms, such as hard clams, soft-shell clams and prawns are the basis of the estuarine commercial fisheries. Other bottom-dwelling organisms, such as polychaete worms and small crustaceans, contribute significantly to the diets of economically important fish. Benthic communities' vary considerably according to environmental conditions (McLusky, 1989). Most benthic macroinvertebrates have highly aggregated small-scale distribution induced by several environmental variables, such as substratum type, food availability and predation (Cummins, 1962). Meghna is the biggest estuary in Bangladesh. The joined flow of the three mighty rivers forms the estuary. Hossain *et al.* 2009 found significant seasonal difference among the benthos species composition and density in the Meghna estuary.

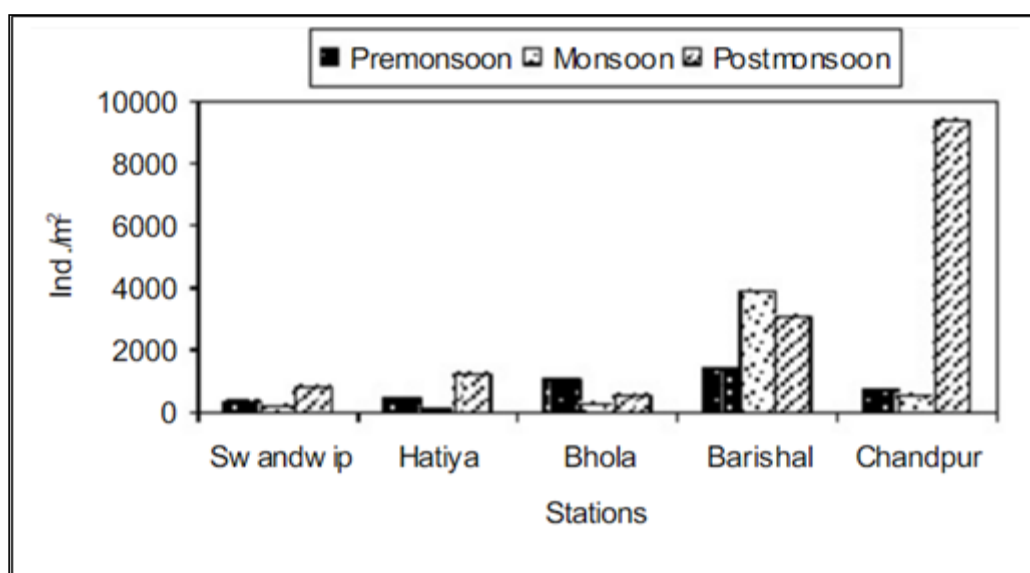


Figure 5-62: Total macrobenthos counted during three at Sandwip, Hatita, Bhola, Barisal and Chandpur (after Hossain *et al.* 2009)

Table 5-42: Taxonomic groups of benthic fauna, their percentage and rank of abundance in the Lower Meghna (Chandpur, Barisal) and Meghna Estuary (Sandwip, Hatiya, Bhola) (Source: Hossain *et al.* 2009)

SL. No.	Taxonomic Groups	Ind./m ²	% of total number	Rank of abundance
1	Ciliopora	20	0.085	15
2	Polychaetea	7871	33.30	2
3	Oligochaeta	12701	53.73	1
4	Nematoda	519	2.20	3
5	Cyclopoid Copepoda	57	0.24	9
6	Calanoid Copepoda	176	0.74	5
7	Harpecticoid Copepoda	9	0.04	18
8	Amphipoda	416	1.76	4
9	Ostracoda	23	0.10	14
10	Branchiopoda	52	0.23	10
11	Mysidacea	16	0.07	17
12	Crab	72	0.30	7
13	Cladocera	21	0.09	16
14	Isopoda	52	0.22	11
15	Coleoptera	68	0.29	8
16	Hymenoptera	32	0.14	13
17	Hemiptera	38	0.17	12
18	Diptera	135	0.58	6

Considering the overall faunal composition in the 5 stations together, oligochaetes were the most dominant group which constituted 53.73% followed by polychaetes (33.30%), mesogastropods (4.94%), nematodes (2.2%) and amphipods (1.76%). Other groups present in small numbers (<1%) were ciliophora, copepods, ostracods, branchiopods, mysids, crab megalopa, isopods, cladocera, insects and bivalvia constituting 4% of the total population (Hossain *et al.* 2009). Maximum population density was found during postmonsoon and

minimum during the monsoon. Diversity and density was higher in both Barisal and Chandpur was higher than the sampling stations located in the estuary. It is established that benthos is rich in the stable environment and increasing depth reduces their abundance. Abundance and composition of benthos vary due to prevailing abiotic and biotic factors. Biotic factors that affects the living organisms in the intertidal zone such as competition for space and food, predation, reproduction substrate settlement preference, osmoregulation (Ramamurthy 1953). Abiotic factors that affect the living organisms in the intertidal area such as salinity, temperature, air and light exposure, tidal flow, waves and current action, substrate, wind direction and strength, dissolved oxygen, storms, natural disasters (Weyl & Peter 1970). In another study in the Meghna Estuary 10 major groups/taxa were identified during premonsoon from all stations. The maximum density (4511 individual /m) was found at Nijhum Dweep Namar Bazaar and the minimum (4332 individual /m) at Nalchira Ghat. The macrobenthos included polychaetes (45.03 %), oligochaetes (16.65 %), 2 shrimp larvae (13.93 %), crab (9.63 %), gastropods (3.56 %), isopods (1.15 %), bivalves (1.15 %), copepods (0.73 %), annelids (0.42 %), amphipods (0.63 %) and others (7.12 %). Polychaetea, oligochaetea, shrimp larvae and crab contributed 85.24 % of total population. Polychaete was dominant by contributing 45.03 % of total macrobenthos (Asadujjaman *et al.* 2012).

Data on fish and shellfish catches and trends

Meghna estuary and its tributaries possess a widespread system of aquatic ecosystem which supports massive amount of species of plants, fish and other organisms. Of all these living organisms, fish are the most important element and is the major source of dietary protein for the national sector (Hossain *et al.*, 2012). The population of Bangladesh depends on wild fish for food and the generation of income. A large portion rural family are engaged in part time fish capture from the rivers and beels (Hughes *et al.*, 1994). For fishing, different types of crafts, gears and traps are used. Different types of fishing method used from primitive times and now fishing methods had been modified (Mia *et al.*, 2015).

Sanctuaries and protected areas (existing or proposed) (also see Section 5.3.1 Sensitive/ Protected Areas)

Fisheries sector of Bangladesh represent a remarkable natural resource, with an intimate connection with the life and well-being of the country and its people. This sector is playing a major role to ensure food security and economic growth of Bangladesh. In 2013-14, Bangladesh has produced 3548115MT fish of which 83.22% % and 16.78% comes from inland and marine fisheries respectively (FRSS, 2014). Hilsa shad, *Tenualosa ilisha* (Hamilton-Buchanan, 1822), which is the national fish of Bangladesh and commonly known as Ilish, is the largest and single most valuable species with annual catch of 340,000 Metric Tons (MT) (DoF, 2013). Total catch of hilsa in Bangladesh ranged between 194,981 and 280,328 tons with an average of 217,681 tons per year from 1987 to 2007 and the total production increased approximately 48% during this period (Mome and Arnason, 2007). Also the hilsa catch in 2011 in Bangladesh was 313,753 tons (BBS, 2012). In the year 2003, the estimated standing stock size and MSY (maximum sustainable yield) were 218,000 tons and

235,000 tons, respectively (DOF, 2005). This indicates the over-fishing of the hilsa stock existed earlier.

Table 5-43: Hilsa spawning grounds boundary

Hilsa spawning ground periphery/demarcation	GPS Point
1 Mayani Point, Mirsarai, Chittagong in the Northeast	91°32.15'E and 22°42.59'N
2 Paschim Syed Awlia Point, Tajimuddin, Bhola in the northeast	90°40.58'E and 22°31.16'N
3 North Kutubdia Point, Kutubdia, Cox's Bazaar in the Southeast	90°52.51'E and 21°55.19'N
4 Lata Chapali Point, Kalapara, Patuakhali in the southeast	90°12.59'E and 21°47.56'N

Source: GoB, 2011

Table 5-44: No Hilsa Catch Zone and Peak Spawning Period of Hilsa

Position Peak	Area	Spawning Period (Ban Period of Hilsa catch)
North-East	Shaher Khali/Haithkandi point, Mirersharai	15-24 October
North-West	North Tajumuddin/West Syed Awlia point	15-24 October
South-East	North Kutubdia/Gandamara point	15-24 October
South-West	Lata Chapili point/Kalapara	15-24 October

Source: DoF, 2011

The government is going to make an addition to the existing list of five sanctuaries for Ilish (Hilsa) fish, one of the major foreign revenue earning natural resources of Bangladesh. Bangladesh Fisheries Research Institute (BFRI) proposed new sanctuary, located in three tributaries of the Meghna River, somewhere between Hijla and Mehendiganj in Barisal district. At present, the five sanctuaries cover a total riverine area of 350 sq-km; the upcoming one is about 60 sq-km in size (Dhaka Tribune, 2015). Whereas The Daily Star (2011) stated that the government is soon going to declare a 20-kilometre stretch of the Padma in Shariatpur a new sanctuary for hilsa to increase the production of the kingly fish.

Table 5-45: Hilsa fish sanctuary area, their boundary and ban fishing period

SN	Hilsha Fish Sanctuary Area	Boundary Point	Period Fishing banned
01	From Shatnol of Chandpur to Char Alexander of Laxmipur (100km stretch of Lower Meghna)	Shatnol Point (90°37.12'E and 23°28.19'N); Char Alexander Point (90°49.30'E and 22°40.92'N)	From March to April of each year
02	Char Ilisha to Char Pail of Bhola District (90km stretch of Shahbazpur Channel, a tributary of Meghna River)	Char Ilisha Mosque Point (90°38.85'E and 22°47.30'N); Char Pail Point (90°44.81'E and 22°05.10'N)	From March to April each year
03	Bheduria of Bhola district to Char Rustam of Patuakhali (100km stretch of Tentulia River)	Bheduria Ferry Ghat Mosque Point (90°33.89'E and 22°42.31'N) Mandol Bazaar (Char Rustam) (90°31.40'E and 21°56.32'N)	From March to April each year
04	Whole 40km stretch of Andermanik River in Kalapara Upazila of Patuakhali District	Golbunia Point (90°19.20'E and 21°57.68'N) Confluence of Bay of Bengal and	From November to January each year

SN	Hilsha Fish Sanctuary Area	Boundary Point	Period Fishing banned
		Andermanik River (90° 3.91'E and 21° 49.43'N)	
05	20 km stretch of Lower Padma between Naria-Bhedorganj Upazila of Shariatpur in the north and Matlab Upazilla of Chandpur and Bhedorganj Upazilla of Shariatpur in the south	Kachikata Point of Bhedorganj UZ of Shariatpur district in the northeast (90°32.60'E and 23° 19.80'N) Bhomkara Point of Naria UZ of Shariatpur District in the northwest (90°28.80'E and 23° 18.40'N) Beparipara Point of Matlab UZ of Chandpur District in the southeast (90°37.70'E and 23° 15.90'N) Tarabunia Point of Bhedorganj UZ of Shariatpur District in the southwest (90°35.10'E and 23° 13.50'N)	From March to April each year
06	Total length of 82 km between three different river points of Barisal District. Three points are: a. Total 13.70 km stretch of the Kalabadar River between Habinagar point, Barisal Sadar Upazila and Bamnar Char Point, Mehediganj Upazila of Barisal	i) Habinagar point: (22°45'1.08"N and 90°25'10.20"E) ii) Bamnar Char point: (22°49'22.44"N and 90°28'5.16"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)
	b. Total 8.81 km stretch of the Gajaria River between Bamnar Char Point of Mehediganj Upazila and Hizla Launch Ghat point, Hizla Upazila of Barisal District	i) Bamnar Char point: (22°82'29"N and 90°46'81"E) ii) Hizla Launch Ghat: (22°90'67"N and 90°53'08"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)
	c. Total 59.51 km stretch of the Meghna River between Hizla Launch Ghat point of Hizla Upazila and Daskhin-Paschim Jangalia point, Mehediganj Upazila of Barisal District	i) Hizla Launch Ghat: (22°90'67"N and 90°53'08"E) ii) Daskhin-Paschim Jangalia point: (22°73'33"N and 90°49'17"E)	From March to April each year (SRO No. 268-Law/2018 dated 10 September 2018)

Table 5-46: Hilsa sanctuary in the lower Padma River (Newly proposed)

Position	Sanctuary area with GPS point	Ban period
North-East	Kasikata, Vedorgonj, Shariatpur (23°19.8' N, 90°32.6'E)	March to April every year
North-West	Vomkora, Noria, Shariatpur (23°18.4' N, 90°28.8' E)	
South-East	Beparipara, Matlab, Chandpur (23°15.9' N, 90°37.7' E)	
South-West	Tarabunia, Vedorgonj, Shariatpur (23°13.5' N, 90°35.1' E)	

Source: BOBLME, 2010

If the new proposed hilsa sanctuaries are finally approved as Hilsa Sanctuary and necessary conservation measures are taken, it can result in the sustainable management of not only Hilsa but also other viable species of Meghna River and its tributaries.

The overall situation of hilsa fishery is under severe stress in Bangladesh and vulnerable to over exploitation. Simulation results show that increased harvesting of the adults entering the rivers and the juveniles in the rivers cause gradual decline in hilsa fish population and even

may cause to disappear this valuable resource within a short period of time (Bala, B.K., *et al.*, 2014). For sustainable production of hilsa fish as well as increase in production sound development policy and management strategies are urgently needed (Bala, B.K., *et al.*, 2014).

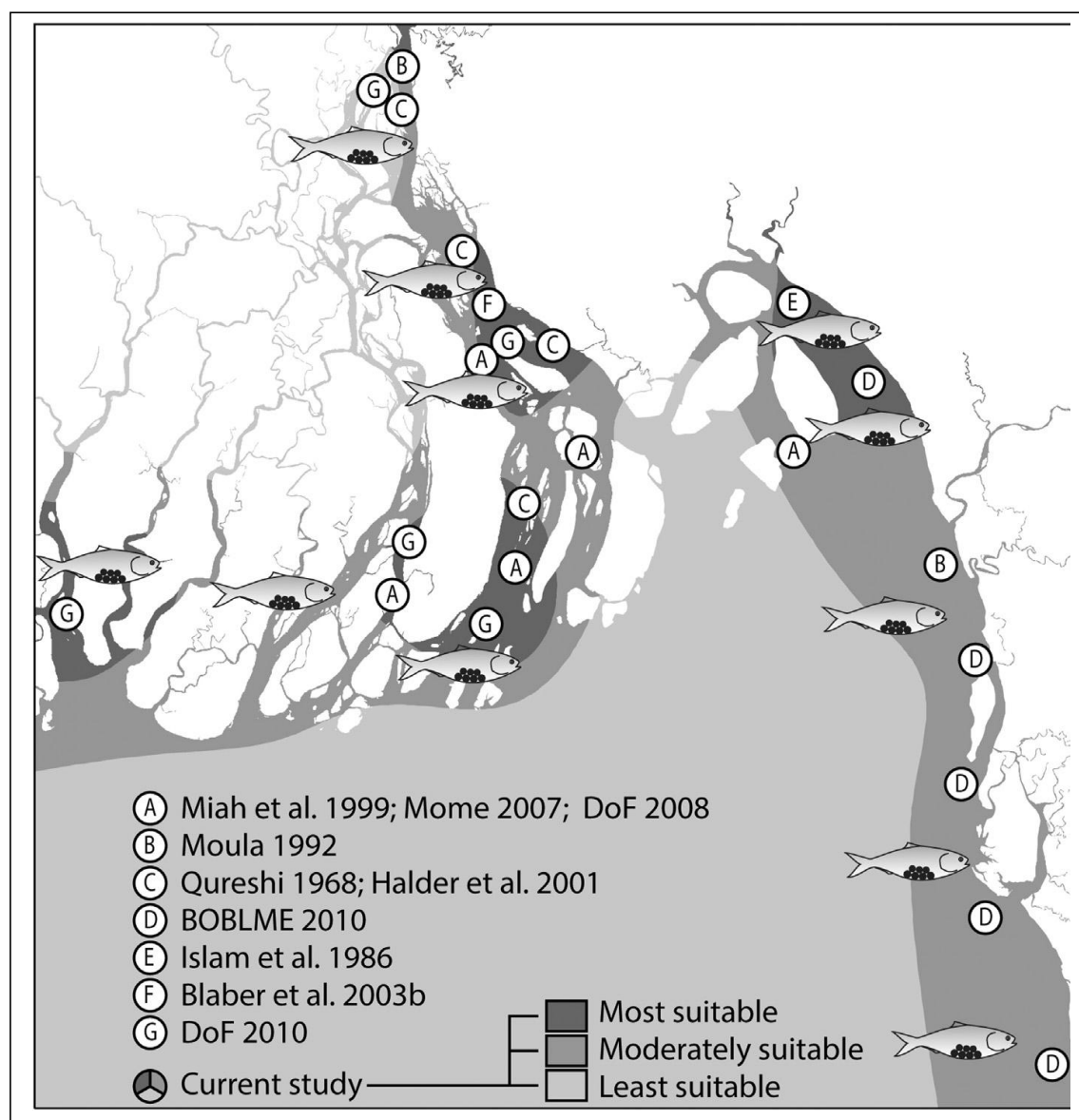


Figure 5-63: Geo-spatial spawning habitats modeling for Hilsa overlap with many authors in the coastal waters of Bangladesh. (Source: M.S. Hossain *et al.* 2014)

Existing threats to coastal ecosystem

Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes. Coastal areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. Unlike watersheds, there are no exact natural boundaries that unambiguously delineate coastal areas. Coastal zone means the coastal waters (including the land therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each and in proximity to the shorelines of the several coastal states, and includes islands, transitional and intertidal areas, salt marshes, wetlands and beaches.

The hydrological cycles; rivers and distributaries from the lands and the ocean currents and waves accumulate huge organic and geochemical substances; thus make highly productive zones with important sources of food and raw materials, energy, minerals, recreation, transport, and trade. Coasts also host an impressive array of valuable habitats with an equally extraordinary collection of species. Excellent landscapes are found on sea shores. They are the best natural defense for keeping the shoreline intact from abrasions. However, coastal zones face serious problems of habitat destruction, pollution, erosion and resource depletion due to human economic activities and probably climate change effects. A combination of human activities like over-fishing, pollution of estuaries and the coastal ocean, and the destruction of habitat, especially wetlands and sea-grasses etc., currently exerts a far more powerful effect on marine fisheries than is expected from climate change.

However, some problems often create disasters and make the lives hard and the whole coastal ecosystem is being disturbed. Among them, tropical cyclones and tornados, tidal surges and floods, erosion, heavy siltation and pollution, especially from the mega-cities and ports, shrimp hatchery and shrimp farms. Deforestation, over fishing and salt fields, overexploitation, and hill cutting for unplanned construction, ships breaking industries and tourism have accelerated ecosystem damages.

The government has developed the Bangladesh National Programme of Action (NPA) for the Protection of the Marine Environment from Land – based Activities under the aegis of the Global Programme of Action (GPA) of the UNEP. This national document, signify the needs and opportunities for the protection of the coastal environment and associated lives and livelihoods.

5.3.4 Floodplain and Char Land Ecology

A floodplain is a flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current.

Lateral connectivity by means of floodplain inundation has been described as a major factor affecting the biodiversity and biocomplexity of floodplain systems. With decrease in connectivity after flood recession the influence of the river on floodplain waterbodies diminishes and floodplain habitats develop their own limnological features. Knowledge of the effects of dry spells and drought on aquatic systems comes primarily from intermittent and arid-zone streams, and the implications of extended dry periods for floodplain waterbodies are still poorly known.

The extended dry period resulted in continuous morphological changes in non-flooded sites as opposed to more drastic changes in sites subject to flooding. Even though habitat characteristics varied through time, most variation occurred between flooded and non-flooded waterholes, as the latter sites presented significantly lower proportions of habitat elements, such as aquatic and overhanging vegetation, algae, debris, leaf litter and root masses. Flooded waterholes showed greater indication of temporal changes, given that many of these habitat elements increased in proportion during the wet season, after flooding.

Flooded sites showed lower pH, conductivity and dissolved oxygen values and higher water temperatures. Inundation decreased turbidity in waterhole sites and increased this parameter at the river site. Flooding, although minor, was an important factor structuring the physical habitat and water quality characteristics of waterholes, whereas the absence of flooding led to more continuous low-magnitude changes. These processes can be expected to influence resources available for consumers such as fish, as well as the habitats available for colonization by the aquatic fauna.

The large rivers characterized by extensive floodplains and the river-floodplain systems are regulated by the flood pulse regime and the hydrological connectivity, which determine high habitat heterogeneity and a wide spectrum of resources for benthic invertebrates. The floodplain environments range from secondary channels of different discharge and flowing regime (intermittent flow, permanent flow) and connectivity degree and fluvial or lacustrine wetlands. The connectivity degree, macrophytes cover, riparian leaf litter, availability of detritus in the bottom sediments determine high habitat heterogeneity at different temporal and spatial scales in the Meghna River floodplain.

The high spatial variability (patches, mesohabitat, regional/landscape scales) and the temporal fluctuations of the system (flood pulses magnitude, duration and frequency, seasonality, etc.), determine a high taxonomic and functional diversity of benthic invertebrates and large amounts of available benthic resources for aquatic and aquatic-terrestrial food webs. Lateral gradients are found among mesohabitats with increasing richness, abundance, biomass and secondary production from the main channel to secondary channels, lakes with different connectivity degree and wetlands. The secondary channels show differences in the benthic invertebrate assemblages among the central strip and the banks, in relation to detritus inputs, granulometry and hydraulic stability degree. The floodplains offer a high heterogeneity in relation to their connectivity degree (mainly at the landscape level). Besides high levels of environmental complexity and significant differences in the benthos assemblages may be found at the patches scale in relation to their area and shore development (embayment, irregularities, debris dams, etc.).

A gradient from the permanent water bodies to the terrestrial zones may be observed in the marginal wetlands in terms of physical and chemical microhabitats and vertebrate and invertebrate assemblages. Moreover, the taxa found in the marginal wetlands can develop desiccation strategies to survive during the drought phase. Despite the importance of floodplain habitats and their natural dynamics for the biodiversity of the system and for the human economic activities, the rivers have been greatly disturbed by engineering and regulating water flow, resulting in a degradation of floodplain-river function and connectivity.

Floodplains and Charlands are two major important biota of river biome. Charlands are low-lying islands whether temporary and permanent land mass within river channel resulted from sedimentation and accretion, while the floodplains are perennial wetlands along the bank of river course comprising of seasonally flooded land, low-lying depression, ox-bow lakes, canals, ponds and ditches. The project influence and study areas cover a wide array of water ecosystems e.g., islands, chars, shoals in the river channels, riverbed and banks, the river

basin/catchments upstream & downstream of the watercourse, floodplains & drainage area and patterns, areas of potential influence of existing and planned river ports, landing, terminals, vessel shelters, ferry crossing and dredge spoil dumping sites, areas of ecological important, irrigation and roads.

Natural Vegetation

The char lands support the natural successions of grass and reed lands. At the estuary the char lands re-colonized the mangrove swamps naturally. The charlands are temporary waterscapes in the rivers houses perennial vegetation comprising of grass and reedlands plan communities. This seasonal succession of charland vegetation is unique evolutionary phenomena which produces highest biomass productivity on earth within a short span of time. During winter season these biomasses are consumed by livestock and wildlife in various forms. People in these delta are from time immemorial are being harvesting grass and reeds as fodder for their livestock, using the sungrass and typha for thatching their houses, use the charlands as foraging and grazing grounds for livestock. The phragmites and Saccarum are used as special fodder for cattle. The aquatic vegetation especially the weeds are used as bio-fertilizer after composting those. Huge quantity of aquatic weeds are using as fire fuel after sun drying.

The Charlands are very fertile land for agriculture. People are cultivating different type of crops including cereal, species, vegetables, sesame, peanuts and mustard.

During monsoon all these biomass from the charland vegetation are the main nutrient to fish and other riverine life. The vegetation when got submerged during flooding becomes decomposed and dispersed naturally into the river course and supplied dissolved nutrient materials to water and soil. The Economic value of charlands agriculture, fisheries and other NTFPs need to be assessed and consider its role in the livelihoods of the charland community. The charlands is also an important gene bank of indigenous aquatic vegetation, wild paddies and indigenous livestock, poultry and duckery.

These are eternal dynamic natural nutrient cycle/process in the river delta which the charlands are performing to keep the riverine natural ecosystem functions intact and sustaining the richness in diversity of aquatic biodiversity. Charlands are also acts as an important natural carbon sink to a greater extent.

But these values and functions of charlands are never been taken into account as such during the multifarious intervention in the forms of water development projects.

Ninety seven species have so far been recorded from the Charlands surveyed. The most common well adapted species of charlands are *Saccharum spontaneum*, *Saccharum ravennae*, *Typha elephantine*, *Vetiveria ziznoides*, *Tilanthera philoxeroides*, *Rottboelia exaltata*, *Lippia nodifolia*, *Echinochloa colonum*, *Alternanthera sessilis*, *Phragmites karka*, *Aeschynomene indica*, *Imperata cylindrica*, *Leersia hexandra*, *Fimbristylis dichotoma*, *Polygonum hydropiper*, *Eclipta prostate* and *Xanthium indicum*. The rare presence of some tree species also noticed in the charlands. These are *Barringtonia acutangula* (hijol) *Trewia polycarpa* (pidali), *Salix tetrasperma* (willow), *Ziziphus mauritiana* (boroi) and *Tamarix gallica* (nonajao). The most common ground cover of charlands is *Cynodon dactylon* (durba), *Hemarthia portens* (chailla), box grass, *Colonum crusghali* (shamagrass), *Cyperus rotundus*

(bhaduli), and *Leersia hexandra* (arali grass). In the wet area of charlands a member aquatics very are very common. These are *Eichhornia crassipes* (kachuripana), *Pistia stratiotes* (topafana), *Ipomoea aquatic* (kolmi), *Nymphaea pubescens* (shampla), *Nymphoides indicum* (chandmala), *Utricularia exoloeata* (jaji), *Ludwigia repens* (mulsi), *Tilanthra phylloxeroides* (helencha), *Hygorrhiza aritrata* (hygorrhiza), *Monochoria hastata* (Nukha), *Sagittaria sagittifolia* (sagittaria), *Hydrolea zeylanica* (hydrolea) etc.

Mammals

Mammalian fauna of Bangladesh is comprised of 124 species including 5 species of marine mammals. Among these species 10 primates, 30 carnivores, 34 bats, 7 artiodactyls, 9 dolphins and whales and one species of elephant is notable (Khan 2010). Among the 30 species of carnivores, 8 species are felids viz. Bengal Tiger (*Panthera tigris*), leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), Fishing Cat (*Felis viverrina*), Asiatic Golden Cat (*Felis temminckii*), Marbled Cat (*Felis marmorata*), Jungle Cat (*Felis chaus*) and Leopard Cat (*Felis bengalensis*). Three species of bears, viz. *Ursus thibetanus* (Asiatic Black Bear), *Melursus ursinus* (Sloth Bear) and *Helarctos malayanus* (Sun Bear) are found in the forests of the country. Among the 19 species of primates of South Asia, Bangladesh supports 10 species. Among these primates 5 species of monkeys, 3 species of Langurs, 1 species of Gibbon and 1 species of Loris inhabits here. Four species of deer viz. *Axis axis* (Spotted deer), *Axis porcinus* (Hog deer), *Cervus unicolor* (Samber deer) and *Muntiacus muntjak* (Barking deer) are found in Bangladesh. Bangladesh is the home of Asian Elephant (*Elephas maximus*) - the largest land mammals of the country. Bangladesh supports a good number of bats (34 species). Among these bats 29 species are insectivores, 4 fruit bats and 1 carnivore (Khan 2008).

On the basis of both primary and secondary data, a total of 26 mammalian species is reported from the study area. The relative abundance of the mammalian species, Critically Endangered was 09 (36%), Common individuals are 3 (12%), Uncommon 04 (16%), Vulnerable 05 (25%) and 02 (8%) species are Rare (See Annex – Mammals).

Terrestrial habitats: include forests, grasslands, reed forest and agriculture lands. They are typically defined by factors such as plant structure, leaf types (eg. broadleaf and needleleaf), plant spacing and climate. Grasslands include a variety of upland grass-dominated habitats. In general, grasslands occur on dry slopes and have well-drained sandy or loamy soils. Terrestrial means living and moving 'on land'. Terrestrial fauna viability is dependent upon maintaining a mix of vegetation quantity, quality and distribution. Maximum number of mammalian species used different vegetative and structural stages for feeding, breeding and cover. The vegetation also changes, both natural and human-caused, the major influences on terrestrial wildlife.

Most mammalian species today are terrestrial. Some mammalian today remain aquatic (Gangetic Dolphin, *Platanista gangetica*), semi-aquatic (Otters), living the first stage of their lives as fish-like tadpoles. Some special habitats are used by special types of wild animals.

Riparian Habitats: A good number of mammalian fauna uses riparian habitats for nesting. These types of habitats are believed to support potential mammalian species (rats, moles, mice, jackals, civits, etc) at risk. These habitats are those adjacent to rivers and streams or

occurring on nearby floodplains and terraces. Riparian habitats are shaped and maintained through seasonal flooding, scour, and soil deposition. Riparian habitats occur along rivers and streams at all elevations, from valley bottom floodplains. Riparian habitats also include springs, seeps, and intermittent streams, and many low elevation alluvial floodplains.

Arboreal habitat is the area of "animal movement" in trees. In every habitat in which trees are present, animals have evolved to move in them. Some animals may only scale trees occasionally, while others are exclusively arboreal. A good number of mammals are adapted in arboreal habitat i.e. False Vampire Bat, *Megaderma lyra*; Leschenaults Fruit Bat, *Rousettus leschenaulti*; Indian Flying Fox, *Pteropus giganteus*; Lesser Rat-tailed Bat, *Rhinopoma hardwickei*, Kelaart's Pipistrelle, *Pipistrellus ceylonicus*, etc.

Arboreal environments pose many functional challenges for animal locomotion including fitting within narrow spaces, balancing on cylindrical surfaces, moving on inclines and moving around branches that obstruct a straight path. Many species of mammals are arboreal and their flexible bodies appear well-suited to meet many of these demands.

Forest Habitat is a large area of land where many plants and trees grow. There are different kinds of forests throughout the study areas and each has its own special characteristics. Climate, soil, and water determine the kinds of plants and animals that can live in a place. In the forest, there are several layers of plants they provides food and shelter for many kinds of mammalian species, etc.

Flagship mammalian species: The keystone species plays a unique and crucial role in the way an ecosystem functions. Many other species rely upon keystone species for some critical aspects of their life history and survival. These species play a vital role in maintaining the structure of an ecological community and help to determine the types and numbers of various other species in the community.

On the other hand, Flagship species are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action. Flagships are viewed as ambassadors or icons of an ecosystem. Each of the particular habitat types of the country has some keystone or flagship species those are very crucial for that particular region, like, Irrawaddy Dolphin, Gangetic Dolphin, Golden Jackal, Fulvous Fruit Bat, Fishing Cat, etc.

Birds

Central Coast of Bangladesh is the cross-road of East Asia -Australasian and Central Asian - Indian Flyways. Central Coast of Bangladesh particularly the NijhumDweep is possibly the best place for the wintering of shore birds in Bangladesh. This site supports more than 200, 000 migratory birds either as their wintering ground or as staging ground during winter quarter. This is mainly because of its pristine habitat and a huge foraging and roosting ground. A total of about 98 species of shorebirds has so far been recorded. Important sites at the central coasts are NijhumDweep, Char Bahauddin, Dhal Char, Char Jonak, Char Nogila, Patar Char and Kalkeniy Char. Highest number of birds arrived in the central coasts are belongs to waders (50000) gulls, terns and egrets (80,000) , ducks and geese (50000).

Some of the rare species of birds those who visit the regularly are: Bar-headed Geese, Greylag Geese, Eurasian Spoonbill, Black-headed Ibis, Goliath Heron, Asian Dowitcher,

Spotted Green Shank, Spotted Red Shank, Spoon-billed Sandpiper and Indian Skimmer. These birds start visiting the site from October and return in the month of April. The early migrants are Common Sandpiper, Wagtail, Lesser Sandplover, Brown-headed Gull.

Bangladesh has 628 species of birds (16 orders and 67 families; 276 passerine and 352 non-passerine), of which 388 are resident (16 orders and 60 families; 171 passerine and 217 non-passerine), and 240 are migratory (10 orders and 33 families; 105 passerine and 135 non-passerine). Sarus Crane (*Antigone antigone*) is the largest (standing about 1.75 m tall) bird in the subcontinent, but it is now a rare occurrence in Bangladesh.

A few flowerpeckers and sunbirds, smaller than the sparrow, are perhaps the smallest. The bird population is shrinking every day. One of every nine species of birds is now threatened with extinction. Today 41 species (out of 388 species of resident birds) are threatened in Bangladesh, of which 19 are critically endangered, 18 endangered and 4 are vulnerable. Of the 388 resident species, the status of 158 could not be evaluated due to paucity of data. The ecological alterations obviously affected the composition of the avifauna. Birds associated with forests of some sort or with a swampy habitat have declined, and their places taken over by other birds.

All members of the family Scolopacidae are migratory. Common among these are 2 spp. of Curlews (Gulinda), (*Numenius* sp.); 2 spp. of Godwit (Jurali) *Limosa* sp., 13-14 spp. of Sandpipers (Chapakhi Pi-oo), (*Tringa* sp.); 5-6 spp. of Snipes (Chaha or Kadakhucha), Gallinago; Woodcock (Bara or Buno Chaga) (*Scolopax rusticola*); 3-4 spp. of Stints and Dunlins (Baman Chapakhi), (*Calidris* sp.), and Ruff (*Philomachus pugnax*). Of these snipes and woodcock usually occur singly and the others are usually found in flocks of several individuals to several thousands. Most are restricted to the coastal areas, estuaries, charlands, beels, baors, haors, mountainous streams, ponds and lakes. Larger flocks are restricted to the larger water bodies. The list of birds in the project area is given in Annex F.

Reptiles

There are 157 reptilian species had so far recorded in Bangladesh (Khan, 2010). One species of crocodile, *Crocodylus porosus* and one Ghorial, *Gavialis gangeticus*, belongs to the Family Crocodylidae and Family Gavialidae. 28 species are turtle and tortoise belongs to 5 families. A total of 31 lizard species represents 6 families and 97 snake species are recorded belongs to 8 families under the order Serpenteria.

A total of 34 species of reptiles are recorded from the study area. The relative abundance of the reptilian species, Critically Endangered was 12(37.5%), Common individuals are 4 (12.5%), Uncommon 03 (9.38%) and 02 (6.25%) species are Rare (Annex F).

Gharial: Gharial, *Gavialis gangeticus*, rarely occurs in the Padma; the species is Critically Endangered (CR) nationally and globally. Some scientist assumes that it is extinct in the wild in Bangladesh. Habitat shrinkage, food scarcity, breeding ground destruction and poaching of eggs and young are the main threats for this species. There are past sighting reports of this rare crocodile in the river and charlands between Shariatpur and Harina.

Turtle and Tortoise: Turtles and Tortoises have a great commercial value as food and ecological services (such as scavengers) at the local level, and they are valued nationally and

internationally for food, medicinal products and the pet trade (Das, 1987). There are 28 turtle and tortoise species in Bangladesh. At present most of the species of turtles and tortoises are threatened. River Terrapin, *Batagur baska* and Cantor's Softshell turtle, *Pelochelys cantorii* these species are critically endangered and occurs in brackish water and large water bodies of Bangladesh. Asiatic soft-shell turtle, *Chitra indica* found in deep water of big rivers and it occurs in study area in good abundance in Padma, although the turtle is categorized as critically endangered in IUCN-Red Data Book - Bangladesh (2015).

A total of 12 species of both freshwater and marine turtles are recorded from the study area. Turtles are usually found to inhabit in ponds, ditches, pools, canals, rivers and estuaries in the study area. During winter season turtles are seen basking on the bank of the waterbeds, vegetation, and semi-submerged bamboo poles, floating material or erected objects in the water. The spotted flap-shell turtle was found in paddy fields under straw in burrowing condition.

Venomous and non-venomous snakes: In Bangladesh among the 82 species of snakes 28 are venomous, 12 species of them are sea snake (Faiz *et al.* 2008). Venomous snakes belong to the families Viperidae, Elapidae (including cobras, kraits, coral snakes), Hydrophiidae (sea snakes and Colubridae (a large family, of which most species are non-venomous and only a few are dangerously toxic to humans) (Paul *et al.* 2008). There are 5 medically important groups of snake in our country, these are- Cobras, Krait, Russell's viper, Green pit viper and sea snake. Among this majority of venomous bites in our country are cobras and kraits. They are mainly neurotoxic, and respiratory failure is the main cause of death following venomation. Snakes bite defensively or when agitated.

The common non-venomous snakes in the present study area are: Checkered Keelback (*Xenochropis piscator*), Striped Keelback (*Amphiesma stolata*), Banded Wolf Snake (*Lycodon aulicus*), Black-barred Kukri Snake (*Oligodon cinereus*), Smooth Water Snake (*Enhydryis enhydryis*), and Rat Snake (*Ptyas* spp.). Common venomous snakes include several species of Cobra (*Naja* spp.), Kraits (*Bungarus* spp.), Pit Vipers and others.

Snakes are found in grassland habitats. This habitat, with its vegetation, attracts rodents and insects, which the snakes prey upon. The high grass also provides protective cover for the snakes. Reed forests are also important habitats for reptiles. Rat snakes (Elaphidae) are found in the jungles, crop fields and backyards of homesteads in good numbers.

Habitats typically contain many niches and support many different species. Habitat is an ecological area that is inhabited by a particular species of animal or other type of organism. A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators. A variety of stable habitats are vital for the long term welfare of reptile species. Some species of reptilian fauna live in the same type of habitat all the years, while others spend the summer in one type of habitat and winter in different habitats. In addition, habitats are quite different for different types of species. Large, wide-ranging species like snake and monitor lizards can travel large distances and use many different types of places or vegetation types. Smaller species, like Wall lizards, Calotes, Mabuya, Gecko, etc. can spend much of their lives near a single fallen log.

A suitable habitat for any given organism will possess the resources required for its survival. Habitats with better resources, including adequate food supplies and safer shelter, may give an individual a selective advantage and improved fitness over others. Differences in habitat use are thought to develop as a result of physiological, morphological interspecific differences, adaptation to a habitat based on independent evolution in different areas, or specialization to optimal habitats because of competition within or between species.

Selection of a habitat can be ordered at the macro and micro levels. First, a physical or geographical location in which to inhabit will be selected as a macro-habitat. Then the animal will secure a home range, limiting their movement spatially. Further selection will occur as an animal makes use of the different habitat components, or microhabitats, in the home range. Habitat availability, relative to the proportions at the macro level, may decrease at the micro level because an animal is selecting for an area where its habitat of preference dominates. Usage by the animal at the micro level can therefore increase relative to the total availability of habitat types.

There are only two types of ecosystems: terrestrial and aquatic ecosystems. However, these ecosystems can be broken down into a variety of smaller, more regional and specialized ecosystems, which are sometimes referred to as biomes.

Aquatic Habitats: Large number of reptile species uses the aquatic habitats which cover lakes, ponds, canals, marshy areas, streams, rivers and intertidal zones. Below is a description of these various aquatic habitats.

Freshwater habitats: Include bogs, ponds, rivers, reservoirs. Freshwater aquatic habitats typically contain water year-round, while wetlands may dry out through the season. Most reservoirs (Marsh, Ponds and other natural water bodies) also are included in these habitats and land cover type, as they represent man-made versions of dishes and ponds, which are difficult to distinguish with imagery. Eventually, when the lakes and reservoir coverage for the state is completed, reservoirs might be separated from natural water bodies. These habitats feature standing water and believed to support turtles, monitor lizards and some snake species. Marsh, lakes and ponds that have not had their hydrologic regime modified provide the best habitat. Rivers and streams are the habitats of aquatic vegetation and animals which ensures food and shelters of turtles, snakes, crocodiles, etc.

Wetland habitat is a place where the water controls the environment and the plant and animal life. They are some places where the ground is wet or covered with water for most of the year. The wetlands are rich in animal life. Since these areas are covered with water, many reptiles like Roofed Turtle (*Pangshura tecta*), Median Roofed Turtle (*Pangshura tentoria*), Three-striped Roofed Turtle (*Kachuga dhongoka*), Yellow Turtle (*Morenia petersi*), Spotted Flapshell Turtle (*Lissemys punctata*), Monitor lizards (*Varanus spp.*), Seibold's Smooth Water Snake (*Enhydra seiboldii*), Dark-bellied Marsh Snake (*Gerarda prevostiana*), etc., could not be easily observed. Wetlands are covered with water during all or part of the year. Wetland habitats are highly diverse and include the following different types:

Swamps and shrub lands are located in depressions, around lakes or ponds or on river terraces. They generally flood seasonally with nutrient-rich waters and are dominated by woody vegetation. Many species of monitor lizards, turtles are frequently found in these habitats. Marshes occur in depressions (ponds), fringes around lakes and along slow-flowing streams. Marshes are seasonally or continually flooded and have water-adapted plants such as sedges, bulrush and floating vegetation. Marshes can have mucky soils resulting in water with high mineral content and dominated by herbaceous species, often including wildflowers. Different types of reptiles like Indian Roofed Turtle, Yellow Turtle, Three-striped Roofed Turtle, Spotted Flapshell Turtle, Peacock softshell Turtle, Black Pond turtle, Ckeckered Keelback Watersnake, Striped Keelback snake, Monitor lizards, etc., live in marshes.

Seasonal ponds and vernal pools hold water during the winter and spring but typically dry up during the dry summer months. Vernal pools occur in complexes of networked depressions that are seasonally-filled with rainwater. They host a variety of reptilian species with unique adaptations.

Terrestrial Habitats used by reptilian fauna: Terrestrial habitats include forests, grasslands, agriculture land and pastures. They are typically defined by factors such as plant structure, leaf types, plant spacing and climate. Grasslands include a variety of upland grass-dominated habitats. In general, grasslands occur on dry slopes and have well-drained sandy or loamy soils.

Terrestrial means living and moving 'on land'. Terrestrial reptiles, lizards, snakes, tortoises, gharials, etc viability is dependent upon maintaining a mix of vegetation quantity, quality and distribution. A substantial number of snakes use different vegetative and structural stages for feeding, breeding and cover. The vegetation also changes, both natural and human-caused, the major influences on terrestrial wildlife.

Riparian Habitats- A good number of reptilian fauna uses riparian habitats for nesting. These types of habitats are believed to support potential reptiles' species at risk. These habitats are those adjacent to rivers and streams or occurring on nearby floodplains and terraces. Riparian habitats are shaped and maintained through seasonal flooding, scour, and soil deposition. Riparian habitats occur along rivers and streams at all elevations, from valley bottom floodplains. Riparian habitats also include springs, seeps, and intermittent streams, and many low elevation alluvial floodplains.

Arboreal habitat- is the area of "animal movement" in trees. In every habitat in which trees are present, animals have evolved to move in them. Some animals may only scale trees occasionally, while others are exclusively arboreal. Arboreal that lives and move 'Above' the ground". A good number of reptiles are adapted in arboreal habitat like Short-nosed Vine Snakes (*Ahaetulla prasina*), Common Vine Snakes (*Ahaetulla nasutus*), Tokey Gecko (*Gecko gecko*), Common Garden Lizard (*Calotes versicolor*), etc.

Arboreal environments pose many functional challenges for animal locomotion including fitting within narrow spaces, balancing on cylindrical surfaces, moving on inclines and moving around branches that obstruct a straight path. Many species of snakes are arboreal

and their elongate, flexible bodies appear well-suited to meet many of these demands, but the effects of arboreal habitat structure on the locomotion of snakes are not well understood.

Amphibians

Present Status of Amphibian species: There are 42 species of amphibian fauna are reported from Bangladesh (Khan 2010), of which order Anura covers all the 42 species belonging to 07 families [Bufonidae = 04, Dicroglossidae =12, Hylidae = 01, Megophryidae =03, Microhylidae =09, Ranidae =12, Rhacophoridae =11]. In the present study only 10 species were identified in the PMBP impact area. Of which, Common toad, *Duttaphrynus melanostictus*, is very common and widely distributed. Of the frog species Bull frog, *Hoplobatrachus tigerinus*; Common skittering frog, *Euphlyctis cyanophlyctis*; and Cricket frog, *Fejervarya limnocharis* is common and widely distributed in the study area (Figure 1-1). Green Frog, *Euphlyctis hexadactylus*; Two-striped Grass Frog, *Sylvirana taipehensis* are vulnerable species in the project area. Of the recorded amphibian species, the relative abundance of the species, Critically Endangered species were 02 (20%), Common individuals were 3 (30%), Uncommon 5 (50%) species.

Table 5-47: List of Amphibian species identified in the study areas.

No	Order	Family	Species	English Name	Local Name	IUCN	*Local
1	Anura	Bufonidae	<i>Duttaphrynus melanostictus</i>	CommonToad	Kuno Bang		CR
2		Dicroglossidae	<i>Euphlyctis cyanophylctis</i>	Skipper Frog	Kotkoti Bang		C
3			<i>Euphlyctis hexadactylus</i>	Green Frog	Sabuj Bang	EN	UR
4			<i>Fejervarya limnocharis</i>	Cricket Frog	Jhijhi Bang		C
5			<i>Hoplobatrachus tigerinus</i>	Indian BullFrog	Sona Bang		C
6		Ranidae	<i>Nasirana alticola</i>	Pointed-headed Frog	Pana Bang	VU	UR
7			<i>Sylvirana taipehensis</i>	Two-striped Grass Frog	Kaad Bang	EN	UR
8			<i>Hylarana tytleri</i>	Leaping Frog	Pana Bang		UR
9		Rhacophoridae	<i>Polypedates leucomystax</i>	Asian Brown Tree Frog	Gecho Bang		CR
10			<i>Polypedates maculatus</i>	Indian Tree Frog	Gecho Bang		UR

Notes: IUCN Status: VU = Vulnerable; EN = Endangered; CR = Critically Endangered.

CITES Status: I=Threatened with Extinction; II=Trade to be Controlled to Help Survival; III=Protected in at Least One Country

***Local Status (Occurrence/abundance):** CR = Common Resident; C = Common; UR = Uncommon Resident; RR = Rare Resident

Terrestrial habitats used by amphibian fauna

Terrestrial habitats- include forests, grasslands, reeds and agriculture lands. They are typically defined by factors such as plant structure (trees and grasses), leaf types (eg. broadleaf and needleleaf), plant spacing (forest) and climate. Grasslands include a variety of upland grass-dominated habitats. In general, grasslands occur on dry slopes and have well-drained sandy or loamy soils.

Terrestrial means living and moving 'on land'. Terrestrial fauna (toads and frogs) viability is dependent upon maintaining a mix of vegetation quantity, quality and distribution. A substantial number of amphibian species used different vegetative and structural stages for feeding, breeding and cover. The vegetation also changes, both natural and human-caused, the major influences on terrestrial wildlife.

Riparian Habitats- A good number of amphibian fauna uses riparian habitats for nesting. These types of habitats are believed to support potential amphibian species at risk. These habitats are those adjacent to rivers and streams or occurring on nearby floodplains and terraces. Riparian habitats are shaped and maintained through seasonal flooding, scour, and soil deposition. Floods replenish nutrients, recharge groundwater, and reset succession processes. Riparian habitats occur along rivers and streams at all elevations, from valley bottom floodplains. Riparian habitats also include springs, seeps, and intermittent streams, and many low elevation alluvial floodplains.

Arboreal habitat- is the area of "animal movement" in trees. In every habitat in which trees are present, animals have evolved to move in them. Some animals may only scale trees occasionally, while others are exclusively arboreal. Arboreal that lives and move 'Above' the ground". A good number of amphibians are adapted in arboreal habitat, i.e. Asian Brown Tree Frog (*Polypedates leucomystax*), Jerdon's Tree Frog (*Hyla annectans*), Striped Asian Tree Frog (*C. vittatus*), Large Tree Frogs (*Rhacophorus* spp.), etc.

Arboreal environments pose many functional challenges for animal locomotion including fitting within narrow spaces, balancing on cylindrical surfaces, moving on inclines and moving around branches that obstruct a straight path. Many species of frogs are arboreal and their flexible bodies appear well-suited to meet many of these demands.

Forest Habitat- is a large area of land where many plants and trees grow. There are different kinds of forests throughout the study areas and each has its own special characteristics. Climate, soil, and water determine the kinds of plants and animals that can live in a place. In the forest, there are several layers of plants they provides food and shelter for many kinds of frogs (*Rachophorus* spp., *Hyla* sp., *Chiromantis* spp., *Philautus* sp., *Polypedetes* sp.), etc.

Invertebrates

Bangladesh is a host of wide range of invertebrate diversity. The report reflects a partial state of species diversity of invertebrate fauna. Annex-F shows the recorded species of insect fauna.

Among the fauna, Insects play a vital role in regulating the ecosystem and contribute to sustainability of the biodiversity. Das (2009) estimated the total number of insect species as

2,444 in Bangladesh. Feeroz *et al.* (2011) recorded 43 butterfly species and 11 species of other groups of insects from Rema-Kalenga Wildlife Sanctuary in Shatchari, Sylhet. Forty four species of butterflies were recorded from Butterfly Research Park in Bhawal National Park in 2012 (Anonymous and Bashir, 2012). In 2012 these researchers made a report on Dudpukuria-Dhopachari Wildlife Sanctuary of Bandarban and reported more than 100 species of insects of various groups including Butterflies, dragonflies, Damselflies, Bees, Wasps, Beetles, Mantids, Grasshoppers and others. They also listed 70 butterflies, 25 dragonflies & damselflies, and 10 species of grasshoppers from Teknaf Wildlife Sanctuary in 2013. Bhuiya (1983-2014) recorded nearly 450 species of parasitic Hymenoptera from Bangladesh.

Bangladesh represents a good diversity in its butterfly species. IUCN (2004) reported a total of 311 species. However, the number of new species reports has increased during 2013 and 2014 by 12 more species in the records making the current total upto 323 species (Khandaker M. *et al.* 2013, Neogi *et al.* 2014, Khan M.K. *et al.* 2014 and Shahadat *et al.* 2014). Notably, Torben B. Larsen (2004) reported 236 in the whole of Bangladesh whereas the rest 75 was done by previous researchers (Alam 1962a, 1962b, Ameen and Chowdhury 1968, Begum and Begum 1986, Alam and Ullah 1995 in IUCN 2014).

Invertebrates constitute the major group of wild fauna in the study area. Annex-F shows the species of invertebrates recorded from the study area. The charlands are good abode of invertebrates in general and the insects in particular. In the shallow water shoals are seen having high density of mollusks. These are important feeds of carnivorous fish, Storks, Ibises, Geese, Great Egrets, Birds of prey and monitor lizards. People collect mollusks in bulk to feed their ducks. Mollusks shells are also burned to make edible lime.

Insects like the grasshoppers and crickets are seen in superabundance which attracts huge flocks of insectivorous birds like drongo, swallow and other flycatchers. Butterfly and moths are also very important groups of arthropods seen in all most all char areas nectaring on flowers of herbs. Bees and wasps are seen in the sesame fields in good populations. These groups are good pollinators of flowers. Beetles, bugs and fireflies are a group of insects found in the backyards of homesteads in good abundance. The list of terrestrial insects is given in Annex.

Threats to floodplain and charland ecosystem

The floodplains and charlands in the Upper Meghna rivers are all most all lost its natural features as result of human-induced changes. These areas are either under cultivation of fish culture. Flood Control, Drainage and Irrigation (FCDI) projects controls the natural connectivity of river flow to and from floodplains which disconnects the migration path of aquatic life between beels and rivers. Thus it destroyed the natural habitats of floodplain capture fisheries. The charlands in the region mostly harbour villages where human population is very high and the natural features of the charlands are damaged. Major part of flood plains cultivable land and beels are land filled for housing, bazaars and other development structures. Water is polluted due to waterlogging in the low-lying areas and the municipal wastes dumped directly to the water.

Over fishing in the Lower Meghna is seen as one of the main threat to the floodplains biodiversity. The rate of erosion is also high in the charlands and river banks in these region which posing threats to the homesteads biodiversity.

The reedlands are being converted to agri-lands which damaging the reedlands habitat for a great number of reedland birds.

Hunting, shooting and trapping of migratory birds in the charlands is an important threat to the migratory bird populations.

Shrip fry collection by mosquito nets posing threats to the plactonic life of more than hundred species of coastal and marine fishes.

Pollution from ships and accidental oil spill from capsized oil tanker are also threats to the aquatic and charland biodiversity

Over-exploitation: A very small areas of swamp forests are now present due to extensive exploitation over the past decades. Natural regeneration of the forest species is not happening anywhere in the wetlands. The reed beds are also significantly reduced from over-harvesting for fuel and converting land into agricultural fields.

Destructive fishing methods: Harvesting the last fish, dewatering of key areas, repeated fish harvest on an annual basis, and leaving only a few fish for breeding are the most unsustainable fishing methods used. As a result, reduction of fish diversity has been happening in this once highly diversified wetland.

Soil erosion: Given a dynamic system, soil and river bank erosion is a major concern in charland and riverine areas respectively.

Water pollution: Excessive use of chemical in agricultural field and Industrial pollution are the major reasons of water pollution which in turn impacts the aquatic ecosystem negatively.

Predicted threats and suggested mitigation measures

To enhance the inland navigation different types of physical intervention has taken place along the river banks. Under this project, construction of Vessel shelter, Launch and Ferry terminal are such structural intervention to be carried out which have far reaching environmental impacts are predicted. From the historical and past experiences it is noticed that growth centers, business hub, bazaars and other development activities are being established by the community centering the Launch and Ferry terminals.

Although the terminal and station itself are not detrimental to environment as such but the associated development activities have adequate negative environmental impacts on the rivers and waters. All the existing terminal and ferry stations are visible examples of such environmental degradations which are resulted from the activities mentioned below.

- Filling river banks, water bodies and crop fields around the terminals for construction of shops/bazaars/bus stands/truck stands
- Illegal encroachment of Khas lands
- Dumping all most all solid/liquid wastes on site and rivers directly
- Air pollution from rice and brick clines
- Waste discharge directly from the factories without treatment

- Waste materials from abattoir, open slaughter house, hotels, restaurants and kitchen are dumped in the water
- Absence of sewerage and drainage systems
- Dumping and discharging toilet waste directly to river from all water vessels ply along the terminal
- Plastic bags/containers consumed by the passengers are thrown to the rivers
- Waste generated from hawkers are thrown all around
- Oils and mobiles slicked from the water vessels to the water
- Noise pollution from loudspeakers used in the ghats for various purposes

There should be an environmental management plan to mitigate the negative environmental impacts specifically the water pollution. Local government authority/bazaar committee/boat operators association under BIWTA should have “Local Environment Safety Protocol” developed, implemented and monitored.

Otherwise all the stations and terminals in near future will make river polluted like that of “Buriganga” in an irreversible state.

There should be an environmental management plan to mitigate the negative environmental impacts specifically the water pollution. Local government authority/bazaar committee/boat operators association under BIWTA should have “Local Environment Safety Protocol” developed, implemented and monitored.

- Prefer degraded habitat for dredge spoil dump at char and avoid dump at chars having high biodiversity and ecological value
- Prepare DO’s and DON’Ts, use those at hoardings and orient the people engaged in the operation
- Keep the birds roost, feeding and nesting ground free from such operation
- Avoid dumping on reedlands
- Avoid Breeding and wintering season
- Translocate the rare wildlife including turtles, izards, frogs, snakes and mammals
- Relocate and transplant the rare vegetation
- No hunting, shooting, trapping and disturbing birds
- Minimize noise level
- Avoid anchoring boats/barges and other vessel in the mudflats
- Regulate oil slick of the vessel/dredger/carrier
- Restrict workers movement/ activities in the charlands
- No disposal of waste from the vessels operating in the water
- Dredge spoil has high demand for land fill and other uses for construction industry, thus *ex-situ* translocation is suggested
- Use boom/barriers/buoys to demarcate no go zones /restricted ecological area/reserves

5.3.5 Land Resources

Agro-Ecological Regions

Bangladesh has been divided into thirty agro-ecological regions and 88 sub-regions (Figure 5.65). The regions have been identified on the physical environments which are relevant for land use and assessing agricultural potential. These layers are: (i) Physiography (land forms and parent materials); (ii) Soils and their characteristics; (iii) Depth and duration of seasonal flooding; (iv) Length of the rain fed Kharif and Rabi growing periods; (v) Length of the pre-Kharif period of unreliable rainfall; (vi) Length of the cool winter period and frequency of occurrence of extremely low (below 0.4°C) winter temperature; (vii) Frequency of occurrence of extremely high (> 40°C) summer temperature.

Geo-morphological and EIA study of river routes dredging, construction and maintenance of vessel shelters and construction/maintenance of launch/cargo terminals mainly located at Demra under Dhaka district, Narayanganjsadar under Narayanganj district, Gajariaupazila under Munshiganj district, Polash(Ghorashal) upazila under Norsindi district, Brahmanariasadar and Ashuganjupazila under Brahmanbaria district, Bhedorganjupazila under Sariatpur district, Shandipupazila under Chittagong district, Raipur upazila under Lakshmipur district, Matlab Uttar, Chandpursadar and Haimcharupazila under Chandpur district, Hatyaupazila under Noakhali district, Sandwipupazila under Chittagong district, Bholasadar and Daulatkhanupazila, Tozumuddinupazila, Monpuraupazila under Bhola district, Hijla Mehendiganj and Sadarupazila under Barisal district.

Agro-ecological zones and sub-regions are very broad units. Fertility status of these regions varies considerably. For detailed information about physical and chemical properties of soils, respective Upazila Nirdeshika of SRDI and Land Zoning Report of Ministry of land consulted. However, for fertility data of a specific area soil samples have been collected for detailed analysis.

The total study area (route) has been estimated about 150,700 ha and comprises of seven agro-ecological regions, namely (i) Old Brahmaputra Floodplain (AEZ-9), (ii) Active Ganges Floodplain (Aez-10), (iii) Ganges Tidal Floodplain (AEZ-13), (iv) Middle Meghna River Floodplain (AEZ-16), (v) Lower Meghna River Floodplain (AEZ-17), (vi) Young Meghna Estuarine Floodplain (AEZ-18), (vii) and Old Meghna Estuarine Floodplain (AEZ:19). The locations of agro-ecological regions are comprises with some physic-chemical properties of soil of AEZs have shown according to land type (in Table-5.48 to Table 5.54)

Table 5-48: Some physic-chemical properties of soils of AEZ-9

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
High land	3.8-6.5	L-M	VL-L	VL-L	L	VL-L	M-Opt	M-Opt	L-M	VL-L	Opt
Medium highland	4.5-7.2	L-M	VL-L	VL-L	L-M	VL-L	M-Opt	M-Opt	VL-L	VL-L	Opt
Medium lowland	4.5-7.2	L-M	VL-L	VL-L	L	VL-L	M-Opt	M-Opt	L-M	VL-L	Opt

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum

Table 5-49: Some physic-chemical properties of soils of AEZ-10

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
High land	6.7-8.1	L-M	VL-L	VL-L	L-M	L-M	M-Opt	H	L	VL-L	M
Medium highland	6-7-8.4	L-M	VL-L	VL-L	L-M	L-M	M-Opt	H	L	VL-L	M
Medium lowland	6.6-8.0	L-M	VL-L	VL-L	L-M	L-M	M-Opt	H	L-M	VL-L	M

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum, H=High.

Table 5-50: Some physic-chemical properties of soils of AEZ-13

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium highland	4.5-8.4	L-M	L	VL-L	M-Opt.	M-Opt.	Opt-H	M-Opt.	L-M	M-Opt.	Opt.

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum, H=High.

Table 5-51: Some physico-chemical properties of soils of AEZ-16

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium Lowland	4.8-6.9	L-M	VL-L	L-M	L-M	L-M	M-Opt	M-Opt	L-M	VL-L	Opt
Lowland	4.0-6.7	L-M	VL-L	L-M	L-M	L-M	M-Opt	M-Opt	L-M	L	Opt
Very Lowland	4.5-5.4	L-M	VL-L	VL	L-M	L-M	M-Opt	M-Opt	Opt	VL	Opt

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum, H=High.

Table 5-52: Some physic-chemical properties of soils of AEZ-17

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
High land	5.5-6.5	M	VL-L	L	L-M	L-M	M-Opt	Opt-H	M-Opt	L	M
Medium highland	4.7-7.6	L-M	VL-L	VL-L	L-M	L-M	M-Opt	Opt-H	M-Opt	L-M	M
Medium Lowland	5.1-7.8	L-M	VL-L	VL-L	L-M	L-M	M-Opt	Opt-H	M-Opt	L-M	M

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum, H=High.

Table 5-53: Some physic-chemical properties of soils of AEZ-18

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium highland	4.5-8.4	M-Opt	VL-L	L-M	L-M	M-H	M-H	M-H	L-M	L-M	Opt

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum, H=High.

Table 5-54: Some physico-chemical properties of soils of AEZ-17 (Old Meghna Estuarine Floodplain)

Major land type	Soil pH	Soil OM	Nutrients status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium high land	4.5-7.8	L-M	VL-L	VL-L	L-Opt	L-M	Opt	Opt	L-M	L-Opt	Opt
Medium lowland	5.4-7.6	L-M	VL-L	VL-L	L-Opt	L-M	Opt	Opt	L-M	L-Opt	Opt
Lowland	5.6-6.7	L-M	VL-L	VL-L	L-Opt	L-M	Opt	Opt	L-M	L-Opt	Opt

OM=Organic matter; VL=Very low, L=Low; M=Medium; Opt=Optimum. (Source: Fertilizer Recommendation Guide-2012, BARC)

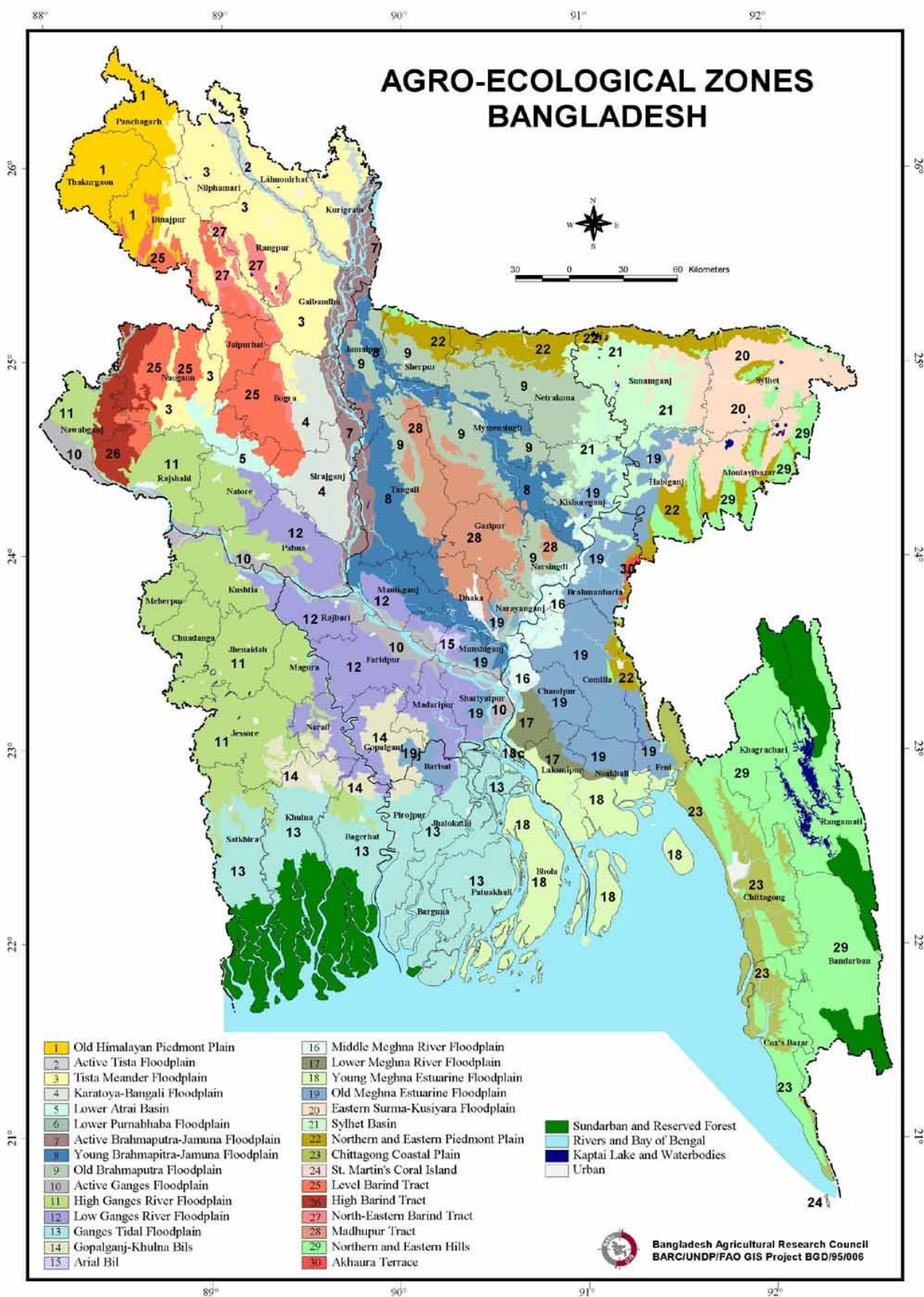


Figure 5-64: Agro-Ecological Zones in Bangladesh

Land Types

Land type classifications are based on depth of inundation during monsoon due to normal flooding on agriculture land. According to Soil Resource Development Institute (SRDI), five land types have been classified in terms of depth of flooding.

The distribution of land types of the study area is presented in Table 5.55. Maximum (59%) area of the project is covered with medium highland (F₁) which is followed by medium lowland (29%). The coverage of low land and very low land are about 9% and 2% of the Net Cultivable Area (NCA). The land type is classified only based on agriculture land which represented as Net Cultivable Area (NCA). Detailed distribution of land type of the study area is presented in (Table 5.55).

Table 5-55: Distribution of land type in the study area (Main land)

Land type	Flooding depth	Depth of Inundation	Flooding characteristics	Area (ha) of NCA	% of NCA
Highland (F ₀)	0-30 cm	Flood free	Non flooded to intermittent	432.9	1
Medium Highland (F ₁)	30-90 cm.	Less than 30 cm	Seasonal	25,539.9	59
Medium Lowland (F ₂)	90-180 cm	30 to 90 cm	Seasonal	12,553.5	29
Lowland (F ₃)	180-275 cm	90 to 180 cm	Seasonal, but remains wet in early dry season	3,895.9	9
Very Lowland (F ₄)	> 275 cm	More than 180 cm	Seasonal but remains wet in most of the dry season	865.8	2
Total				43,288.0	100

Sources: GIS estimation, SRDI and Field Survey'2015

Soil Texture

Soil texture is the relative proportions of sand, silt and clay. It is very important for agriculture crop production. The sandy loam soil texture of the project area is about 46% which is followed by clay loam (25%). The clayloam soil texture is favored for growing dry land crops in the Rabi/dry season and also rice and jute. Detailed soil texture is presented in Table-5.56

Table 5-56: Detailed soil texture of the Top- soil (0-15 cm) in the study area (Composition (%) in riverbank site permanent Village land)

Texture	Area (ha) of NCA	Percentage of NCA
Clay	3,463	8
Clay Loam	10,822	25
Loam	6,926	16
Sand	2164.4	5
Sandy Loam	19912.5	46
Total	43,288.0	100

Sources: GIS estimation, SRDI and Field Survey 2015

Land Use

Main land (village land)

The dredging work would be done in both sides of the river bed. The total corridor (study area) is about 150,700 ha of which about 28.7% is net cultivable area (NCA). Settlements with industries and water bodies constitute about 6.5% and water bodies 64.7% respectively of the total area of the project. Detailed land use of the area is presented in Table-5.57.

Table 5-57: Present land use of the study area

Land Use	Area (ha)	Percent of total area
Total Area	150,700	-
Net Cultivable Area (NCA)	43,288	28.7
Settlements, Industries, Roads, bushes, trees	9,868	6.5
Rivers, Khals, channels, ponds, and Water bodies	97,544	64.7
Total	150,700	100.0

Sources: GIS estimation, Google map and Field survey'2015

Char land

There are two types of Char is found in the study area. The char land is included with the River areas which are about 19,180 ha. Detailed of land use of char land area is presented in Table 5.58.

Table 5-58: Present land use of Char land

Land use	Area (ha)	Percent of total area
Char land	19,180	-
(i) Old accredited land	14960.4	78
(ii) Newly accredited land	4219.6	22
Total	19,180.0	100

Sources: GIS estimation, Google map and Field survey'2015.

5.3.6 Agriculture Resources

Farming practices

Farming practices in the study area are largely controlled by physical, biological, climatological and socio-economic factors. Agricultural crops are grown by cropping seasons. There are two distinct cropping seasons in a year, Kharif and Rabi seasons. The Kharif season starts from March and ends in October while the Rabi season starts from November and ends in February. Based on crop adaptability and crop culture, the Kharif season has been further sub-divided into Kharif-1 (March-June) and Kharif-II (July-October) season.

Kharif-I is characterized by high temperature, low humidity, high evaporation, high solar radiation and uncertainty of rainfall of low alternating dry and wet spells. In this season, mainly HYVAus, B.Aus rice, Jute are grown. The Kharif-II season is characterized by high rainfalls, lower temperatures, high humidity, low solar radiation and high floods that recede

towards the end of the season. Rice (Aman) is the predominant crop grown during this season due to the submergence of soils. Excessive soil moisture also restricts other crops suitable for a high temperature regime. B.Aman and High Yielding Varieties of Transplanted Aman (HYV Aman) rice are grown in Kharif-II season in the study area.

The Rabi season starts from mid November and ends in March. During this season, crops are favored with high solar radiation, low humidity and temperatures, but lacks of adequate soil moisture depresses the crop yield because of very low or even no rainfall throughout the season. Wide ranges of crops can be grown in this season. Major crops grown in this season of the study area are HYV (Boro), Pulses, Wheat, Mustard, Potato and Vegetables. However, there are occasional overlaps such that Kharif-II season crops (Aman rice) are harvested in Rabi season and Rabi season crop (Boro, Wheat, Oilseeds, Groundnut, Watermelon, Potato and vegetables) are harvested in Kharif-I season and Jute is harvested in Kharif-II season. In the study area, the practice of B Aus and Watermelon, Chili and Pulses are common especially in Char land.

Cropping Pattern (existing) and Cropping Intensity

Mainland

Both country sides (Main land), cropping pattern is defined as the sequence of crops grown in Kharif-I, Kharif-II and Rabi crops in a plot of land in any one year. In the study area, different cropping pattern in different location based on land type, soil fertility, soil texture and monsoon period are practiced. The existing major cropping patterns practiced in different land types in the study area are presented in Table-5.59. The dominant cropping patterns in high land type of annual crops are Betel nut/leaf. In the medium highland, prominent cropping patterns are Fallow-HYV Aman-HYV Boro. In medium lowland, the dominant cropping patterns are Fallow-HYV Aman-HYV Boro. HYV Boro and Local Boro are grown as single crop in low land and very low land respectively (Table 5.59).

Total cropped area is about 95,233.6 ha. The single, double and triple cropped area are about 3,679.5 ha (8.5%), 52,811.4 ha (61.5%) and 38,959.2 ha (29.5%) respectively and about 0.5% cultivable land remain fallow due to flood and water logging. The net cultivable area is 43,288 ha. The cropping intensity of the project is about 220 % (Table 5.59).

Table 5-59 : Existing major cropping pattern by land type (Main land)

Land type	Kharif-I (March-June)	Khartif-II (July-Oct)	Rabi (Nov-Feb)	Area (Ha)	% of NCA
F₀	Betel nut/leaf	Betel nut/leaf	Betel nut/leaf	432.9	1
Sub-total				432.9	1
F₁	Fallow	Aman(HYV)	Pulse	2,597.3	6
	Fallow	Aman(HYV)	Mustard-Boro(HYV)	1,298.6	3
	Vegetables	Aman(HYV)	Boro(HYV)	432.9	1
	Fallow	Aman(HYV)	Boro(HYV)	12,986.4	30
	Jute	Aman(HYV)	Potato	1,082.2	2.5
	Aus(HYV)	Fallow	Watermelon	865.8	2
	Aus(HYV)	Aman(HYV)	Wheat	1,731.5	4

Land type	Kharif-I (March-June)	Khartif-II (July-Oct)	Rabi (Nov-Feb)	Area (Ha)	% of NCA
	Aus(HYV)	Aman(HYV)	Groundnut	3,030.2	7
	Fallow	Aman(HYV)	Vegetables	1,515.1	3.5
Sub-total				25,539.9	59
F₂	Fallow	Aman(HYV)	Boro(HYV)	7,359.0	17
	Jute	B.Aman	Soyabean	1,731.5	4
	B.Aus	Aman(HYV)	Pulse	3,463.0	8
Sub-total				12,553.5	29
F₃	B.Aus	Fallow	Boro(HYV)	1,298.6	3
	Fallow	Fallow	Boro(HYV)	2,597.3	6
Sub-total				3,895.9	9
F₄	Fallow	Fallow	Boro (local)	649.3	1.5
	Fallow	Fallow	Fallow	216.4	0.5
Sub-total				865.8	2
Total				43,288	100
Cropping Intensity (%)				220	

Source: Field survey'2015 and secondary data from Upazila Agricultural Offices of the study area.

Cropping Pattern (existing) and Cropping Intensity

Char land

In char land, cropping pattern is defined as the sequence of crops grown in Kharif-I, Kharif-II and Rabi crops in a plot of land in any one year. In char land area, different cropping pattern in different location. The dominant cropping patterns in char lands are B.Aus-Fallow-Watermelon.

Total cropped area in char land is about 19,180 ha. The single, double and triple cropped area are about 956.0 (5%) ha 8,631.0 (45%) ha and 3,836 (20%) ha respectively. The net cultivable area is 19,180 ha. The cropping intensity of the char area is about 155 % (Table 5.60).

Table 5-60: Existing cropping Patterns in Char area

Kharif-I(March-June)	Khartif-II(July-Oct)	Rabi(Nov-Feb)	Area (Ha)	% of NCA
Aus (HYV)	HYV Aman	Chili	3,836	20
B.Aus	Fallow	Watermelon	5,178.6	27
Fallow	Aman (Local)	Maize	3,452.4	18
Fallow	Fallow	HYV(Boro)	959	5
Fallow	Fallow	Fallow	5,754	30
Total			19,180	100
Cropping Intensity (%)			155	

Source: IWM field survey, 2015 and secondary data from Upazila Agricultural Offices of the study area.

Cropped Area

Mainland

Total cropped area is 95,233.6 ha of which 74,238.94ha is under rice crop and non-rice crop is about 20,994.7 ha. About 78% and 22% cropped area are covered with rice and non-rice crop respectively. Among the rice crops, Aus, Aman and Boro are covered about 14%, 50% and 35.9% respectively. About 90.4% of the area is occupied by high yielding varieties and about 9.6% area is covered by local varieties of rice crop. The non-rice crops include Jute, Pulses, wheat, Potato, Mustard, Soybean, watermelon, groundnut, betel leaf/nut and Vegetables etc.

Char land

Total cropped area is 29,729 ha of which 17,262 ha is under rice crop and non-rice crop is about 12,467 ha. About 58.1 % cropped area is covered with rice crop. Among the rice crops, Aus, Aman and Aman are covered about 52.2 %, 42.2 % and 5.6% respectively. About 41.9% of the area is occupied by non- rice crop. The non-rice crops include chili, maize, water melon, etc.

Crop production

The total crop production has calculated on the basis of damage-free area and damaged area. In the damage-free area, the normal yield of crops has considered. In the damaged area, damaged yield against the damaged area has considered. This may be expressed as:

Total crop production = damage free area × normal yield + damaged area × damaged yield.
There is no main agriculture crop considering production in the study area.

- a) Main Land:** The total annual crop production is about 281,685.6 metric tons of which rice production is about 158,650.5 metric tons and non-rice production is about 123,035.1 metric tons. Among the rice crops, (HYV Boro, local Boro, B. Aman, HYV Aman, B. Aus and HYV Aus) are contributing about 56.3%, and non-rice 43.7% of the total production.

Crop Damage

Main land

Crop production loss has been calculated using the formula:

Crop production loss = Total cropped area × normal yield - (damaged area × damaged yield + damage-free area × normal yield).

Total loss of cleaned rice production is about 27,682.7 metric tons in 19,458 ha of land and total non-rice production loss is about 532.5 metric tons in 541.1 ha of land

6 SOCIOECONOMIC BASELINE

This section provides an overview of demographic trends, sources of livelihood, land use, agriculture, fisheries, public health, communications, social infrastructure, gender issues, cultural resources, demand for dredged material, and other relevant issues. The study route has been divided in terms of the river route and launch terminals, proposed 06 storm vessel shelters and 03 ferry crossing routes. The river routes include Dhaka and surrounding to Bhairab Bazaar, Chandpur, Barisal and to Chittagong. Dhaka and Chittagong are the major urban centers for business development, urbanization, export-import and industrialization of the country. Shadarghat, Bhairab, Ashuganj and Chandpur are the most important and busiest business and river transport routes of the country. The baseline information indicates that regions nearer to the main land enjoy better privilege in terms of education and medical services, employment opportunity and other advantages. On the other hand, some Char and Islands in the coastal area along the proposed river routes are still facing lack of basic civic amenities i.e. education, health services, electricity, road communication, gas connection, etc. This is an obstacle to industrialization of these regions. This section will scrutinize baseline information of project area more elaborately. The Table 6-1 below presents the total sample population (2,793) from the study area with average HH size (4.77) and sex ratio.

Table 6-1: Sample population, HH information and sex ratio;

HH	Population						Ave. HH size	Sex ratio
	Male		Female		Total			
No.	No.	%	No.	%	No.	%		
585	1529	54.74	1264	45.26	2793	100	4.77	121:100

Source: EIA study, September-October 2015;

6.1 Overview of the project

The Dhaka-Chittagong inland waterway has been used as a vital river way for many decades. At present, the people of this area are fundamentally using this river route for their necessity. But the present condition is very pitiable of this overall route. That is the genesis of this project for improvement of navigation and river route simultaneously. And time has come to modify it to keep pace with the many other transportations of our country. The interior issue is how to develop the river way and it is one of the claims of all walks of people of this region. If the proposed river way project is implemented, the people can get a positive touch to adjust their lives and livelihoods in pace with this developing world. Now-a-days a large number of people is traveling throughout the country by river way.

Not only human being but also a massive numbers of raw materials and other goods are transported from one place to another. For example, Ashuganj, Mozu Chaudhuri Ghat plays a major role in transporting structure materials and receiving international merchandise. People are using boats (without engine), launches, trawlers, steamers, ships, etc., to maintain the daily necessities. There are many types of vessels in terms of size. River transport related workers basically the people of this area, launch captain, local BIWTA officials and people of the passenger terminals warmly received the project. They also advised the project to include

river traffic system by inclusive development of signaling across the river routes to reduce hazards across the routes, reduce accidents, save time and improve security across river routes. Some ghats contain the commercial importance in the perspective of transforming goods and raw materials. Here carries the most important ghats are Shadarghat, Chaudhuri Ghat, Munshiganj Sadar launch ghat, Chandpur Sadar launch ghat, etc. After implementation the proposition of the business will run in a very smooth way. And mass people will enjoy a safe journey throughout the river way and total length of way will decrease after proper dredging and completion of the project.

On the other hand, some people especially those who are students and office staff of government and non-government sectors and tourists; they are entertaining by travelling through river. They seem that travelling through river route is comparatively safe, cheap and way of proper refreshment and amusement. And people are coming to take the real taste of travelling through the river way. The people basically riverside people can easily use almost cent percent of the river related transports in some specific area of proposed river way. People who are very enthusiastic to travel one place to another can get a proper river related transport services through the proposed routes. At present Boro Station Mul Head (Dakatia Mohana) is a tourist spot and it would be more attractive spot after modifying the transport system. It is hoped that a large number of people will satisfy their recreational demand to visit the spot.

River side population along the project routes face river erosion, flood or other natural disasters that damage their lives, assets, domestic animals, vegetables, residences, business structure etc. For this reason, they face a lot of financial losses more or less every year through all over the proposed river area. Some fishermen suspected that it is an oversize construction especially in the proposed vessel shelters and they will not get sufficient fishes after finishing the project intervention. Because, reverberation hampers the flow of all type of fishes and it would be affecting these people in the long run. Nevertheless, all of the survey and consultation participants opined that when improvement of the proposed river route is done, more or less people of this locale will be benefitted with many facilities. For example they can easily travel, will reduce the time of travelling and will get many opportunities in technological advancement. As a result, 100% of the population is looking forward to the project as a key to their socio-economic development.

6.2 Demography

Demography is the scientific study of the number of population, especially with reference of their size, structure, sex distribution, population density, literacy rate, etc. The core point is the 10 Districts basically the people of specific 17 Upazilas (Sub-district), through which the project will pass through. Here the number of population is given along with some major related topics which are very relevant to demography.

Dhaka, the capital of Bangladesh is the largest city in Bangladesh and highest densely populated which has experienced an extremely rapid population growth after the independence, from only 1.6 million in 1974 to about 15.4 million in 2011. Dhaka grew strongly between 2001 and 2011 and is by far the most densely populated urban area in the

world. Dhaka's density is estimated at 115,000 per square mile or 44,000 per square kilometer, with slum (informal dwelling) densities reported as 4,210 per acre, or 2.7 million per square mile (1 million per square kilometer). At this density, all of the world's 3.7 billion urban residents could be accommodated in an area approximately equal to that of the Washington (DC-MD-VA) urban area. All of Dhaka's urban population of 15.4 million fits into a land area equal to that of the city (municipality) of Portland (population less than 600,000). Nonetheless, analysts have referred to this example of the ultimate of urban density to be "sprawling".

Although only the southern part; near the launch terminals will be included as project sites and area of influence, as no discrete information were found from secondary sources for the southern part, the demographic information demonstrates information on the whole metropolitan.

Again, the number of population of Keraniganj Upazila is 794,360 and it is the highest in the perspective of Upazilas in study area. On the other hand, Monpura Upazila of Bhola District carries the lowest number of population that is 17,080. Population density is the highest and lowest respectively in Dhaka (30551) and Monpura (205). The average household size is plus or minus 4.72 except Dhaka Metropolitan. The largest household size is 8.42 in Dhaka Metropolitan. Again, Tozumuddin and Keraniganj Upazilas carry the 4.42 house hold size. These two Upazilas are the lowest number of house hold size in the total study area. It indicates that Dhaka city being the capital; people from all parts of the country migrate to Dhaka in search of employment, education and all other facilities. The city is growing at a rate of 6% every year. On the contrary Monpura and other char Upazilas offer less opportunity and people migrate out of these places to area with better opportunity. The project might play a role in decentralizing some facilities to some remote river surrounded areas with better communication and transport opportunity.

The percentage of male is the highest and lowest in respectively Keranigong (113) and Sandwip (86) in Chittagong. Among the ten districts, literacy is top in Dhaka (74.6) and Barisal Sadar Upazila that is 69.3% and the bottom Upazila is Monpura under Bhola District that is 32.1%.

The social study team has identified and surveyed for baseline information in 26 adjacent sites throughout the proposed river route and the consultation team has conducted 24 community level stakeholder consultation meetings. The team has not come across any small ethnic community to be noted as indigenous population. Therefore, the World Bank policy OP 4.10 will not be triggered in this project. Nevertheless, further studies will be carried out prior and during implementation of the project. Table 6-2 underneath demonstrates some key demographic information and literacy rates across impact Upazilas based on secondary sources (BBS, GOB Web portal, etc).

Table 6-2: Demographic information and literacy rates across proposed route

Literacy rate	Population density	Sex ratio	HH size	Population	Upazila	District
42.7%	2141	97	5.01	298309	Bhairab	Kishoreganj
40.5%	1713	94	4.82	535796	Roytura	Narsingdi
51.2%	2673	96	5.37	180000	Ashuganj	B. baria
74.6%	30551	125	8.42	8906039	Metropolitan	Dhaka
58.5%	4760	113	4.42	794360	Keraniganj	
56.1%	1509	95	4.69	465919	Chadpur Sadar	Chandpur
48.1%	817	96	4.43	109575	Haimchar	
56.7%	1624	87	4.6	210050	Matlab South	
54.4%	1122	93	4.6	292053	Matlab North	
51.9%	1425	91	4.71	684000	Laksmipur Sadar	Laksmipur
34.2%	300	98	4.98	453000	Hatiya	Noakhali
45.2%	1042	99	4.85	430520	Bhola Sadar	Bhola
41.6%	532	98	4.86	168537	Doulatkha	
42.9%	247	105	4.42	126940	Tojumuddin	
32.1%	205	102	4.48	17080	Monpura	
51.5%	365	86	4.9	278605	Sandwip	Chittagong
69.3%	1625	97	4.49	198739	Barisal Sadar	Barisal

(Source: Bangladesh Government Web Portal)

The Table 6.3 represents age-sex distribution of the sample population. It indicates that majority of the respondents are in the age group of 5-24. The number of population below the age of 04 and more than 60 years of age is very low compared to the other age groups. Percentage of female population is 45.26%.

Table 6-3: Age-sex distribution of sample population;

Age Group	Male	%	Female	%	Total	%
Up to 4	113	4.05	96	3.44	209	7.48
5 to 14	322	11.53	293	10.49	615	22.02
15 to 24	319	11.42	236	8.45	555	19.87
25 to 34	247	8.84	175	6.27	422	15.11
35 to 44	162	5.80	183	6.55	345	12.35
45 to 59	218	7.81	183	6.55	401	14.36
60 & above	148	5.30	98	3.51	246	8.81
Total	1529	54.74	1264	45.26	2793	100.00

Source: EIA study September-October 2015;

Marital status of the sample population has been furnished in Table 6-4 below. It indicates that married population is more than the unmarried population. The percentage of unmarried men is higher than unmarried women. The number of widows is high compared to the abandoned or divorced population.

Table 6-4: Marital status of sample population;

Marital Status	Male	%	Female		Total	%
Married	715	25.60	722	25.85	1437	51.45
Unmarried	803	28.75	499	17.87	1302	46.62
Widow/widower	8	0.29	35	1.25	43	1.54
Abandoned	3	0.11	7	0.25	10	0.36
Divorced	0	0.00	1	0.04	1	0.04
Total	1529	54.74	1264	45.26	2793	100.00

Source: EIA study September-October 2015;

Table 6-5: Religious distribution of the population;

Table 6-5 describes religious distribution of the sample population. Large majority of the population are followers of Muslim religion. A few Hindu participants were found among the respondents. But no small ethnic community was identified during the study.

Religion	%
Islam	97.61
Hinduism	2.39
Total	100

Education level of the sample population is lower than that of the advanced area of Bangladesh. Only 0.45% of the sampled population found post graduate whereas 1.49% of the people obtained graduation degree. More than 25% of the people read up to class four. Among the total population male are more educated than female as there is religious and social obstacles in free movement of the female students. Yet, dropout rate is high especially in case of female students. The Table 6-6 below shows a decreasing tendency of the female students compared to male.

Table 6-6: Education level of population;

Education level	Male	Female	Total
	%	%	%
Up to Class 4	12.92	12.88	25.81
Primary School Certificates (PCS)	7.80	6.85	14.66
Six to Seven	5.41	5.12	10.53
Junior School Certificate (JSC)	4.75	3.67	8.42
Nine to Ten	3.88	2.73	6.61
Secondary School Certificate (SSC)	3.14	1.73	4.87
Higher Secondary School Certificate (HSC)	2.52	1.03	3.55
Bachelor of Arts (BA)	1.11	0.37	1.49
Masters of Arts (MA)	0.33	0.12	0.45
Higher Education/Advanced Degree/PhD	0.17	0.04	0.21

Education level	Male	Female	Total
	%	%	%
Hafez-E Quran	0.41	0.00	0.41
Can sign only	6.40	5.37	11.77
Illiterate	6.32	4.91	11.23
Total	55.16	44.84	100.00

Source: EIA study September-October 2015;

6.3 Livelihood Sources in various locations

Livelihood means a supporting of one's existence, especially in terms of financial support. It encompasses people's capability, assets, income, etc. Most of the people near river side depend on their sources of livelihood by river correlated activities. In most cases businessmen, ferry ghat users, passengers, vessel operators will get benefit from the developed ferry terminals/launch ghats. The people living in the surrounded areas of the ferry ghat and launch terminals are also dependent on the ghats for their daily livelihoods. Livelihood sources of the various categories of people in various Ghats/terminals are described below-

Sadarghat (in Dhaka): It provides livelihood support to about 300-400 boatmen, who are depending on river related transports. There are also a large number of laborers in this ghat those who are working hard heartedly. Here the major sources of livelihood are carrying people and goods by boat, day laboring, selling of vegetables and other raw materials, selling clothes, rickshaw or van pulling, whole and retail selling of fruits, begging, etc. Most of the laborers are male and a few are female particularly small traders, vegetable sellers and beggars. More or less all types of daily necessities are available in this populous and busy ghat. There is a huge number of hotel and/ or restaurant in this ghat area. People are leading their livelihoods from various sources in this ghat.

Aganagar ghat: On the opposite side of Shadarghat, the Aganagar ghat is located where there is a little mark of terminals or ghat. People of this area usually cross the river by boat and they carry local handicrafts to a greater extent. The people of Zinzira (where small-scale industries are concentrated) are using this ghat for crossing the Buriganga River to go to Dhaka city. Again, the ghat of Keraniganj (Aganagar) has developed employment opportunities for various categories of people including male and female.

Munshiganj Sadar launch ghat: A large number of people are engaged in Munshiganj Sadar launch ghat as small and medium businessmen, mobile vendors, day labourers, etc. Again fruits and vegetables sellers and other business men are leading their livelihood at Munshiganj Sadar launch ghat. There has been a possibility to generate more livelihoods for particular labour groups and floating labourers.

Bhairab Bazaar Launch Ghat: There is a big market at Bhairab Bazaar launch ghat where there are about 700 business units/shops in the nearby area of this ghat. A huge number of people (more or less 10,000) cross the river through this ghat for their daily livelihood including business, job, day laboring, etc.

Ashuganj Ghat: The Ashuganj ghat is now playing a major role as international transit route and cargo terminl for transporting materials from India and other various districts of Bangladesh especially Sylhet regions. There are thousands of large, medium and small scale business enterprises at or near Ashuganj ghat. Boatmen, water vessel workers, small traders, sand businessmen, daily wage laborers, etc. are earning livelihoods from the ghat areas,

Harina ferry ghat: At Harina ferry ghat, approximately 500 fishermen are leading their lives by catching fishes from the river traditionally. Apart from this, small traders, vendors, wage laborers are also leading their livelihood from the Harina ferry ghat area.

Chairman ghat: At Chairman ghat (Boyar char) and sounding area there are about 15,000-20,000 fishermen who are directly or indirectly dependent on the launch ghat at Chairman Ghat. The most interesting and important issue is that the highest numbers of fishermen earning livelihoods from the river at or near the Chairman Ghat all along the proposed river routes.

Chandpur Sadar launch ghat: A large market is established at Chandpur Sadar launch ghat area with some businesses units of vegetables, fishes, fruits and other necessary goods. There are more or less 1,000 shops are located here. These goods especially vegetables are mostly brought by boat from adjacent Chars.

Mozu Choudhuri ghat: Mozu Choudhuri Ghat itself has 500-600 shops focusing on the inbounds and transport facilities of the ghat. Therefore, developing the terminals by extending its capacity and efficiency will directly enhance local economy in each case. There are 600-700 shops according to field survey result of the social survey team at Harina. But it needs to extend more shops to facilitate the local large population. So a number of people can clear up their occupation as shopkeeper and other related business.

Dakatia Mohana at Chandpur Sadar is a recognised tourist spot at present and has a glorious future for the local people, labourers, entrepreneurs and the small traders for livelihood. The river-based Chandpur provides livelihood to a large number of peoples as fishermen, fish sellers, vegetables vendors etc. The people who are living in the bank of river all over the route are collecting fishes as the sources of livelihood. Some boatmen are running their occupation as ‘majhi’.

The beneath table shows that 16.31%of total population of Dhaka, Munshigong, Gagaria and Chandpur launch route are business men, 5.70% are catching fishes, 8.21% are working as day labour, 1.14% operating boat (boatman). The major issue is that about 8.67% people are more or less unemployed. It is mentionable that there are also all types of common professions are available here. And like to the vessel shelters locations, here women are mostly housewives (33.87%).

The table represents findings on proposed vessel shelter spots indicating that 13.22% people are leading their livelihood by business, 1.99% by rickshaw or van puller, 7.25% by catching fishes (fisherman), of them 0.54% are female in six proposed vessel shelters. The most interesting issue is that almost all of the sampled female population (33.15%) are housewife in nearby location of the proposed storm vessels shelters except 0.18% teacher and 0.54% fishermen.

Table 6-7 refers that 19.23% of the sampled population are businessmen, 7.07% are rickshaw or van pullers, 1.11% are boatmen, 7.22% are fishermen and many other common occupational groups in and around ferry ghats. There are also 34.07% women are housewife which is very similar to the vessel shelters and launch route. It is mentionable that 8.89% of people are unemployed in the spots.

Table 6-7: Primary Occupation across proposed project route;

Occupation	Rivet Route & launch terminals			06 vessel shelters			Ferry Crossing Route		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Agriculture	1.03	0.11	1.14	4.53	0.00	4.53	3.70	0.00	3.70
Teacher	0.11	0.23	0.34	0.18	0.18	0.36	0.37	0.00	0.37
Overseas jobs	0.68	0.00	0.68	0.54	0.00	0.54	0.74	0.00	0.74
Service	3.08	0.23	3.31	2.54	0.00	2.54	2.59	0.19	2.78
Housewife	0.00	33.87	33.87	0.00	33.15	33.15	0.00	34.07	34.07
Fisherman	5.70	0.00	5.70	6.70	0.54	7.25	7.22	0.00	7.22
Business	15.51	0.80	16.31	11.78	0.00	11.78	19.26	0.00	19.26
Day Labor	7.98	0.23	8.21	3.44	0.00	3.44	2.04	0.37	2.41
Driver	1.60	0.00	1.60	2.17	0.00	2.17	0.56	0.00	0.56
Mason	0.23	0.00	0.23	0.18	0.00	0.18	0.37	0.00	0.37
Carpenter	0.23	0.00	0.23	0.72	0.00	0.72	0.19	0.00	0.19
Unemployed	6.27	2.39	8.67	5.80	1.81	7.61	7.41	1.48	8.89
Tailor	0.11	0.00	0.11	0.18	0.00	0.18			
Doctor	0.11	0.00	0.11	-	-	-			
Herbalists	0.00	0.11	0.11	-	-	-			
Boatman	1.14	0.00	1.14	2.17	0.00	2.17	1.11	0.00	1.11
Student	7.30	3.42	10.72	7.79	5.43	13.22	7.96	2.78	10.74
Rickshaw/ Van Puller	1.25	0.11	1.37	1.81	0.18	1.99	3.52	3.52	7.04
Aged People	2.05	2.96	5.02	3.08	4.71	7.79			
Servant	0.34	0.23	0.57	-	-	-			
Shoemaker	0.11	0.00	0.11	-	-	-			
Mechanic	0.23	0.00	0.23	-	-	-	0.19	0.00	0.19
Launch Master	0.23	0.00	0.23	-	-	-			
Barber	-	-	-	0.36	0.00	0.36	0.37	0.00	0.37
Total	55.30	44.70	100.0	53.99	46.01	100.0	57.59	42.41	100.00

(Source: EIA study, September-October 2015)

The income and expenditure are very closely related to well being of the population. If the expenditure is more than one's income, he or she will fall in the trap of poverty. Here, it is noticeable that the income should be in a standard figure to match the way of life. Table 6-8 beneath demonstrates that the yearly expenditure is more than the income of this locale people in specially six proposed vessel shelters. So it would be a common phenomenon that

the poverty level will be high if the interrelated other query are firm. It is due to dependency of the people on the agriculture in most cases and fishing. There are no other alternative major sources of income as reported. Therefore, people living along the river cannot come out of the poverty circle. According to BBS, lower poverty line is considered to be BDT 60,000 per year. The study represents that the incidence of poverty is higher among river route compared to the vessel shelter and ferry route locations.

Table 6-8: Yearly Income and expenditure level of households through the route;

River route and Launch Ghats				
Income and expenditure Ranges (Yearly)	Yearly Income		Yearly expenditure	
	No.	%	No.	%
Up to 60,000	16	5.95	18	6.69
60,001 – 90000	30	11.15	38	14.13
90001-120,000	59	21.93	71	26.39
Above 120,000	164	60.97	142	52.79
Total	269	100.00	269	100.00
Vessel Shelters				
Income and expenditure Ranges (Yearly)	Yearly Income		Yearly expenditure	
	No.	%	No.	%
Up to 60,000	4	2.42	6	3.64
60,001 – 90000	22	13.33	29	17.58
90001-120,000	39	23.64	51	30.91
Above 120,000	100	60.61	79	47.88
Total	165	100.00	165	100.00
Ferry crossing				
Income and expenditure Ranges (Yearly)	Yearly Income		Yearly expenditure	
	No.	%	No.	%
Up to 60,000	3	1.99	6	3.97
60,001 – 90000	12	7.95	22	14.57
90001-120,000	45	29.80	50	33.11
Above 120,000	91	60.26	73	48.34
Total	151	100.00	151	100.00

(Source: EIA study, September-October 2015)

6.4 Land use

Dhaka to Chittagong river route used the land of government from the very beginning of its origin. As a result, ghats, terminals, jetties etc. are all established on government land mostly BIWTA or DC *khush* land. The proposed 06 vessel shelters are also planned to be constructed mostly on public land to avoid private land acquisition, displacement, etc. and any other negative impacts on the community/ population at or near project sites. Yet, extension of launch and ferry terminals may imply some land acquisition. The project will consider all possible options to avoid, minimize and mitigate resettlement impacts. For the situation, where impact on land, structure, trees or any other properties irrespective of title to the land is unavoidable, a resettlement action plan will be prepared following the World Bank operation

policy (OP) 4.12 and GoB land acquisition (LA) law which has been described in the resettlement policy matrix of the RPF of the project.

Land use pattern adjacent to the river route has two different scenarios for rural and urban sites. Terminals are established in urban or semi urban areas that have developed the Ghat areas as commercial centers of the region with shops and markets. These terminals generate sources of livelihoods for thousands of HHs. On the contrary, the terminals in rural regions with minimal transportation facilities are mostly surrounded by fellow land, cultivable land, ponds, ditches and canals. For example, Daulatkhan (Bhola), Sandwip, Tojumuddin, Laharhat have fewer shops and commercial entities compared to other terminals. Almost 65% of the private lands around the Ferry Ghats and Launch Ghats are found to be used for agricultural production.

Land ownership pattern has been identified during field level survey. Table 6-9 indicates that majority of the participants use their land for mostly commercial purpose. Other than land owners, majority of the participants are using GoB land for business and other purposes.

Table 6-9: Land ownership pattern;

Land ownership pattern	River route	06 vesselshelters	Ferry crossing
	%	%	%
Owner of land	70.26	80.61	94.70
Structure Owner with land	0.00	1.21	0.00
Sharecroppers	0.74	0.61	0.66
Lessee	7.06	1.82	1.99
Non-Titled (Squatters)	21.93	15.76	2.65
Total	100	100.00	100.00

(Source: EIA study, September-October 2015)

6.5 Fisheries

The population of Bangladesh depends on wild fish for food and the generation of income. A large portion rural family are engaged in part time fish capture from the rivers and beels. Until 70s, there was an abundance of fish in the natural waters of the country to well-satisfy the demand. In recent years, however, capture fish production has declined to about 50%, with a negative trend of 1.24 % per year (Ahmed, 1995). In spite of these in 2013-14, Bangladesh has produced 3,548,115 MT fish of which 83.22% and 16.78% comes from inland and marine fisheries respectively (FRSS, 2015).

Fishermen comprise a major portion of the inhabitants by the riverside in this project area. They catch fish all the year round. Although they have some modes of established system of their product transportation, this project will add a new dimension in the fish trade as it will develop the navigation as well as port management through vessel shelter construction. However, agriculture (excessive removal of surface water and abstraction of groundwater for irrigation), pollution (domestic and industrial), and unregulated discharge of untreated industrial and farm effluents, habitat destruction also have significant impact, as does the regular over flooding and lack of flooding rain in the last few decades (Hossain, 2014).

The present study has identified an ethnic community named *Bede* in Dakatia River (a tributary of Meghna River in Chandpur). They are living here for round 100-150 years following their ancestors. Their daily income is about 300-500 BDT. Their main occupations are fish capture and selling. No proper sanitation system has been developed for them. Their children get no schooling facility. They drink river water by mixing with Alum. There is several floating cage-fish culture in the Dakatia River. Though it is under culture practice, some people are still making money out of it. Tilapia and carp species are mainly cultured in this system.

In Horinaghat, fishermen stated that, they usually eat the small fishes (Bacha, Dain, etc.) of the net and sell the big fishes (Hilsa, Pangus, etc.). Another important living source among the fishing communities is the net sewing. A consultation meeting with local residents of Choumohuni, Barisal revealed that, if vessel shelter is made here, a lot of people will earn money for their livelihood and will contribute in this area's economic status. Most of the fishermen near this area are in debt from different loan providers (ASA, Grameen Bank, BRAC, Podokkhep, etc). This same situation was observed in Daulatkhan, Bhola where some families were recorded to leave their home and fishing boat to escape from the loan provider's reminder. This has become a common phenomenon in the fishermen's village. 'Katha' fishery (pile fishing - a special type of fishing, practiced in Bangladesh to aggregate fish in a certain place of open water) is also a temporary subsistence option for some people around the area. This practice was quite common in Dakatia river, Koroitola Khal (a tributary of Kirtonkhola river, Barisal), Shitalakhya river (less common than the previous two). One of the main problems was lack of capital for buying fishing gears and crafts. Most of the fishermen are Muslim in religion but Hindu fishermen are another significant group. Fishermen are engaged in fish catching in the Meghna River throughout the year. January, February, March, April are almost dry season. At that time water level usually is low and riverine environment is not suitable for the growth of fish. So, during this period fish were not available (Mia *et al.*, 2015). Fishermen basically change their income source to labor-based works at their locality. Almost all fishermen community is disadvantaged in social capital such as the networks, groups, trust, access to institutions, etc. Social organizations to support fishermen are scanty in the surveyed areas. Lack of social capital has affected socio-economic condition of poor people in fishing communities (Mia *et al.*, 2015).

The government of Bangladesh has adopted a programme to protect *jatka* in 2003-04 to ensure sustainable *Hilsa* production. By this programme, *jatka* catch, sell, carry and transport have been prohibited during 1st November to 31st May (7 months). It is not unlikely that *jatka* fishers earn their livelihood by selling *jatka* and they do not have any alternate source of income. That's why the government has given special importance this year for alternate sources of income for *jatka* fishermen so that they can earn their livelihoods by some other means during the 'no catch period' of *jatka*. For the rehabilitation of *jatka* fishers there was a programme named '*Jatka* Protection and *Jatka* Fishers Rehabilitation Progame'. A total of Tk.2.00 crores/year has been allocated for rehabilitation of *jatka* fishermen during the years 2008-2010. Beside this programme a project named "*Jatka* Conservation, Alternate Income Generation for the *Jatka* Fishers and Research Project" has been implemented within *jatka* available and sanctuary surrounding upazilas for giving alternate income generation activities

during the ban period. As this rehabilitation programme was implemented and it helped their livelihood, this made it comparatively easy to keep the fishermen away from catching *jatka*. This project covers 21 upazilas of 4 districts. Through this project the Government has allocated Tk. 10,000 for each *jatka* fisher to maintain their family during the *jatka* catch ban period since the project started.

The Government initiated to help the fishers affected by *Hilsa* ban which includes rice provision through VGF (vulnerable group feeding) per household for four months during the ban period in order to mitigate the sufferings of the fishermen. This programme has started since 2004-05. Programme has covered 85 upazilas of 15 districts for each year (Ahsan *et al.*, 2014).

According to Mondal *et al.* (2013) in Lakshmipur (Ramgati upazilla) of Lower Meghna a total of 82% of fishermen are professional and 18% are seasonal where 25,500 fishermen in this area are dependent on the riverine fish for their livelihood and protein supply. The study also states that, two types of fish marketing channel exist in the study area. In first type (84%) involving fishermen to directly consumers and 2nd type (16%) involving three intermediaries (*aratdar*, wholesaler and retailer). During the peak season, the monthly incomes of fishermen were adequate and the range was BDT 5,000 to 30,000. But during the lean period their income reduces to even zero. 80% fishermen are fishing with boats (consider as one unit) and the rest without boats. This underprivileged group of people of our society is the provider of our national protein demand.

6.6 Public Health

According to investigation, partial places of the project influenced area are rural areas whilst some are towns. Sanitary conditions in towns are good. Residents drink tap water and live in good houses. Sanitation and epidemic prevention achieve good effects. People are in good health status. However, sanitary conditions in rural area are much poorer than that in towns. Collective water supply is realized only in some towns. Most rural residents drink water in the well. Due to limitation of sanitary conditions and impact of living habits, drinking water quality is hard to be ensured.

The main water related diseases in the project influence area include dysentery, hepatitis, typhoid, paratyphoid fever and arsenicosis etc.

Dysentery- Dysentery is featured with bacillary dysentery. The patients and carriers are sources of infection. Disease germ is excreted to the outside of the body with the feces of the patients. Hand touch and mouth infection through drinking water lead to occurrence of disease. The peak is in summer and winter. It often occurs in areas with poor sanitary conditions.

Hepatitis- Hepatitis has many types. Hepatitis B is infected through blood and daily contact while hepatitis A is infected through mouth. Hepatitis A easily causes outbreak. (Outbreak means that three persons are infected in a unit). Such disease seldom occurs in evaluation area.

Typhoid fever and paratyphoid- Healthy carriers, drinking water and food that are polluted by soil of the patients are infection resources of typhoid fever and paratyphoid. The diseases

occur when people drink and eat the polluted water and food. Typhoid fever often occurs in the project area. This disease can be controlled through vaccination. Paratyphoid, similar to typhoid fever, is not so serious.

Arsenicosis- Arsenicosis is caused by exposure over a period of time to arsenic in drinking water. Arsenic contamination in water may also be due to industrial processes such as those involved in mining, metal refining, and timber treatment. Drinking arsenic-rich water over a long period results in various health effects including skin problems (such as color changes on the skin, and hard patches on the palms and soles of the feet), skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure and reproductive disorders.

Survey on 269 respondents in the project influence area revealed that 74.35 percent is sought treatment from the drug store attendants who are trained healers and 8.55 percent received treatment from private clinic while 7.43 percent took it from government hospital for the normal disease (Table 6.10). On the other hand, in case of critical disease, most of them received treatment from government hospital and upazila health complex which are 76.95 percent and 18.22 percent respectively (Table 6-11).

Table 6-10: Health seeking behavior in case of normal diseases

Health Service providing institutions	No. of People Reported	Percent (%) of People Reported
Government Hospital	20	7.43
Upazila Health Complex	15	5.58
Private clinic	23	8.55
Rural Dispensary	200	74.35
Family welfare centre	5	1.86
Community Clinic	6	2.23
Total	269	100.00

Table 6-11: Health seeking behavior in case of critical diseases

Name of Health Service providing institutions	No. of People Reported	Percent (%) of People Reported
Government Hospital	207	76.95
Upazila Health Complex	49	18.22
Private clinic	8	2.97
Rural Dispensary	3	1.12
Family welfare centre	2	0.74
Community Clinic	0	0.00
Total	269	100.00

6.7 Communications

Currently the communication practice of BIWTA is to circulate information through websites and stakeholder's consultation at field level. BIWTA also publishes all necessary documents in print media. The main stakeholders of BIWTA are dredging community, traders, owners of ships and cargos and port authorities.

The purpose of this project is to effectively operate Dhaka-Chittagong Inland Water Transport Corridor by establishing water structures and dredging the river channels to popularise water transportation in the country with a view to cut pressure on road and rail communications.

It is recognised that to achieve this outcome, a broad range of potential audience groups are required to be targeted, each with differing communication activities and approaches. However to be effective each target audience needs to have a different communication strategy and approach. The priority audience groups have been identified for communication activities are shown in Table 6-12.

Table 6-12: The priority audience groups for communication activities

Stakeholders/Audiences	
INTERNAL	EXTERNAL
The Ministry of Shipping - BIWTA - Bangladesh Inland Water Transport Corporation (BIWTC)	Aid Agencies and Donors - World Bank
Project staff - Dhaka office - Local staff	Local Government - Upazila Parishad - Union Parishad
Government agencies - Bangladesh Water Development Board (BWDB) - Department of Agricultural Extension (DAE) - Department of Fisheries (DoF) - Department of Environment (DoE) - Land Ministry - Ministry of Commerce - Ministry of Industries - Department of Fisheries - Department of Hydrology - Chittagong Port Authority (CPA) - Mongla Port Authority (MPA) - Land Port Authority	Local communities - Women - Community leaders - Fishermen - Farmers - School teachers - Opinion leaders - Community-based organisations
	NGOs/Research Organisations - Bangladesh Center for Advance Studies (BCAS) - Bangladesh Environmental Lawyers Association (BELA) - BRAC - Center for Sustainable Development (CSD) - Center for Natural Resource Studies (CNRS) - Coastal Area Resource Development and Management Association (CARDMA) - Centre for Advanced Research in Natural Resources & Management (CARINAM)

Stakeholders/Audiences	
INTERNAL	EXTERNAL
	- Centre for Coastal Environmental Conservation (CCEC) - Center for Environmental and Geographic Information System (CEGIS) - Development of Biotechnology and Environmental Conservation Centre - Environment and Social Development Organisation (ESDO) - Wild Team - Forum of Environmental Journalists of Bangladesh (FEJB)
	Media - Print media (newspapers) - Broadcast Media (Television and Radio) - Online
	Development practitioners - Institute of Governance Studies (IGS) - BRAC University
	Private sector - Bangladesh Cargo Vessel Owners' Association - Bangladesh Launch Owners' Association - Bangladesh Inland Waterways Passenger Carrier Association - Dhaka Chamber of Commerce and Industry (DCC) - Federation of Bangladesh Chambers of Commerce and Industries (FBCCI)

6.8 Social Infrastructure

The project routes will navigate through 17 Upazilas of 10 districts in Bangladesh. Upazila wise existing health care facilities, educational centers have been collected from secondary sources. On the other hand, location wise distances of nearest health and educational facilities have been tabulated from survey findings. **Table 6.13** underneath indicate that on an average that the communities have the benefits of having rural dispensary, community clinics and welfare centers, yet, health complex hospitals have been mostly identified further from their convenience. This distribution has developed into a trend of depending on local unauthorized medication from local pharmacies or dependency on herbal or other medication (Kabiraji, homeopathy, etc).

Table 6-13: Distance of Health Service providing institutions

Name of Health Service providing institutions	Launch Ghat					Vessel Shelter					Ferry Ghat				
	Within 1 km	1 to 3 km	3 to 5 km	5 km+	Total	Within 1 km	1 to 3 km	3 to 5 km	5 km+	Total	Within 1 km	1 to 3 km	3 to 5 km	5 km+	Total
Government Hospital	34.9	8.7	5.6	50.8	100	15.3	7.6	0.6	76.4	100	2.1	5.7	5.0	87.1	100
Upazila Health Complex	49.1	16.2	6.0	28.6	100	14.8	9.7	15.5	60.0	100	4.4	16.1	16.8	62.8	100
Private clinic	67.1	12.3	4.1	16.4	100	41.4	21.4	17.9	19.3	100	43.3	23.6	13.4	19.7	100
Rural Dispensary (RD)	95.2	4.4	0.4	0.0	100	95.7	3.1	1.2	0.0	100	97.3	2.0	0.7	0.0	100
Family welfare centre (FWC)	77.4	18.3	1.0	3.4	100	69.9	23.5	2.2	4.4	100	65.9	22.8	10.6	0.8	100
Community Clinic	81.3	17.2	1.0	0.5	100	73.5	22.0	3.0	1.5	100	55.3	39.8	4.1	0.8	100
Others	80.0	20.0	0.0	0.0	100	66.7	33.3	0.0	0.0	100	0.0	100.0	0.0	0.0	100

(Source: EIA study, September-October 2015)

The numbers of educational institutes have been listed in the project impact Upazilas that are demonstrated in **Table 6.14**. Unfortunately no authentic list for total number of educational institutions was found in Dhaka Metropolitan city. Yet, being the capital and the most developed cities of the country, Dhaka metropolitan has uncountable number of public and private educational institutions including universities. On the other hand, the list indicates that the area has a number of primary educational institutes, with fewer colleges and not many institutions for higher education.

Table 6-14: Educational institutes

Upazilas	Total No. primary schools	Total No. High schools	Total No. colleges	Total No. Universities	Others (Madrasas)
Bhairab	93	19	6	-	8
Royapura/Raipura	147	30	3	-	8
Ashuganj	48	13	6	-	13
Dhaka Metropolitan	Not listed				
Keraniganj	158	76	12	-	9
Chadpur Sadar	210	50	7	-	49
Haimchar	77	11	1	-	10
Matlab South	136	30	4	-	17
Matlab North	168	37	7	-	10
Laksmipur Sadar	265	68	12	-	54
Hatiya	255	40	5	-	16
Bhola Sadar	198	65	13		177
Doulatkha	109	21	3	-	21
Tojumuddin	118	18	1	-	12
Monpura	38	7	2	-	7
Sandwip	149	32	5		19
Barishal Sadar	178	50	10	1	29

Source: Bangladesh Government Web Portal⁴

The EIA study findings also indicate that there are quite large numbers of primary schools and other basic educational institutes at convenient locations but a few numbers of higher study institutions. It is found that primary schools are located within 1 km whereas most of the universities and colleges are beyond 5 km from their place of residence. It is reported that the inhabitants are getting more facilities when they are travelling more distance in terms of all educational institutions particularly for higher studies. Proposed navigation infrastructures distance from educational institutions is described in Table 6.15.

⁴ Cited: 21.10.2015

Table 6-15: Distance of Educational Institutions;

Nam of educational and service providing institutions	Launch Ghat					Vessel Shelter					Ferry Ghat				
	Within 1 km	1 to 3 km	3 to 5 km	5 km+	Total	Within 1 km	to 3 km	to 5 km	5 km+	Total	Within 1 km	to 3 km	to 5 km	km+	Total
University	21.3	3.8	5.4	69.5	100	4.0	5.3	4.6	86.1	100	0.0	2.2	3.6	94.2	100
College	42.4	16.9	15.3	25.5	100	11.7	19.6	29.4	39.3	100	3.6	12.2	33.8	50.4	100
Secondary School	69.1	23.3	5.2	2.4	100	54.9	33.3	11.7	0.0	100	39.3	40.7	11.0	9.0	100
Primary School	94.6	5.4	0.0	0.0	100	95.1	4.3	0.6	0.0	100	90.8	8.6	0.0	0.7	100
Non-formal primary school	83.3	10.1	3.6	3.0	100	91.7	8.3	0.0	0.0	100	77.9	16.3	2.3	3.5	100
Moktob (Basic Islamic school)	89.5	9.2	1.3	0.0	100	93.4	6.6	0.0	0.0	100	88.1	11.2	0.7	0.0	100
Others	66.7	0.0	0.0	33.3	100	100.0	0.0	0.0	0.0	100	75.0	0.0	25.0	0.0	100

Source: EIA study September-October 2015;

Safe drinking water is very necessary for all. Tube well water is highly used in study area. The highest number of sources of potable water in three components of the project is reported as tube well; such as in launch ghat (66.15%), vessel shelters (66.46) and ferry ghats (74.83%). On the other hand, 8.54% of people in vessel shelters are using river water for drinking after purification as they have limited access to the road communication and other civic amenities in most cases whereas 0.77% and 1.99% of the sampled population of launch ghat and ferry ghats are using river water for drinking. Although they are drinking river

water after purification but still it is unhygienic and dangerous to health. List of source of water for drinking purpose is mentioned in Table 6-16.

Table 6-16: Source of Water for drinking purpose;

Source of Water for drinking purpose in %	Dhaka, Munshigong, Gagaria, Chandpur Launch Ghat %	Vessel Shelter's Area %	Ferry Ghat %
Hand tube well	66.15	66.46	74.83
Deep Tube well	21.54	21.95	21.85
Pond	0.00	1.22	0.66
River	0.77	8.54	1.99
Supply water	8.08	1.83	0.66
Rain Water	3.46	0.00	0.00
Total	100	100.00	100.00

Source: EIA study September-October 2015;

Water is being used for daily activities mostly for bathing, dish washing, and other household purposes. The highest numbers of households use river water (32.42%) throughout the proposed route and 57.42% in proposed vessel shelters. On the other hand, 74.83% (the highest) people use tube well water in ferry crossing routes for domestic use. All along the river routes it is common phenomenon that people are mostly dependent on the river. Although it is also reported that due government and non-government initiatives people are using tube well water for their daily activities. Source of Water for household purpose is mentioned in Table 6-17.

Table 6-17: Source of Water for household purpose;

Source of Water for household purpose in	Dhaka, Munshigong, Gagaria, Chandpur Launch Ghat (%)	Vessel Shelter's Area%	Ferry Ghat%
Hand tube well	25.57	14.84	74.83
Deep Tube well	6.39	1.94	21.85
Pond	26.48	25.16	0.66
River	32.42	57.42	1.99
Supply water	3.20	0.65	0.66
Rain Water	5.94	0.00	0.00
Total	100.00	100.00	100.00

Source: EIA study September-October 2015;

The people of the river route area use 72.12% sanitary toilet, 12.64% use non-sanitary toilet, katcha toilet is 11.15% and open defecation is 4.09%. According to the national statistics only 3% of the people are still habituated in open defecation but in the river bank this number is a bit higher than national average. On the other hand at the Storm Vessels Shelters, 67.27% of the sampled population used sanitary toilet. Non-sanitary, Katcha and open space are used respectively 20%, 9.09% and 3.64%. Again, 67.55% people of ferry crossing route is used

sanitary toilet. Non-sanitary and katcha toilet are used by 21.19% and 9.27% respectively. Here only 1.99% people use open space in terms of toilet. But overall toilet facilities in the launch and especially ferries are inadequate considering the passenger load. It is to be mentioned that the facilities need cleanliness support to maintain a hygienic condition. Types of required toilet facility are mentioned in Table 6-18.

Table 6-18: Type of Toilet;

Type	Dhaka-Munshiganj-Gajaria-Chandpur-river route (%)	Six Vessel Shelters (%)	Ferry crossing route (%)
Sanitary	72.12	67.27	67.55
Non-Sanitary	12.64	20.00	21.19
Katcha	11.15	9.09	9.27
Open Space	4.09	3.64	1.99
Total	100	100.00	100.00

Source: EIA study September-October 2015;

The electricity facility of river route area is very underprivileged in the project districts. The shops, business and some other entities have managed other sources like solar panels, unauthorized electric connections, etc. Access to electricity has been illustrated below by Figure 6-1.

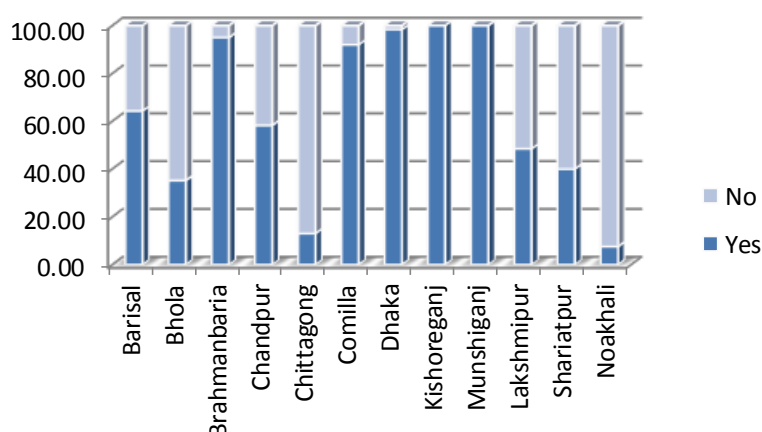


Figure 6-1: Access to electricity;

The figure represents a significant factor regarding access to electricity through the project area. It indicates that, the areas, where the project sites have been chosen from islands, access to national grid electricity is limited. On the contrary, access is better in the main land. The islands and char areas mostly rely on generators or solar panels.

The overall infrastructure of the river side area seems inadequate considering demand and activity in the surrounding. It is certain that there are immense opportunities and demand for improvement in the area.

6.9 Demand for dredged Materials

Bangladesh is a 'delta', formed by river sediments and being mostly plain land, a huge amount of sediments is delivered by the rivers that are brought by course of their travel. These sediments play a major role in cultivation and fertility of our land, but increasing

amount of sediments cause barrier to navigation system through the rivers. Dredging is a key focus of this project to improve river navigation and therefore, dredging is very important for river related transport all over the route. In terms of previous knowledge of the respondents, they have experienced waste of previous dredging kept on the river bank or river side chars/cropping field. And finally it took place in the river during rainy season or caused river erosion in preceding places and also causes lack of fertility of land. Therefore, the first choices to the dredge materials have been to take them away from river. As means of keeping the spoil from the river bank, the first choice has been to sale the spoil sediments to willing buyers. In some sites near to polders, the participants advised to use the dredge spoils for maintenance and increasing heights of polders. Some suggested increasing heights of yard of community properties like school Eidgah, etc. During field study, the respondents near Dhaka, especially Shadarghat and Jinjira opined that the river bed is fully contaminated therefore dredged material near shadarghat in Buriganga river is not usable. They are not interested to buy the dredged materials at this location. On the other hand, dredged material from Ashuganj, Bhairab, Homna, Raipura and further downstream are very much welcomed by the sand traders. The local sand traders are willing to buy dredged materials. Apart from this, local people have also demand for the dredged materials for their community use such as filling up yard of the community properties (School, Madrasah, and College) and rural roads, dyke, embankment.

6.10 Gender Issues

Gender related issues across river side population through project route will be an influential focus in Social Impact Assessment for ensuring socio-economic safeguard of the attached population. Similar to many other regions of this lower middle income country, the effort of women in socio-economic development and well being of their family and surrounding is rather invisible. The sample population in this assessment study has been chosen mostly from river terminals and bordering shops and business centers, where majority are male employers or workers. On the other hand, common passengers and other female stakeholders encountered during study have been impulsive and defiant to participate in the study, which has been a major challenge to overall learning in this project. However, the current river transport systems do not have any specific facility dedicated for women. There are no separate ticket counters, waiting rooms or rest rooms for women. This has made the female passengers more dependent on road transportation. The female respondents also complained about sanitation facilities in the terminals and in water transports and expected the project to mitigate these problems. Among the total HH population of the survey, 45% were female and the survey findings have been deliberated based on their circumstances. The study findings indicate that the project sites offer minimal opportunities to women for economically active participation. In addition to that, the study also reveals that decision making role of women in the HH is negligible with only 1.03% households being headed by women.

On the contrary, better communication and transport facility may convey additional facilities and introduce more choices for their pursuit. Figure 6-2 demonstrates such opportunities according to the survey respondents. Majority of the participants believed that the project will bring more employment opportunities to women in addition to education, which will play a role in gender balance and enhance better role in business for women. Other than that, some respondents also highlighted that with better transport and communication facility, women will be able to receive better medical facility and overall situation for women will be developed.

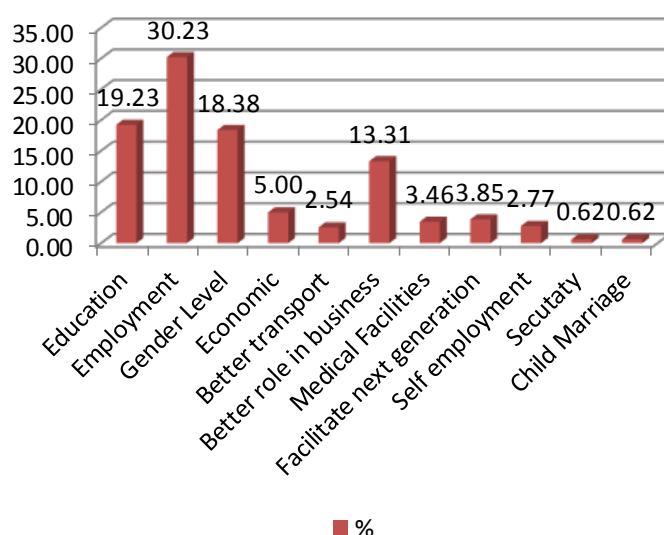


Figure 6-2: Project role in women empowerment;

The baseline information in the study area indicates that the project site lacks higher education as well as proper health service facilities. Special focus should be paid on sanitation facilities across river route. The constraint added to the women correspondents is that due to lack of transport facility, attaining service from distant sites is more inconvenient. In addition to that, Table 6-19 represents recreational preferences of various age and gender groups. It indicates that men and boys are enjoying the most of the facilities compared to women, girls and children. Again, women's movement is mostly induced by household work (by the river) and socialization (ceremonies in community centers).

Table 6-19: Recreation to different age and sex groups;

Recreational preference	Men	Women	Boys	Girls	Child
By the river	8.80	3.45	10.38	6.71	2.97
Common ground	5.00	1.55	9.71	3.77	5.58
Community centre	6.35	5.03	0.45	1.97	0.23
Club	8.03	0.26	1.81	0.29	0.10
Local Tea Stall	16.09	0.10	1.06	0.19	0.13
Total	44.28	10.38	23.41	12.93	9.00

Source: EIA study September-October 2015;

The major limitations through project locations for women empowerment is employment opportunities to women. The business, transportation and all other opportunities are compact with male appearances. In addition to that, convenient transport facility to education facility is also a major requirement to gender balance. Some advancement in women empowerment and decision making has been noticed during EIA study. It is presented in Figure 6-3.

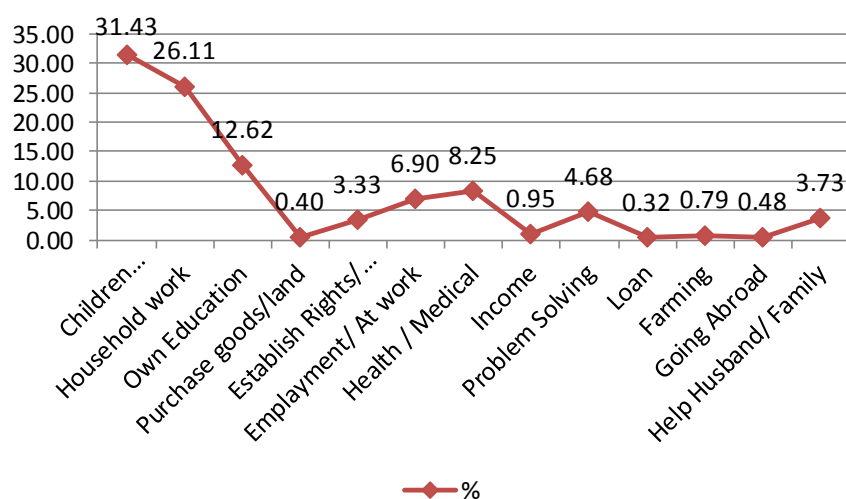


Figure 6-3: Women's' role in decision making;

The findings indicate that women enjoy the liberty of decision making about their children's study and well being, household work and their own facilities like education, medication, work, etc. to some extent. But they have limited hold on expenditure, income, loan, moving abroad, etc external issues.

Majority of the project sites are considered remote in terms to transport and other service facilities. It can be expected that improvement of the river navigation routes and promoting transport facilities can improve overall gender balance and promote women empowerment to some extent.

6.11 Cultural Resources

Culture is one of the most important central concepts in any socio-economical issue. Basically it refers to the way of life. More than anything else, culture is that complex whole which includes knowledge, belief, arts, moral, laws and any other capabilities as a member of society. Natural sites, archaeological resources, cultural resources and historical sites carry an importance of a place.

A historical place also plays a major role to the proper development of a city. Dhaka is highly enriched to the historical places. All the districts (Chandpur, Bhola, Munshiganj, Lakshmipur, Noakhali and others) have a number of historical places. List of cultural resources/archeological places along the routes is given in Table 6-20.

Table 6-20: List of cultural resources/archeological places along the routes

Upazilas	Archaeological, cultural and historical spots
Bhairab	Syed Nazrul Islam bridge
Royapura/raipura	Panthaosala
Ashuganj	Ashugong fertilizer company limited, Bank of Meghna river
Metropolitan	No information
Keraniganj	Bashundhara Park, Dhaleswari river
Chandpur Sadar	Chowdhury Bari
Haimchar	Bank of Meghna river (old college)
Matlab South	Boalia Jamider Bari, Dhonagoda river
Matlab North	Satnal tourist spot
Laksmipur Sadar	Dalan Bazaar Jamidar Bari, Charmanasha hawa park
Hatiya	Nijhum Dwip (island) is one of the most important tourist spots of the country. Sun rise and sun set can be viewed from the vast extended sea beaches located on the southern and western extremities of the island. Kazir Bazaar, Surjomukhi are also another tourist spots
Bhola Sadar	Birsasto Mostafa Kamal Museum
Doulatkhan	Bangla Bazaar Hatam Khanom Complex Mosque
Tojumuddin	Char Mozemmal and Char Johiruddin
Monpura	Monpura landing station, Chowdhury project
Sandwip	Solar energy project, Shabus Char
Barisal Sadar	Korapur Mia Bari Mosque, Barisal river port, Banghabondhu Uddan

Source: GoB web portal

7 CLIMATE CHANGE AND ADAPTATION

7.1 IWT and Climate Change

Situated in the lower end of the three great rivers, the Brahmaputra, the Ganges and the Meghna, Bangladesh is one massive alluvial flood plain criss-crossed by a network of several rivers, their numerous tributaries and canals. Inland water transport (IWT) is a very important mode for maintaining transport link between the various remote parts of the country and at the same time a means for transporting export-import cargo as well. Bangladesh is recognized as one of the most vulnerable countries to climate change impacts in the world. It has a history of extreme climatic events claiming millions of lives and destroying past development interventions (DoE, 2007). The exposures to different risks get aggravated because of varying high population density, and concentration of economic activities in different parts of Bangladesh (Ahmed, 2006; DoE, 2007). Drought, flooding, cyclonic storm surge are frequent water borne disaster in Bangladesh, which will be worse under climate change effect. Numerous studies have been performed to characterize the effects of climate change. A combination of sea level rise, changes in monsoon rainfall and more extreme events will have large scale impacts on the country. Climate change is likely to increase flood and drought risks, increase monsoon river flows and increase salt water intrusion, intensification cyclonic storm surges. As a result climate change will have large impacts on water management and water related sectors such as inland navigation. Global warming with higher associated rainfall and relative sea level rise will also likely cause significant changes in sediment and erosion regimes. Consequently, rivers may be disturbed requiring long periods of adjustment in fluvial processes and morphological forms. Being subjected to upstream condition which is beyond control, changes in hydrological and climatic parameters would make the rivers of Bangladesh more vulnerable as well as unpredictable. The main issues of climate change that may affect River navigation i.e. sedimentation and erosion in the river are (a) changes in flood regime due to changes in precipitation pattern (b) changes in sediment load due to changes in precipitation and river flow (c) changes in water level due to sea level rise. Climate change is now a fact. It is also now widely accepted that human activities are playing a role in the increase of greenhouse gas emissions that have accelerated global warming during the last century, although the significance of the human contribution is still a matter of debate. IPCC has introduced several global climate change scenarios, from which projections are made, based on that projection impacts and responses can be identified. IPCC introduced new AR5 scenarios.

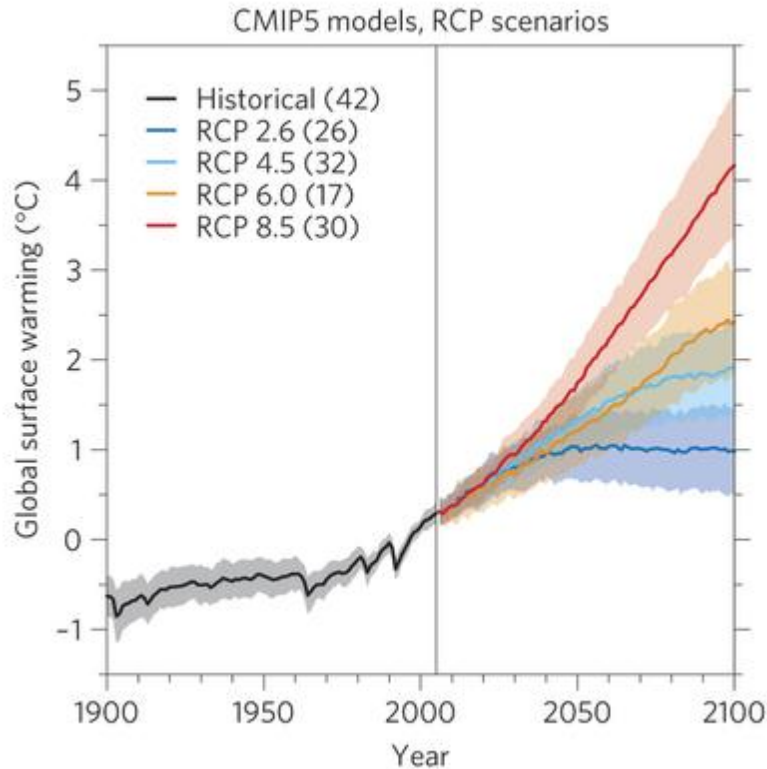


Figure 7-1: IPCC climate change scenarios and projection of global temperature change

AR5 scenarios are categorized according to the carbon emission which is briefly described the following Table 7.1.

Table 7-1: Main characteristics of each RCP

Scenario Component	RCP2.6	RCP4.5	RCP6	RCP8.5
Greenhouse Gas	Very low	Medium-low mitigation	Medium baseline	High baseline
Emissions		Very low baseline	high mitigation	
Agricultural area	Medium for cropland	Very low for both cropland and pasture	Medium for cropland but very low for pasture (total low)	Medium for both cropland and pasture
Air pollution	Medium-Low	Medium	Medium	Medium-high

The recent climate change information in Bangladesh has been discussed based on information available in published sources and some updated knowledge has been generated based on the analysis of long-term historical data of some important climatic parameters.

The country average of minimum, maximum and mean temperature for the period 1948-2011 has been subjected to least square time regression analysis to estimate the trends for country

average temperature. During the winter and pre-monsoon seasons the minimum temperature has increased more than the maximum temperature. The changes in winter temperature are significant while the trend for maximum temperature is not significant. However, for the monsoon and post-monsoon season the maximum temperature has increased more than for the minimum temperature. Increasing trends in minimum, mean and maximum temperature are evident in the following Figure 7.2 & Figure 7.3.

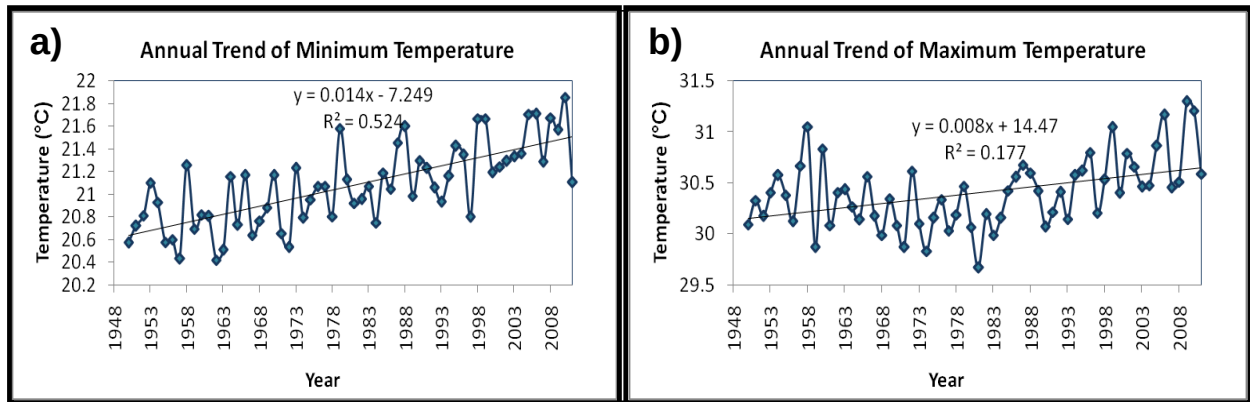


Figure 7-2: The time series plots of annual minimum (a) and maximum (b) temperature (Source BDP2100)

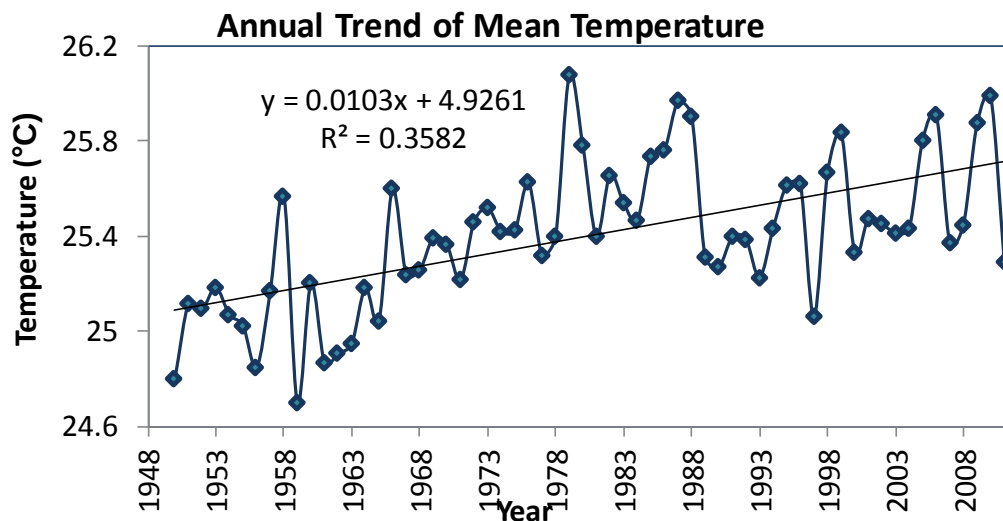


Figure 7-3: The time series plot of annual mean temperature (1948-2011). The thin straight line is the least square best fit line showing the trend of mean temperature (Source: BDP2100: Climate Change Baseline Study)

Trend analysis has been carried out based on the annual maximum, average and minimum of available water level data for selected tidal water level stations (Hironpoint at Pussur River, Khepupara in the Tentulia River and Rangadia in the Meghna estuary) by IWM to find the change in relative sea level rise.

Hiron Point

The available data at Hiron Point is from 1977 to 2013. The trend equation of yearly maximum water level at Hiron Point has been obtained $y = 0.0078x - 12.916$. The slope of this equation indicates the change of water level per year. Positive slope indicates the increasing trend and vice versa. The slope of trend equation of annual maximum water level at Hiron Point is 0.0078 which indicates that the rate of increase of water level at the surrounding region of Hiron Point is (i.e. Koyra Upazila, Khulna division, Sundarban) 7.8 mm/year. Similarly rate of increase of annual average water level is 6.8 mm/year (Figure 7.4). But annual minimum water level does not show any significant trend.

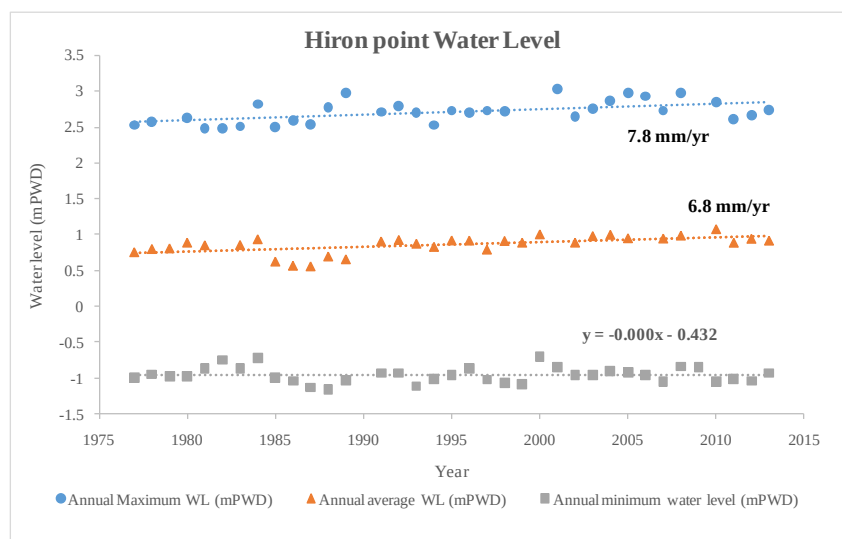


Figure 7-4: Trend analysis of annual maximum, annual minimum and annual average water level at Hiron Point

The trend analysis shows that water level has been increasing over the years, which is combination of global warming and local effects.

Khepupara

The available data at Khepupara in the Barisal area is from 1988 to 2012. The annual maximum, minimum and average water level has been calculated from this data set. The trend equation of yearly maximum water level at Khepupara has been obtained $y = 0.0081x - 13.61$, which indicates that the rate of increase of water level is 8.1 mm/yr at around Patuakhali. Similarly, the rate of increase of annual minimum water level is 0.6 mm/yr and rate of increase of annual average water level is 3.7 mm/yr as seen in Figure 7.5.

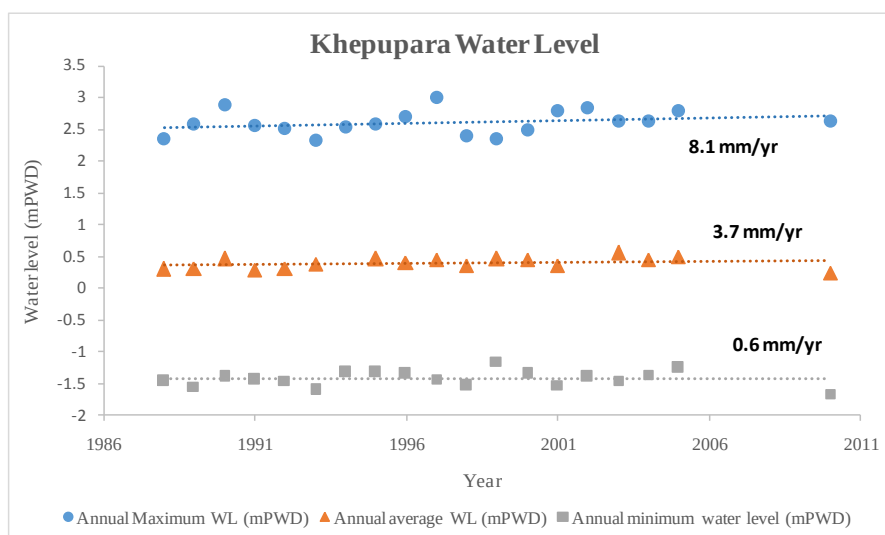


Figure 7-5: Trend analysis of annual maximum, annual minimum and annual average water level at Khepupara

Rangadia

The available water data at Rangadia (located in the Chittagong district at the outfall of the Karnaphuli Rivers) from 1993 to 2012. The annual maximum, minimum and average water level data were calculated from this data set. It is seen that the trend of annual average water level is 4 mm/yr and significant trend is not found for annual minimum water level as seen in the Figure 7.6.

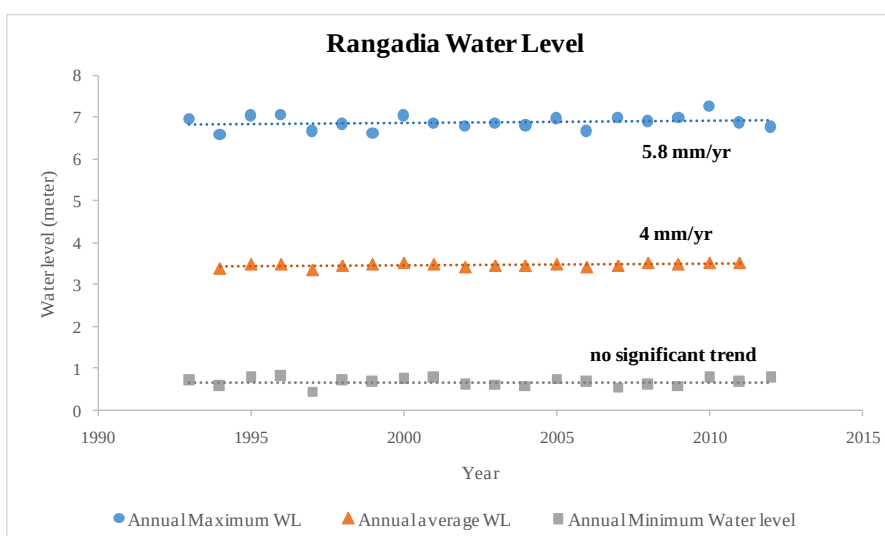


Figure 7-6: Trend analysis of annual maximum, annual minimum and annual average water level at Rangadia (Source IWM)

Assessment Report 5 (WG1AR5, TS-5,2013) of IPCC stipulates that it is certain that Global Mean Surface Temperature (GMST) has increased since the late 19th century. Each of the past three decades has been warmer than all the previous decades in the instrumental record, and the decade of the 2000's has been the warmest. The global combined land and ocean temperature data show an increase of about 0.89°C [0.69–1.08] over the period 1901–2012

and about 0.72°C [0.49- 0.89] over the period 1951–2012 when described by a linear trend. Similar to the analyses above all the last IPCC (2013) report concluded that it is very likely that mean annual temperature has increased over the past century over most of the Asia region, but there are areas of the interior and at high latitudes where the monitoring coverage is insufficient for the assessment of trends (see IPCC 2013, Chapter 2, Figure 24-2). New analyses continue to support the AR4 and SRES conclusions that it is likely that the numbers of cold days and nights have decreased and the numbers of warm days and nights have increased across most of Asia since about 1950, and heat wave frequency has increased since the middle of the 20th century in large parts of Asia (see IPCC 2013, Section 2.6.1). Rainfall variability in Bangladesh is extremely high. There is a large difference between the different regions of the country and large differences between seasons. Also the inter-annual differences are large. This large variability makes it difficult to find significant trends in historical rainfall records.

Impacts and adaptations

In addition to trends for an ongoing rise in global temperature and associated sea level rise, it is anticipated there will be an increase in the frequency of such extreme events as storm surges floods and droughts. Climate change effects are also expected to increase in the coming decades, in part because of the relative lack of success to date in implementing mitigation measures (i.e. measures designed to reduce greenhouse gas emissions), and in part due to the thermal inertia of the oceans, the ‘climate engine’. Climate change and sea level rise is very likely to cause the changes in the state variables or indicators of the river and estuary. The schematization of climate change influencing the use of waterways is presented in the Figure 7.7

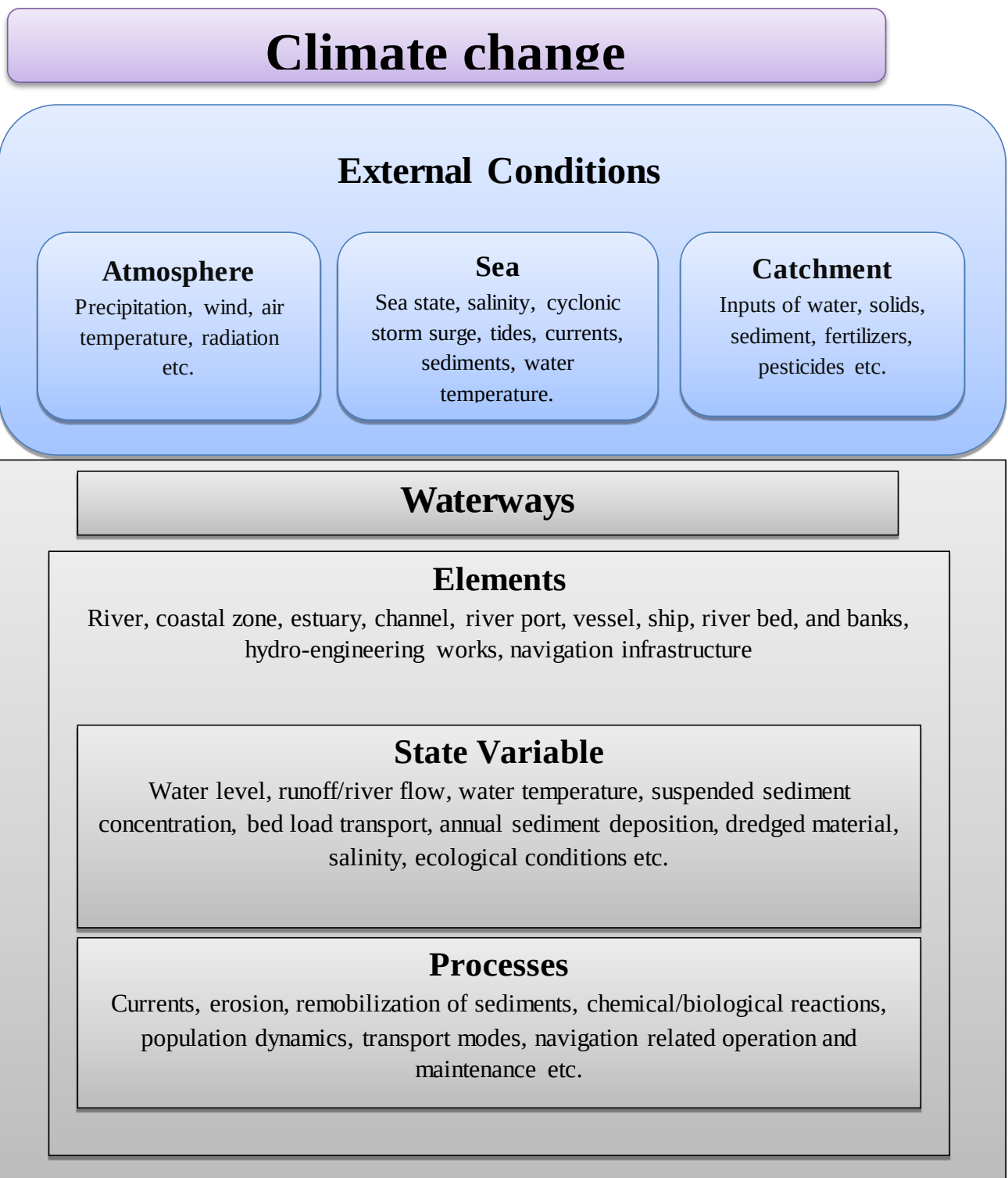


Figure 7-7: Flow chart of climate change and processes influencing the use of waterways

Projection on Climate Change

Assessment Report 5 of IPCC (IPCC, AR5, 2014) has provided the projections on temperature, precipitation, sea level rise and wind speed for the latest 4 climate change scenarios in global and regional scale. Table 7.2 presents the projection on temperature and precipitation for South Asia. The precipitation responses are first averaged for each model

over the 1986–2005 periods from the historical simulations and in the projected periods of the RCP8.5 experiments. (Source: IPCC chapter 14SM; Table 14.SM.1b)

Table 7-2: Precipitation change projections (at SOUTH ASIA) by the CMIP5 global models

Scenario	Region	Month	Year	Min	25%	50%	75%	100%
RCP 8.5	South Asia	DJF	2035	-13	-2	1	6	20
			2065	-16	-4	4	10	23
			2100	-17	-1	12	21	42
		JJA	2035	-3	1	3	5	16
			2065	-1	7	10	13	27
			2100	-9	13	17	23	57
		Annual	2035	-2	1	3	5	11
			2065	0	6	8	11	17
			2100	-7	11	18	21	45

This projection is in regional scale and is not wise to use for Bangladesh. Bangladesh Water Development Board (BWDB) is implementing the Coastal Embankment Improvement Project 1 (CEP1), a World Bank funded project, use the statistical downscaling results of GCMs for climate change scenario of RCP 8.5. Bangladesh Delta Plan 2100 (GOB, 2014) suggests that the climate change scenarios will be based on the analyses on a low (RCP4.5) and high emission scenarios (RCP8.5). Likely impacts on navigation would be insignificant under RCP4.5. However, there very likely that navigation routes will experience impacts under RCP 8.5 with higher increase of precipitation and sea level rise. The monthly projection for 2050 based on statistical downscaling results of 15 GCM is presented in the following Table 7.3. The list of GCMs is presented in Table 7.4

Table 7-3: Monthly Rainfall Projection (at 2050's) for RCP 8.5 scenario at selected coastal zone of Bangladesh (calculated from selected 15 GCM's)

West coastal zone Rainfall			Central Coastal zone Rainfall		
Month	% change	Delta factor	Month	% change	Delta factor
January	-12.39	0.88	January	-14.53	0.85
February	4.68	1.05	February	3.24	1.03
March	-5.29	0.95	March	-0.4	1.00
April	-11.85	0.88	April	-10.7	0.89
May	3.06	1.03	May	6.46	1.06
June	1.05	1.01	June	3.55	1.04
July	15.75	1.16	July	16.71	1.17
August	16.08	1.16	August	19.6	1.20
September	22.47	1.22	September	26.99	1.27
October	14.46	1.14	October	16.09	1.16
November	-6.75	0.93	November	-11.53	0.88
December	12.26	1.12	December	-16.97	0.83

Table 7-4: List of Selected 15 GCM's are provided below:

SI No.	GCM (General Circulation Model)	SI No.	GCM (General Circulation Model)
1	ips1-cm5a-lr	9	bcc-csm1-1
2	ips1-cm5a-mr	10	bnu-esm
3	miroc-esm	11	canesm2
4	miroc-esm-chem	12	ccsm4
5	miroc5	13	cesm1-bgc
6	mpi-esm-lr	14	cnrm-cm5
7	mpi-esm-mr	15	gfdl-esm2g
8	mri-cgcm3		

Source: The calculations are performed from the output of Climate Change Group of World Bank Team. Source of data can be found at <http://climatewizard.ciat.cgiar.org/wbclimateanalysisistool/>

The projection covers the Lower Meghna River, Meghna Estuary and Barisal area, which is shown in the Figure 7.8.

In accordance with the projection on precipitation the rainfall in the dry season will be decreased. It implies that the water flow/discharge is very likely to be decreased in the river during dry season causing decrease of navigation depth. The decrease of navigation depth might increase the maintenance dredging volume in the navigation routes. In the monsoon the precipitation is increases in accordance with the downscaling results of GCM. The increase of precipitation will increase the river flow during monsoon, which may lead river bank erosion in the navigation routes. In such situation the alignment of the dredging is very likely to be changed keeping adequate distance from the river bank to avoid dredging induced erosion.

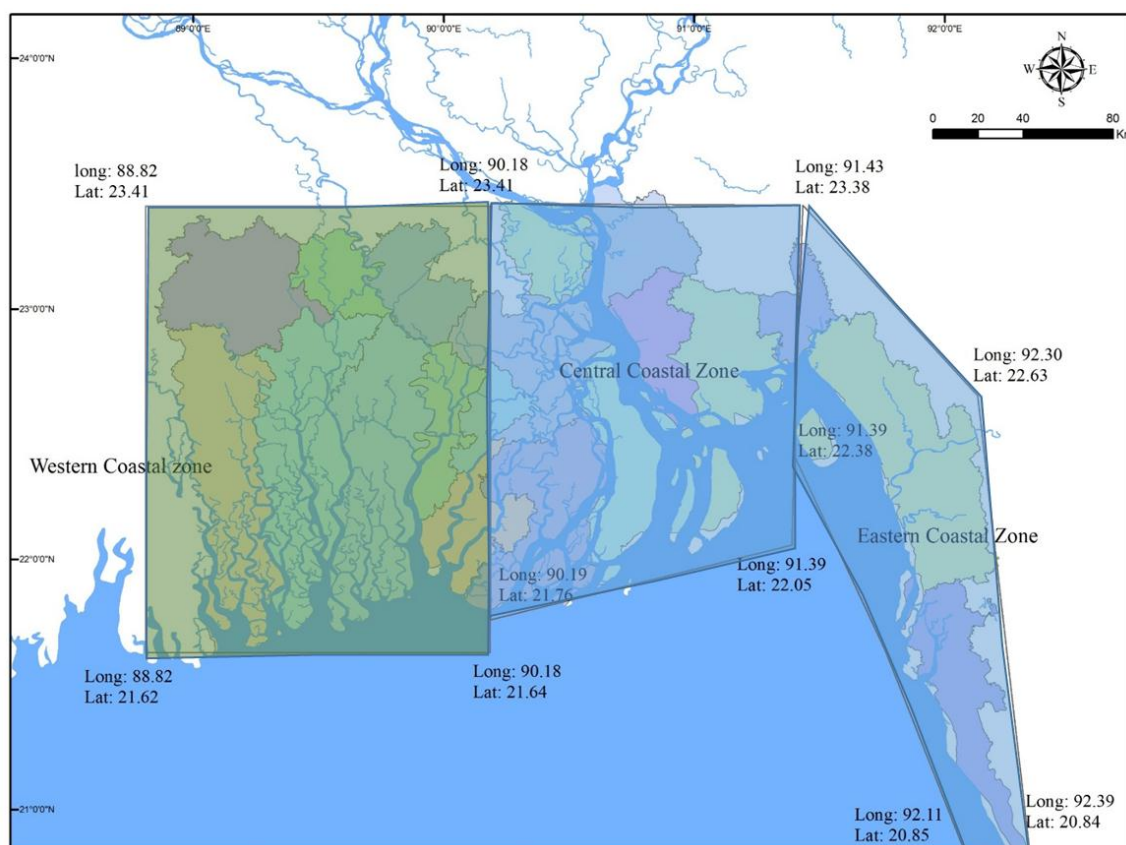


Figure 7-8: Coastal zones for downscaling results of GCMS

IUCN (2007) addressed following likely impacts on navigation in the changing climate;

- Loss of navigability due to increase in frequency and duration of dry spell (drought) may imply higher prices and losses; Increase in frequency in wet and stormy period may imply higher costs due to weather disturbances and safety;
- Gradual low flow conditions and resulting economic losses;
- Large variations and reduced water depth;
- Sharp increase in frequency of extreme costs;
- Damage from cyclone and storm surge to IWT infrastructures

Again it is worthy to mention that dredging activities for inland navigation improvement mostly will take place in rivers and Meghna estuary. The morphology of these areas is influenced by sediment supply, currents, waves, winds, water levels and tidal range. Changes in these conditions due to global warming may induce changes in erosion and sedimentation patterns, with potential consequences for both inland and in the estuary dredging requirements to maintain adequate navigation depth. Adaptation measures might be dredging of increased volumes sediment or locations, the type or number of dredging tools, or new dredging methodologies. Navigation interests could be affected through changes in the shape and depth of channels, formation of submerged shoals or a change in maintenance dredging frequency and volume. Changes in water quantity will cause changes in river discharge; especially, the probability of extreme hydrological events will increase such as floods and drought. This could cause changes in river channel erosion, sedimentation and sediment transport. The morphology reflects the supply and transport of sediments in rivers. In the

event of climate change, both sediment supply and sediment transport are subject to change. Dredging technique and dredging method should be determined in a manner that can adapt to the erratic conditions of the rivers due to climate change. Through morphological and social studies dredge materials may be discharged to raise the river banks. For sustainable navigability river training work should also be carried out as well. Despite BIWTA's aid to navigation support along the channel, change of river course has become almost unpredictable. As a result, vessels are grounded often cause huge economic loss for the vessels operators, which is likely to be increased under climate change through channel shifting and that demand close monitoring of navigability. Changes in cyclonic storm duration and/or frequency may lead to decreased regularity of river ports, increased downtime and the requirement for more storage capacity at cargo and container terminals for use in times of closure especially in the Meghna estuary not in the rivers in the non-tidal area like Buriganga, Shitalakhya Rivers. The planning and design of passenger, cargo terminals and ferry ghats needs to be carried out considering flood level and storm surge height in the changing climate. Climate change adaptation measures need to be based on a well-informed, proactive and integrated approach; adequate monitoring and follow up programmes will be important. BIWTA also needs to consider adaptation to include strategies that adapt the current systems and infrastructure to account for changing climate.

7.2 Climate Change impacts and adaptation in the D-C IWT Project

7.2.1 Climate Change Impacts

Bangladesh is a disaster prone country due to its geographical location. On the other hand, geography of the country is mostly plain land and the height of southern region of the country is very close to sea level. This makes it more vulnerable to climate change impacts. The country suffers from storms and cyclones, the intensity of which is also about to increase due to climate change issues.

The proposed river route of the Dhaka-Chittagong inland water transport corridor project travels across southern river terminals of the country. Especially Bhola, Monpura, Hatiya, Sandwip, etc. char islands will suffer the consequences of climate change more intensely. Therefore, the vessel shelters and terminals to these sensitive regions should have hazard maps and locations of nearest cyclone shelters clearly marked in visible locations near the entrance of the terminals. In addition to that, an emergency Hotline number should be included in all the terminals to ensure safety and security of the passengers. A detailed investigation is required to find likely impacts on navigation routes and adaptive measures under climate change and sea level rise.

There are very limited researches and studies on assessment of effect of climate change on inland waterways.

Potential impact on navigation:

- I. Change in river erosion and sedimentation
- II. Increase of local sea level and storm surges
- III. Decreasing flow during dry season causing reduced navigation depth
- IV. Increase of wind conditions
- V. Evolution of wave action
- VI. Evolution of tidal propagation and range
- VII. Changes in ocean coastal and estuarine morphology
- VIII. Changes in storm events
- IX. Relocation of designated environmentally protected areas
- X. Change in navigation route alignment.

7.2.2 Climate change mitigation and adaptation

A Climate Change Unit will be established in the BIWTA for mainstreaming the climate change issues in the project planning and implementation. The following mitigation and adaptation measures will be pursued during implementation of the Project.

In parallel to the project implementation, the World Bank will provide technical assistance to MoS, BIWTA and other relevant agencies to develop a strategy and action plan for “greening the waterways”, and will pilot select activities under the plan, to test approaches and generate lessons learned to enable scaling up in a future operation. This study will include a large focus on identifying mitigation measures to reduce carbon dioxide and other greenhouse gases emissions from ships, cargo handling equipment and related hinterland transport. Possible activities to be included in the action plan are:

- Preparing GHG emissions inventory (from the current operations) and setting goals to reduce emissions. Also periodic reporting.
- Exploring the introduction of cleaner fuels such as CNG (comparatively less emissions) in the vessels owned by the ministry to set a good example for others to follow.
- Developing an incentive scheme to encourage vessel owners to upgrade vessel engines, such as conversion to CNG or installation of emissions control measures.
- Educational campaigns for users of the waterways to tackle behavioral aspects of reducing emissions and other forms of pollution.
- Improving efficiency within the logistic chains by streamlining the movement of cargo, truck traffic and inland navigation access
- Reduce energy dependence within the ports by developing and using renewable energy sources

On the adaptation front, the project will foremost ensure that river terminals and landings are designed in consideration of maximum flood levels expected with climate change, as well as potential decreases in minimum flows during dry season.

In addition, in parallel to the project, the World Bank will provide technical assistance to support a detailed climate change vulnerability assessment and development of an adaptation/resilience strategy for the IWT sector as a whole. Potential adaptation measures to be explored at the sector level include:

- Climate change modeling and developing forecasts for river water levels and changing sedimentation patterns
- long term planning and design for new infrastructure in consideration of climate vulnerabilities
- Identify the vulnerabilities in the IWT sector and proactive actions
- Design of new wider vessels that could accommodate low drafts
- Planning for future upgrading / modification of additional BIWTA-owned facilities to account for future flood levels expected from climate change

8 POTENTIAL SIGNIFICANT ENVIRONMENTAL IMPACTS

8.1 Alternative Dredgers Types (Equipments/Techniques)

Potential types of dredgers and their functions

According to engineering design basically there are 3 kinds of dredgers; they are mechanical, pneumatic and hydraulic dredger. As known, though there are some mechanical dredgers are in use by BWDB, BIWTA (those are being used they are very old), being inefficient this type is not the preferred one.

Hydraulic type dredgers mainly of two types: *trailing suction hopper dredger* and *cutter suction dredger*.

Cutter Suction

Cutter suction dredger consists of a centrifugal pump and the suction tube that has cutting mechanism (rotary blade) at the end. The main technique is applied in dredging is that loosening the sand and cutting are done simultaneously, and the dredged material is sucked by the dredging pump and transported through a pipeline. Though can be used in sandy, clayey soil, due to the capacity of cutting it has preferred use in case of dredging on bedrock or very hard soil or gravel deposits. Usually, the distance of transportation pipe line by design could be 2-3 km. However, by adding booster pump to the pipeline the dredge-spoil can be transported/dumped to a further distance.

Trailing Suction Hopper Dredger

The *trailing suction hopper dredger* is practically a ship that by the use of dredging equipment can dredge desired location and discharge into the ship's container and can sail it in order for releasing the dredge elsewhere. A description of its functionality and uses are also given in **Section 3.3.2**.

In principle, its dragging technique is basically similar to a vacuum cleaner. That means sail-and-drag, sucking by creating vacuum and hence loading, then sailing to unload elsewhere. The hopper suction dredger has self-loading and unloading capacity. As an operation procedure, one or two suction pipes having trailing suction head connected to the end descend onto the river bed (desired dredging location). There are nozzles in the head that are connected to a high pressure installation that are capable of loosening the bed material (sand). With respect to limitation of its uses, since it prepare and collect dredge by loosening sediments and dragging and also steel teeth are not so big, so it is capable of working on relatively loose and soft substance.

As to the components of equipments, apart from the ship with engine, it has rearward extending one or more suction pipes, one or more dredging pumps in order to create suction (under pressure) to extract dredged sediment inside the pipe, transportation pipes in order to send dredge

into the hopper, an overflow device to get rid of the redundant water overboard, kind of degassing devices to remove any gas from the substance.

A comparative consideration

Where pumping is possible, hydraulic dredgers are much more efficient than mechanical dredgers. However, any situation that limits the uses of hydraulic dredging other types can be used. For example, due to hard rock, debris or narrow channel with a lot of passing traffic, which does not allow the floating pipeline. In such circumstances, grab dredgers can be used. Again, in such situation hopper barges would be required to convey the dredged spoil to the desired dumping sites. On the whole, choosing an appropriate dredger type is a matter of optimization between the issues - dredging project, constraints and dredging equipments. A good guidance on the suitability of types of dredging equipments depending on the soil condition can be seen in Table 8.1

Table 8-1: Suitable types of dredging equipments on the soil criteria

Type of Equipment	Soil				Site		
	Silt	Clay	Gravel	Rock	OFF SHORE	IN SHORE	
						Traffic	No Traffic
Bucket Dredger	G/R	R/G	R/G	R/G	NA/R	NA	G
Plain Suction dredger	R	NA	G	NA	R/G	NA	G
Cutter Suction Dredger	Good	G	G	R	R	NA	G
Trailing Suction Hopper Dredger	Good	R	G	NA/R	G	G	G
Grab Dredger	R/G	R	G	NA	NA	NA/R	G
Back Hoe	R	G	G	R	R	R	G
Bed Leveller	Good	NA/R	R	NA	NA	G	G

** R=restricted; NA= NO APPLICATION

[Courtesy: H van Muijen, IHC]

Feasibility under this project

In this project the dredging operation involves a number of rivers of hundreds of kilometers and they are well-wide, and most locations of dredging will be well inside the coastline. From efficiency consideration with respect to all aspects – technical, capacity, cost, the mechanical dredgers would not be feasible. Their use is diminishing day by day, when other robust and efficient devices are available. Using of hydraulic-type would be feasible due to the size of the river (long, wide), type of sediments (no bed rock, all navigation paths and routes pass through flood plains and estuaries, all are late holocene sediments, no debris etc). Therefore, cutter suction type dredger would be the feasible option from both technical and financial point of view. However, while dredging locations are the coastal area, for example downstream of Bhola, Lakshmipur hopper suction type dredger might be considered provided if costing favours in choosing such type. In no way hopper suction would be a viable option for inland rivers, since the sailing distance will surely be very long, the capacity, therefore, be low and hence the cost for each unit volume of sediment would be quite high. As known so far known from BIWTA, it

will be using for dredging inside inland rivers 18-inch cutter suction dredger. And in the estuary area either hopper suction or 26-inch cutter suction dredger will be used.

8.2 Dredge Material Placement Locations

There are several suitable locations have been selected for disposal of dredged material. These locations are given in the below Figure 10.1 and illustrated in the Table 10.1.

8.3 Environmental, Health and Safety Impacts

8.3.1 Impact of Dredging on Benthic Habitat, Dolphin, River Turtles and Important Bird Area

The impacts of dredging on biological resources can be short term or long term, direct or indirect. There can be short-term impacts from the dredging, and long-term impacts associated with habitat modification. Short-term impacts could include local changes in species abundance or community diversity during or immediately after dredging. Long-term impacts could include permanent species abundance or community diversity changes caused by changes in hydrodynamics or sediment type, or a decline or erratic trend beyond the normal range of variability in the years following new dredging.

Direct impacts would be directly attributable to the dredging activity, such as a direct loss of mudflat habitat. Dredging involves the removal of substrate and benthic organisms at the dredging site, resulting in immediate localized effects on the bottom life. Besides the decimation of organisms at the dredging site, there is the removal of the existing natural or established community with widely varying survival of organisms during dredged material excavation. Aside from the initial physically disruptive effects, a long-term environmental concern is the recovery (repopulation) of bottom areas where dredging has occurred. Dredging thus opens the area for recolonization on a new substrate that may resemble the original substrate or be completely different in physical characteristics. Recolonization of the dredging site can begin quickly, although reestablishment of a more stable benthic community may take several months or years after the dredging operation has occurred. The effects of habitat loss or alteration at the dredge site may extend beyond the boundaries of the dredging operations. However, dredging-induced habitat alterations are minor compared to the large-scale disturbance of benthic habitat.

During all dredging operations, the removal of material from the riverbed also removes the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, dredging may initially result in the complete removal of animals from the excavation site.

Where the channel or berth has been subjected to continual maintenance dredging over many years, it is unlikely that well-developed benthic communities will occur in or around the area. It is therefore unlikely that their loss as a result of regular maintenance dredging will significantly benthicaffect the aquatic ecology. However, certain aquatic species and communities are more sensitive to disturbance from dredging than others.

Dredging activity removes the existing benthic community which is important in nutrient cycling and as a source of food. The rate of recovery for the benthic community is highly variable and depends on the type of sediment, system size, the composition of nearby communities, the amount of sediment removed, and salinity. For instance, recovery is reported as faster for benthic communities in low versus high salinity habitats, and those associated with fine grained sediments versus coarse grained sediments.

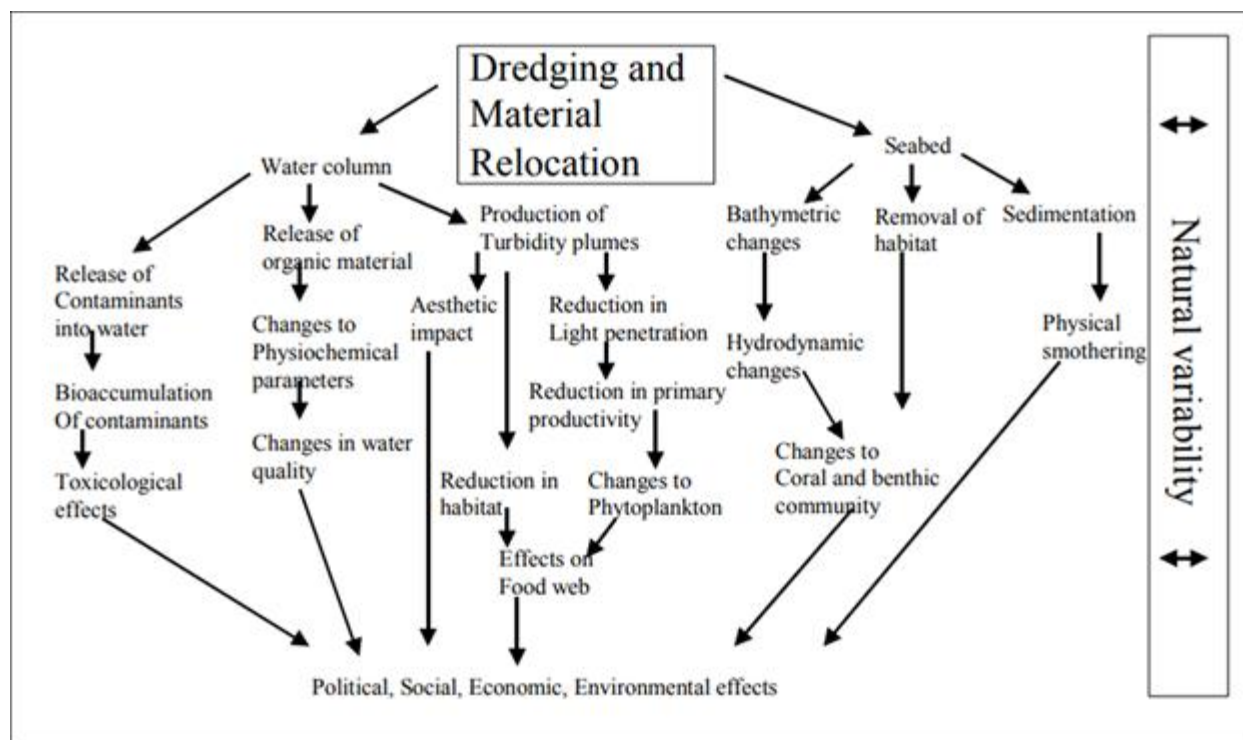


Fig. 8.1. Generalized impacts due to dredging and relocation of dredged materials.

Recurring physical disturbances (such as maintenance dredging) can alter the sediment chemistry and reduce recruitment of new benthic animals. Over time, a decrease in benthic community abundance and diversity is likely.

Human influences on benthic habitat include not only dredging and disposal, but also waste discharges, sediment deposition from hydraulic mining, filling of Bay margins, fresh water diversions, and introduction of exotic species. When the disturbance ceases, recolonization of the benthic substrate occurs; reestablishment of a more or less stable benthic community can take several months or years.

Assessing the recovery of benthic habitats disturbed by dredging and dredged material disposal operations is an important and growing management issue throughout the world. Although many projects have been monitored and a substantial literature on the subject exists, few generalizations can be made about typical recovery rates because biological responses are influenced by numerous factors, including site-specific bathymetry, hydrodynamics, depth of deposited sediments, and the spatial scale of the disturbance, sediment type, and the timing and

frequency of the disturbance. Additionally, there is no accepted definition of what constitutes “recovery.”

The dredging and disposal activities will also have impacts on the bird habitats such as reed lands and mudflats, and habitats of dolphin and dolphin and turtles etc. Detailed impact assessment on these species and their habitats are presented in Annex C: Biodiversity Management Plan. The impact on birds will be mainly from the noise pollution associated with the dredging and associated activities. The dredging activities and disposal activities if carried out any near the reed lands will disturb the habitats of the resident birds. Mud flats in the lower Meghna and Meghna Estuary are an Important Bird Area and are the winter destination for some migratory birds. They also act as foraging ground and essential stepping stone for others on longer migratory journeys. Changes in the mudflats caused by the disposal activities may affect the habitat quality of the migratory birds due to altered sediment concentration. January and February are the periods that migratory birds usually habitat these areas. Any dredging activities carried out during these periods near the mudflats might have an impact on the birds. Hunting of migratory birds by the construction workers associated with dredging activities will also be a major concern.

River turtles generally lay eggs in the chars and river banks in the Lower Meghna. 15 March to 15th April is generally breeding period for the critically endangered river turtle, *Batagur Baska*. Dredging and disposal activities in the chars and on the banks during these periods will have a significant impact on the turtle’s habitat. Noise generating from the dredging activities and movement of dredgers and associated vessels will also have impact on the reptiles. Underwater noise levels generated by the dredging will have impact on the dolphins, and turbidity and sediment dispersion associated with dredging activities may also affect the dolphins prey.

The impacts on the habitats of resident and migratory birds will be avoided by carrying out any dredging activities minimum 100 m away from the reed lands and mud flats which is possible because the reedlands and mudflats (mainly the IBAs) are located in sections of the rivers and estuary which has broad expanse and the navigation route maintains a distance from these sensitive areas. Special attention to be paid during the months of January and February. The dredged material will not be disposed in the reed lands, mudflats and other areas known for habitats of resident and migratory birds. A monitoring mechanism will be established under the biodiversity management plan to monitor the disposal and dredging activities. Similarly the dredging activities will also carried out minimum 100 m away from the chars and river banks in the lower Meghna area. Impacts on birds, turtles, dolphins and other species can be avoided by employing a ‘soft start’ approach by the dredger, in which the dredging speeds will be increased gradually to allow these species leave the dredging areas. Dolphins will also be chased by use of pingers.

Table 8-2 : Physical Factors Affecting Benthic Recovery

PHYSICAL FACTORS AFFECTING BENTHIC RECOVERY	
Depth of Overburden at Disposal Sites	Some benthic organisms such as burrowing polychaetes, amphipods and molluscs can colonize newly deposited sediments through vertical migration, therefore, if dredged material depths are limited to within the vertical migration capacity of these organisms (20-30 cm), recovery rates may be quicker than if colonization is dependent upon the lateral migration of juveniles and adults from adjacent areas and larval settlement.
Habitat Type (disturbance history)	Shallow benthic habitats (< 20 m depth, Hall 1994) experience relatively frequent wave, wind, and current induced disturbances and thus are typically inhabited by low-diversity, selected benthic assemblages that can readily re-establish themselves under conditions of high frequency disturbances (Dauer 1984, Clarke and Miller-Way 1992, Ray and Clarke 1999). These communities are naturally held in early successional stages and therefore, are able to recover more rapidly than communities in deeper, more stable environments (Newell <i>et al.</i> 1998, Bolam and Rees 2003).
Sediment Type	Rapid recolonization of soft-bottom benthic habitats is frequently associated with either unconsolidated fine grain sediments (Cruz-Motta and Collins 2004) or the rapid dispersion of fine-grained dredged material by currents (Van Dolah <i>et al.</i> 1984). Newell <i>et al.</i> (1998) characterized typical recovery times at 6-8 months for mud habitats and 2-3 years for sand and gravel substrata.
Spatial Scale of Disturbance	The spatial scale of the dredged or disposal area may be proportional to recovery times (Zajac <i>et al.</i> 1998, Guerra-Garcia <i>et al.</i> 2003). For small-scale disturbances, the edge/surface area ratio of the disturbed area is larger than for larger disturbances, therefore colonization through adult immigration from surrounding undisturbed areas may facilitate recovery. With larger disturbed areas, the central portion of the disturbed areas is reliant upon settlement from the water column for colonization, which is very dependent on seasonal recruitment patterns and local hydrodynamics.
Timing and Frequency of Disturbance	Avoiding dredging activities after seasonal larval recruitment periods is a common practice when possible. Deposition of sediments in several smaller units rather than one deep deposit also may be less detrimental to the benthos. In a microcosm study, sediment deposited in a single event caused more severe changes to nematode assemblages than the same amount of sediment deposited in smaller doses (Schratzberger <i>et al.</i> 2000).

Some of disposed material may accumulate as fine sediment over time along with new/fresh sediment brought in by the river. The sediment deposition rate and depth of sediment is difficult to estimate as it depends on various factors like sediment load, type of sediment, water current velocity, differences in the velocity at different locations, etc. The dredging depth varies at different locations. Since this is maintenance dredging project, the Class I routes have to maintain a depth of 4m during dry season. To maintain the required depth of the waterway, the estimated dredging depth is shown in the Table 8.3 below.

Table 8-3: Estimated average dredging depth in different sections of the rivers under different zones

Location/Zones	Average Dredging Depth (m)
Upper Meghna	1 – 1.5
Satnol	0.5
Sitalakhya	0.5
Lower Meghna	1 – 1.5
Barisal	1

Mitigation

- Excavation and dredging methods should be selected to minimize suspension of sediments, minimize destruction of benthic habitat, and increase the accuracy of the operation.
- As part of the daily/weekly inspection, examine the benthic communities and examine the level of Turbidity, pH, temperature, salinity, BOD, COD in excavation area and also in the outlet of the disposal area.
- Carry out dredging activities a minimum of 100m from reedlands, mudflats, and other areas of important bird habitat. The specific locations are shown in Figure 10.1.
- Do not dispose of dredge material on reed lands, grassland, floodplain, mud flats, and other areas of important habitats of fish spawning and breeding, resident and migratory birds or turtles during nesting period in the areas shown on Figure 10.1 during the months in Table 10.1. In case such disposal cannot be avoided due to insufficient submerged discharge locations in proximity to the dredge site, the following rules shall be applied to minimize impacts to mudflats and riverbank areas of important habitat for fishes, migratory birds and turtles.
- To compensate for possible unavoidable impacts to benthic communities as well as reedlands/mudflats and other riverbank areas of important habitats, a biodiversity conservation program will be developed and implemented to strengthen conservation efforts in key charlands, carry out mangrove, reedland and other habitat restoration, etc. (refer to the TORs presented in the Biodiversity Management Plan presented in Annex E).

8.3.2 Impact of Dredging on Water Quality and Fish

Water Quality

Water quality effects of dredging activities are variable depending on increases in turbidity, suspended solids, and noise; reduced light transmittance; changes in salinity, temperature, and pH; reduced dissolved oxygen (DO); and releases of nutrients, heavy metals and organic contaminants (Connor *et al.* 2004; US Navy 1990).

Short-term Water Quality Impacts

Conceptually, the water quality impact of dredging activities is two-fold: 1) suspended sediment plumes resulting from dredging or disposal activities, and associated water quality changes in the water column, and 2), sediment disturbance, and associated changes in the chemical properties of the dredged sediment. This overview addresses the first, short-term water quality impacts in the water column associated with plumes, which include chemical transformations, release of oxygen-demanding substances/reductions in DO, decreased pH, release of contaminants, and changes in bioavailability.

Chemical transformations: The most significant chemical transformation processes in dredging plumes are probably the releases of ferrous iron (Fe^{2+}) and sulfides from oxygen-depleted resuspended sediments and their subsequent oxidation with the DO in the aerated water column (Jones-Lee and Lee 2005). The oxidation of sulfides to sulfate and of Fe^{2+} to iron oxides/hydroxides is the primary chemical processes driving DO reductions in sediment plumes. In addition, they control the release of ionic metals and their short-term speciation and bioavailability during resuspension.

In anoxic (oxygen-free) sediments, sulfur occurs in the form of sulfide species (S^{2-} , S^{2-}/S^- , H_2S , and HS^- species), and iron occurs as Fe^{2+} . During resuspension of the anoxic sediment in the oxic water column, both Fe^{2+} and sulfides react with DO. Sulfides are oxidized by DO to form the highly acidic sulfate (SO_4^{2-}) species. Thus, the reaction of sulfides with oxygen can both reduce DO and also contribute to pH decreases in the water column. Fe^{2+} is oxidized by DO to form ferric (Fe^{3+}) hydroxide [$\text{Fe}(\text{OH})_3$], which is exceedingly insoluble within the normal pH range of oxygenated waters and rapidly precipitates.

Heavy metals occur mostly as sulfides (CdS, CuS, PbS, etc) in anoxic sediments. The low solubility of metal sulfides results in low porewater concentrations. Upon resuspension of anoxic sediment into the oxic conditions of the overlying water, Fe and also Manganese (Mn) are rapidly oxidized (first few minutes following sediment resuspension) to insoluble oxides/hydroxides. The insoluble Fe and Mn oxides/hydroxides precipitate again from the water column and are subsequently deposited, thus contributing to the formation of fresh sediment layers. Compared to the rapid oxidation of iron sulfides (FeS) and manganese sulfides (MnS), the oxidation kinetics for heavy metal sulfides is much slower. Laboratory studies showed that oxidation of CuS, CdS, and PbS takes more than 8 hrs. Once oxidized, however, they are quickly scavenged by, or coprecipitated with, the iron and manganese hydroxides or complexed by organic matter.

Releases of oxygen-demanding substances/reductions in dissolved oxygen: DO in SW1 and SW12 exceeded the DoE guideline. Dissolved oxygen (DO) concentrations in the water column may be reduced when oxygen-demanding substances (for example, organic material) are mixed into the water column by dredging or disposal activities. Inorganic oxygen demand is caused by abiotic (non-biological—inorganic)-based reactions consuming DO in waterbodies. The most important inorganic constituents responsible for DO reductions in aquatic systems are sulfides and reduced iron. When released from the reducing anoxic sediments into the oxidative conditions of the water column, they will be oxidized in reactions with the oxygen present in the water column. Therefore, anoxic sediments containing reduced substances such as Fe^{2+} and sulfides that react with DO would cause the greatest temporary depression in DO at the disposal site.

Decreased pH: The extent of pH decreases during sediment resuspension is mainly a function of the oxidization of sulfides to highly acidic sulfate (SO_4^{2-}). The formation of sulfate depends on the amount of sulfide in the sediment and how much it is oxidized during the release.

pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Gupta 2009). The variations in pH are an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes. However, seasonal variations of pH ranging from 6.73 to 7.28 are considered satisfactory for the production of biomass. (George 1997).

Release of sediment contaminants: Dredging and dredged material disposal can release sediment-associated metals and other pollutants by dispersion within the resulting sediment plume. The dispersion of pollutants can occur in the dissolved or in the particulate state. The release of contaminants into the water column is difficult to draw, because of the complex and specific nature of the physiochemical processes in each case. While the processes and mechanisms are well known, the exact results are dependent on numerous conditions that regulate them. Examples are the influence of ambient water concentrations on sorption and desorption from sediment particles, the role of dissolved organic carbon (DOC) and particulate organic carbon (POC) vs. mineral particles per se (e.g. bi- and tri-partite clay minerals), and how these processes are controlled by changes in redox potential and other factors.

Heavy Metals of concern of concern, due to their potential toxicity to fish, include cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), zinc (Zn), silver, (Ag), chromium (Cr), and arsenic (As). Research to date has investigated the effect of dredging-induced sediment resuspension on many potentially toxic metals. However, despite the many comprehensive studies, there is very little consensus on the release of metals and their effects. However, heavy metal test results indicate all test results are within the standards of DoE and EHS.

Table 8-4: WHO Effluent Guidelines

Effluent Guidelines (To the applicable at relevant wastewater stream: E.G, from FGD system, Wet ash transport, washing boiler/air pre-heater and precipitator, boiler acid washing,regeneration of demineralizers and condensate polishers,oil-separeted water,site drainage,coal pile runoff and cooling water)	
Parameter	mg/L,except pH and temp
pH	6 - 9
TSS	50
Oil and Grease	10
Total Residual Chlorine	0.2
Chromium-Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1
Zinc (Zn)	1
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temparature increase by themal discharge from cooling system	• Site specific requirement to be established by the EA • Elevated temperature areas due to discharge of once-through cooling water (e.g. 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge points.
Note: Applicability of Heavy Metals should be determinde in the EA. Guideline limits in the table are from varoius references of effluent performance by thermal power plants.	

Overall, only a small fraction of the total amount of heavy metals is dissolved, because of their general tendency to be bound to Fe and Mn oxyhydroxides. In anoxic pore waters the dissolved heavy metal fraction that occur as single, positively charged ions in water (e.g., Cd, Cu, Hg, Ni, Pb, and Zn) is reduced further by precipitation with sulfide. Thus, the direct contribution of these metals from anoxic sediments is considered to be negligible.

Ammonia. There is a possibility of short-term changes in unionized ammonia in conjunction with near-bottom turbidity plumes caused by disposal. Ammonia toxicity is known as a confounding factor in toxicity tests with benthic organisms.

Organic contaminants are mostly particle-bound due to their hydrophobic (“oily”) nature. Thus, direct contribution from pore water is low, unless it contains high concentrations of dissolved

organic matter (DOM). In this case, pore water may contribute substantial amounts of DOM-bound pollutants: organic contaminants may adsorb to DOM, forming a complexed fraction which is included in the operationally defined dissolved state (particles $<0.45\ \mu\text{m}$), although the micropollutants occur in bound form. Then, a substantial amount of apparently dissolved, yet DOM-bound pollutants may enter the water column during dredging.

During dredging, several changes occur when sedimentary material is dispersed into the water column:

1. the particulate organic matter (POM) concentration in the water increases;
2. DOM-bound pollutant concentration in the water column increases;
3. the total concentration of pollutant in the water increases; and
4. POM with different pollutant concentrations are mixed.

According to the partition theory, a new equilibrium will be established Figure 8-2. The concentrations in this newly equilibrated situation can be estimated using partition theory, which says that, for a given compound, the ratio of the concentration associated with POM ($\mu\text{g/g}$) and the dissolved concentration in the water (in $\mu\text{g/L}$) is a constant, characteristic for that compound. In many cases, the concentration on the sediment POM can be expected to be higher than the concentration on suspended POM already in the water column. In that case, mixing of sediment particles will cause desorption, according to the partition theory, to restore the equilibrium. However, for organic contaminants, desorption rates tend to be quite slow, and it may take months to years for these chemicals to desorb and reach equilibrium partitioning between the solid and dissolved phase (Table 8-4)

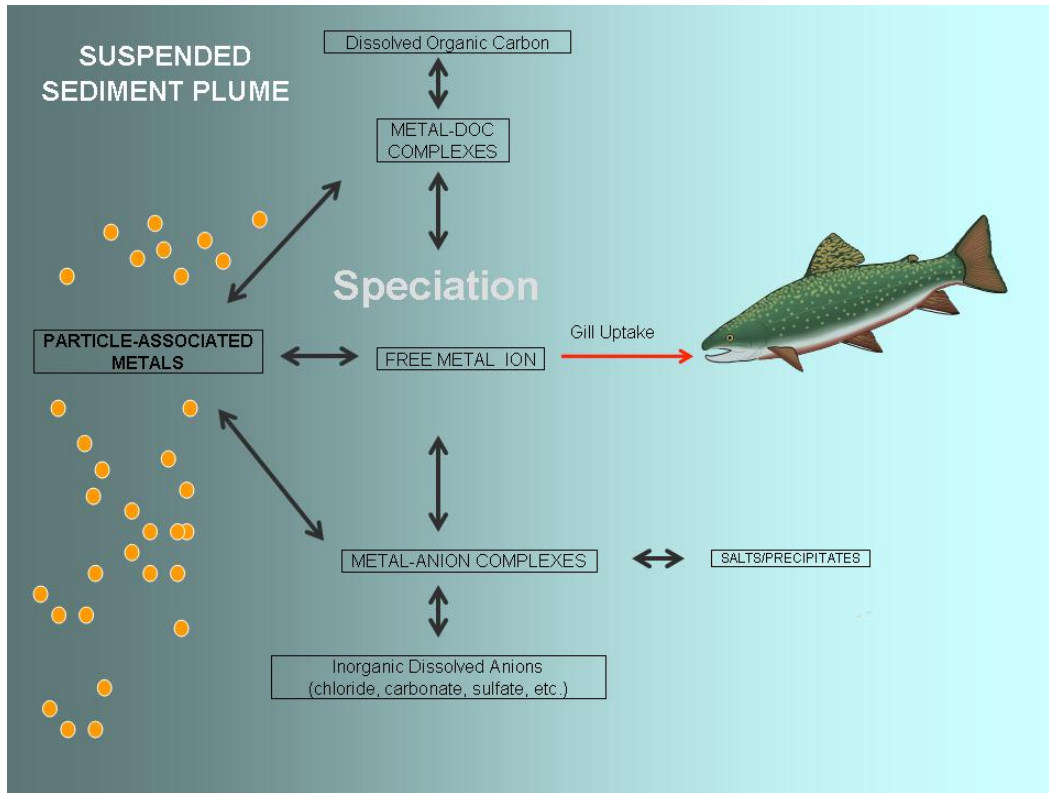


Figure 8-1: Bioavailability and toxicity of waterborne metals is very speciation dependent

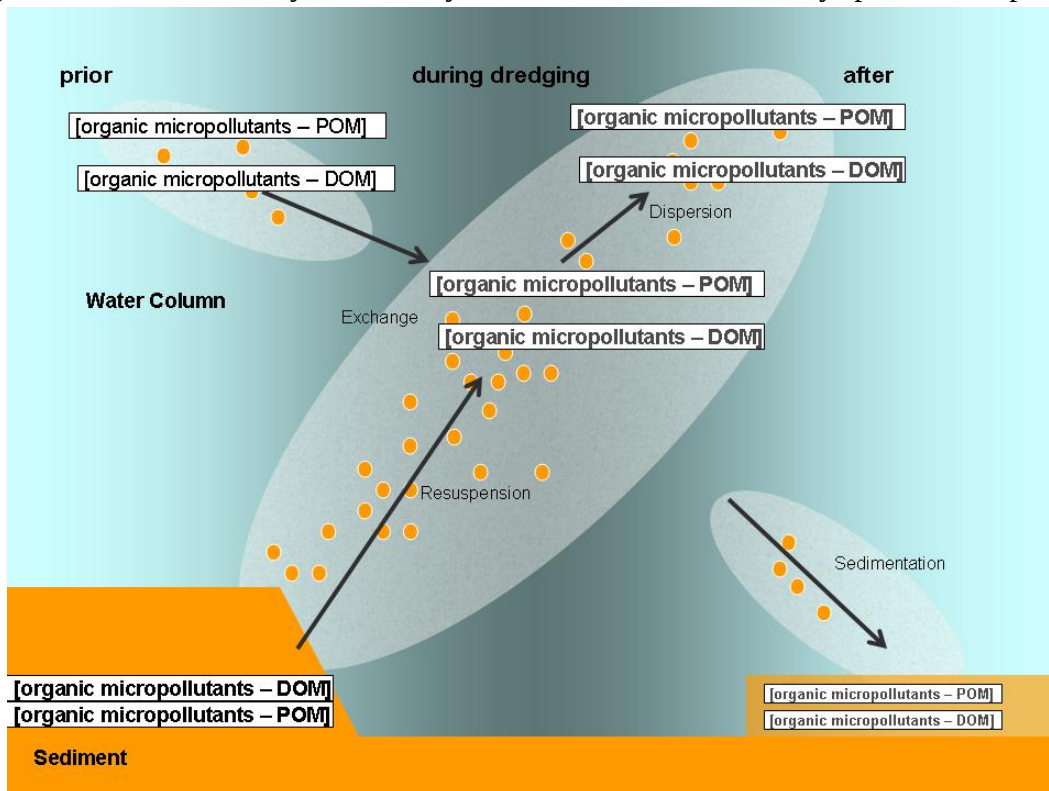


Figure 8-2: Schematic representation of the processes controlling the chemical and biological availability of organic

Changes in bioavailability: Contaminants are available to fish via gill uptake or ingestion with food. Branchial uptake of dissolved contaminants in the water column is presumably the most significant route of exposure for short-term acute toxicity in fish. In general, dredging and resuspension result in the exposure of anoxic sediment to DO, which results in a positive change in the redox potential (Eh), which can accelerate desorption, oxidation, complexation, and the bacterial degradation of sediment contaminants. An example is the mobilization and transfer of metals from sulfide minerals (FeS/MnS) to the dissolved phase during the initial exposure of reduced sediments to DO. However, these processes are sediment, compound, and animal specific. Dredging related bioavailability is mainly site-specific and dependent on the degree of contamination, the amount of suspended sediment, the duration of the disturbance, and the organism.

Mitigation

Fish

Potential short-term effects on fish species are a function of the type of contaminant, its concentration in the sediment, environmental conditions at the time of dredging (e.g. low oxygen or reducing environments), and the duration of the exposure. Although there are numerous studies on the direct effects contaminated sediments may have on fish, there are few studies that look specifically at the acute toxicity of suspended contaminated sediments due to dredging.

Heavy metals. Branchial uptake of dissolved metals is presumably the most significant exposure route for short-term acute toxicity in fish. Bioavailability and toxicity of waterborne metals is very speciation dependent. Chemical speciation concerns the nature and quantity of the various forms in which a chemical element occurs. Typically, the free metal ion is the most toxic form, and metals complexed with dissolved organic and inorganic anions show lower degrees of bioavailability and toxicity. This general rule, however, is not always valid. Notable exceptions are organometallic compounds such as the very toxic methyl mercury and tributyl tin. In any case, risks from heavy metals released during dredging would be primarily related to changes in conditions promoting the shift of heavy metals from the particulate into the dissolved state.

Organic contaminants such as pesticides, polychlorinated biphenyls (PCBs), and polyaromatic hydrocarbons (PAHs) are generally not very soluble in water and direct toxicity by exposure to dissolved concentrations in the water column is not very likely. Nevertheless, the particulate bound portion of chemicals can also be toxic (Figure 8-3). Various acute toxicity and biological effects have been attributed to organic contaminants based on laboratory studies: pesticides may cause paralysis or avoidance; PCBs may influence enzyme activities, and PAHs have a narcotic mode of action involving interference with key membrane-mediated physiological and biochemical processes. PAHs can be acutely toxic in the parts per million (ppm) ranges. The lethal concentration for 50% of the population (LC50) values for acenaphthene and pyrene determined in short-term freshwater toxicity studies (exposure 1 day) with rainbow trout were 1.6 mg/L and 2.0 mg/L (USEPA 2007). Deleterious sublethal responses include growth and

development anomalies, cancer, or susceptibility to infectious disease, but these are only known to occur due to long-term exposure.

Low dissolved oxygen (Figure 8-4). DO concentrations between the aquatic life criterion and several mg/L below the water quality objectives (WQO) would be expected to slow fish growth rate; the amount of impact is proportional to the amount of depletion below the WQO. If the DO would remain at or below a critical DO level of about 2 to 3 mg/L, significant mortality is expected in fish populations. Generally, reduced DO concentrations due to sediment resuspension would be expected to be localized and short term, with minimal impacts.

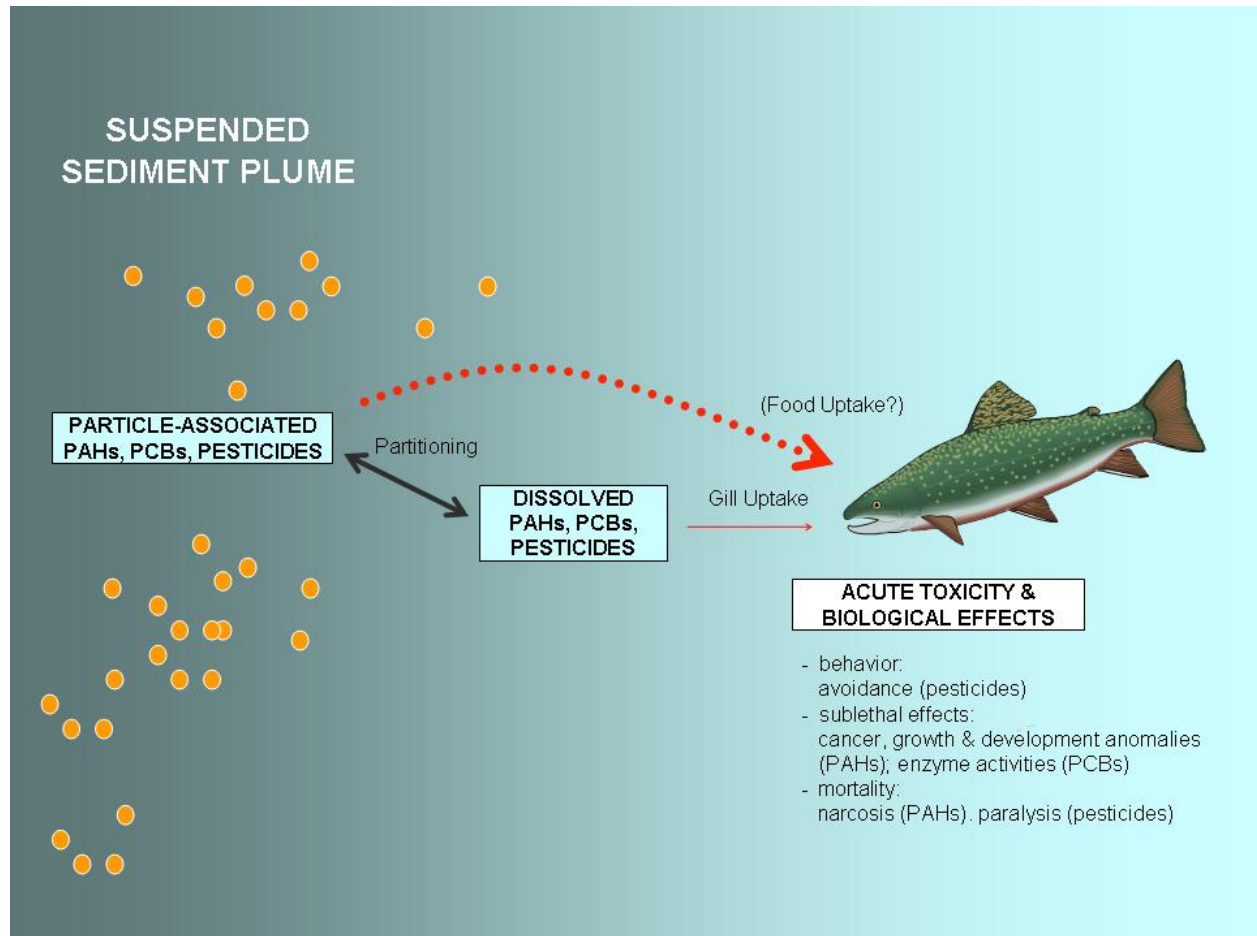


Figure 8-3: Conceptual model of direct short-term toxicity due to exposure to organic contaminants in resuspended sediments

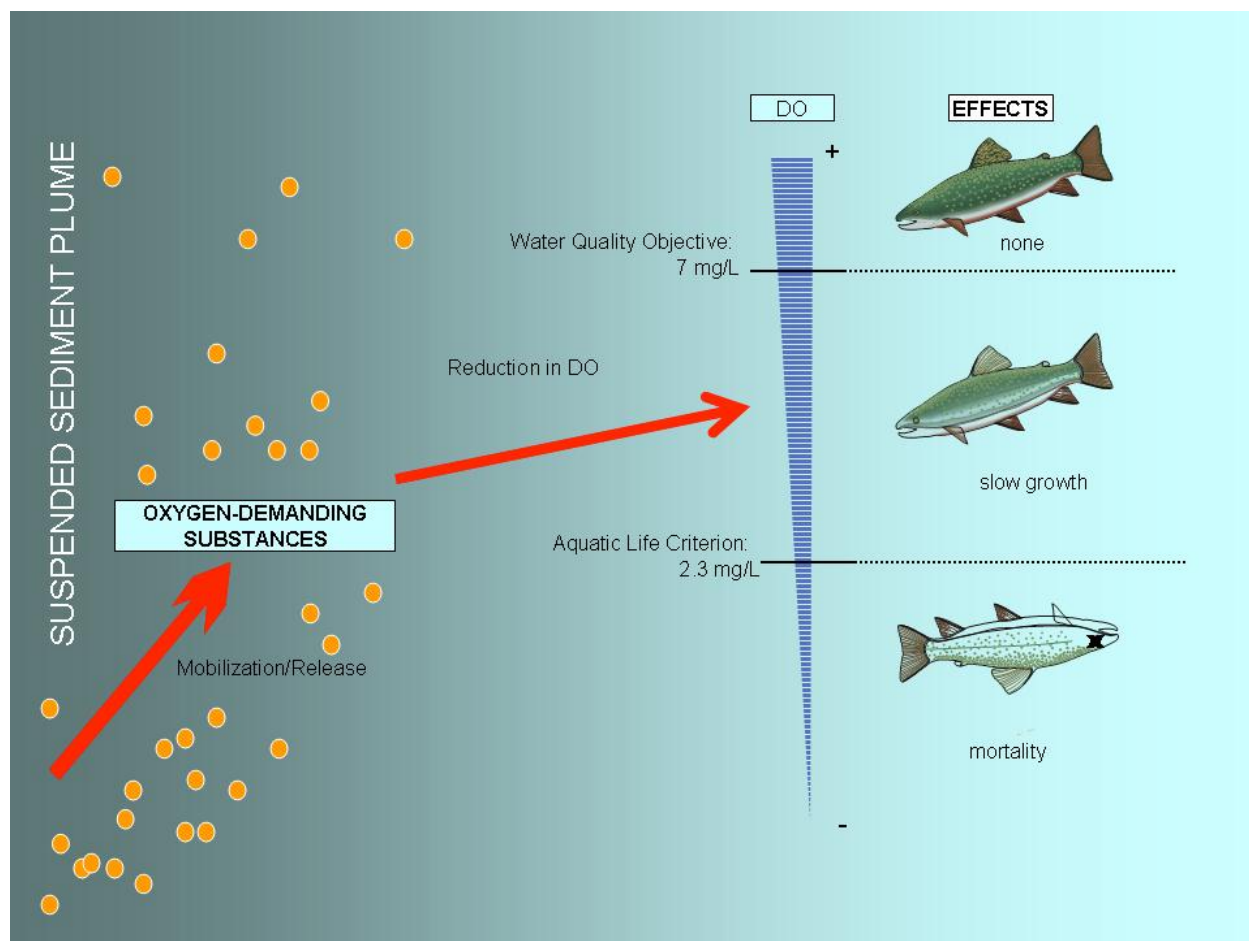


Figure 8-4: Conceptual model of reduced DO impacts on fish

Hydrogen sulfide (H_2S) is a metabolic poison that is lethal to most fish at less than 1 mg/L (USEPA 1976). Effects on fish are difficult to determine because H_2S usually occurs only in association with hypoxic conditions; that is, situations with extremely low DO below the aquatic life criterion that are also lethal to fish (Figure 8-5). Aside from ephemeral releases of H_2S , risks to fish may be of greatest concern when dredging operations result in depressed DO concentrations near the bottom. Risks of H_2S to fish are dependent on temperature, pH, and DO. In general, fish exhibit a strong avoidance reaction to H_2S .

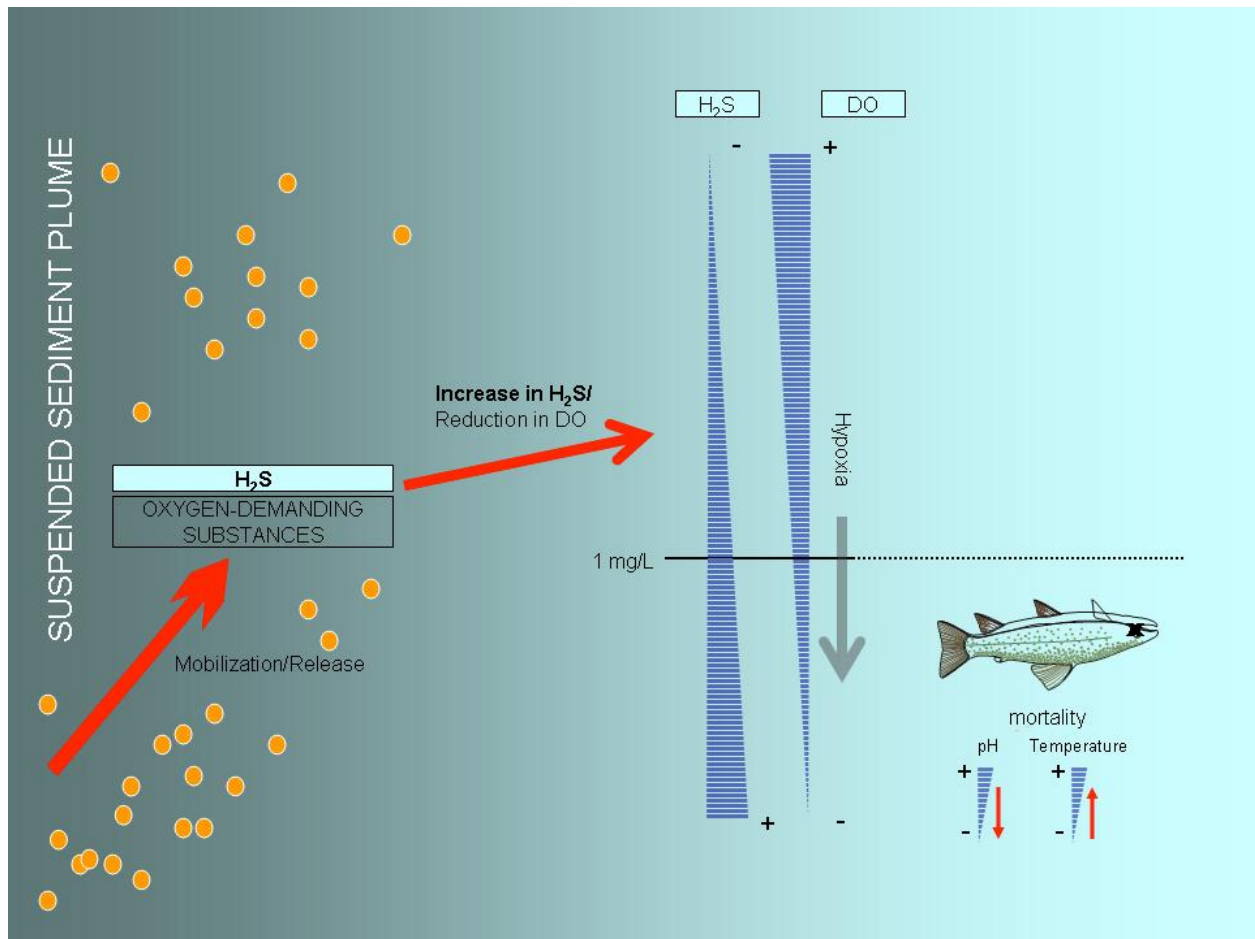


Figure 8-5: Conceptual model of potential acute H₂S toxicity to fish during dredging. H₂S toxicity is associated with hypoxic (low DO) conditions that are also toxic to fish

Ammonia toxicity is strongly influenced by differences between species and pH. Salinity and temperature also influence ammonia toxicity, but the effect is comparatively minor compared to pH. In general, ammonia toxicity is based on the presence of unionized ammonia (NH₃). In estuarine fish, the toxicity of ionized ammonia (NH₄⁺) may also occur, since the gills show some permeability to this ion.

During ammonia exposure, estuarine fish are most likely to be at risk during larvae or juveniles stages if the temperature is elevated, if salinity is near the sea water value, and if the pH value decreases below pH 7. They are also likely to be more at risk in waters of low salinity, high pH and high ammonia levels. These conditions favor transfer of ammonia from the environment into the fish, as both ionized and unionized ammonia, and retention of ammonia by the fish is likely. Since ammonia interferes with nervous function, there may be impairment of activity and behavior. Fish will be further at risk from ammonia toxicity if they are not feeding, if they are stressed, and if they are active and swimming. Episodic exposures to ammonia, as would be the case for dredging-related exposure, should be considered in relation to the rate at which the

animal is able to accumulate and excrete ammonia, and the effects of ammonia ionic regulatory and acid-base processes in the gill. The rate of unloading the accumulated ammonia from the body will be of critical importance in determining response to the next episode. If the next episode occurs before ammonia unloading is substantially complete, then a larger and potentially more damaging burden of ammonia may accumulate, with possible disruption of ionic regulatory processes.

Salinity: Many studies have reported an influence of water salinity on fish development and growth. In most species, egg fertilization and incubation, yolk sac resorption, early embryogenesis, swim bladder inflation, larval growth is dependent on salinity. In larger fish, salinity is also a key factor in controlling growth. Numerous studies have shown that 20 to >50% of the total fish energy budget are dedicated to osmoregulation. However, recent ones indicate that the osmotic cost is not as high (roughly 10%) as this. Temperature and salinity have complex interactions. Many hormones are known to be active in both osmoregulation and growth regulation, e.g. in the control of food intake (Boeuf and Payan, 2001).

Temperature: In an established system the water temperature controls the rate of all chemical reactions, and affects fish growth, reproduction and immunity. Drastic temperature changes can be fatal to fish (Patil *et al.* 2012). For most fish, body temperature is very close to that of the habitat. The diversity of thermal habitats exploited by fish as well as their capacity to adapt to thermal change makes them excellent organisms in which to examine the evolutionary and phenotypic responses to temperature. An extensive literature links cold temperatures with enhanced oxidative capacities in fish tissues, particularly skeletal muscle (Guderley 2004).

The general effects of climate change on freshwater systems will likely be increased water temperatures, decreased dissolved oxygen levels, and the increased toxicity of pollutants. In lotic systems, altered hydrologic regimes and increased groundwater temperatures could affect the quality of fish habitat. In lentic systems, eutrophication may be exacerbated or offset, and stratification will likely become more pronounced and stronger. This could alter food webs and change habitat availability and quality. Fish physiology is inextricably linked to temperature, and fish have evolved to cope with specific hydrologic regimes and habitat niches. Therefore, their physiology and life histories will be affected by alterations induced by climate change. Fish communities may change as range shifts will likely occur on a species level, not a community level; this will add novel biotic pressures to aquatic communities. Genetic change is also possible and is the only biological option for fish that are unable to migrate or acclimate (Ficke *et al.* 2007).

Mitigation

- Dredging area should be checked every day prior to commencement of dredging work. Rather, pingers will be used to chase away aquatic mammals, dredging equipment will ramp up slowly to minimize noise disturbances and allow for animals to swim away, and that minimum distance will be maintained with sensitive habitats (reedlands, marshlands, etc.)
- Measuring physical parameters of the aquatic habitat like surface water temperature, pH, turbidity (using Secchi disc) on a monthly basis.

8.3.3 Impact of Dredge Material Placement on Land

Under the project the likelihood of disposal of dredged materials on land is limited to upper reach of the Meghna and its tributary and distributary. Major disposal along the Lower Meghna including coastal area will be primarily in the stream. The actual need of land for on land disposal may be less than 10 ha. However, the option of landbased disposal is a reality and as such it needs to be discussed. Bangladesh is highly populated country and generally has high conservation or residential value and finding land close to the water and suitable for storing dredge material is difficult. However, the likelihood of land placement is low under this project and that this approach has specifically been adopted to minimize impacts and issues (both E&S) related to on-land disposal. Therefore 10 ha of land is not expected to be needed. Nonetheless option of land-based disposal cannot be ruled out.

The excavated material is pumped to a land based site as slurry (a mixture of sediment and water). Excess water would need to be treated to remove fine particles and ensure clear water was discharged back into the aquatic environment. It takes years to dry, preventing any access to, or use of, the storage area. Areas need to be fenced off to ensure human and animal safety.

Dredged material from estuary is saline and therefore is unsuitable for agricultural and vegetation rehabilitation uses. Establishing any vegetation on spread or stockpiled dredged material is expensive and can take years to become successful. Moving the material from a land based site would involve large numbers of truck movements considering the volumes involved creating community amenity issues and increased greenhouse gas emissions.

Water Quality Impacts of on-land disposal of dredge material (Tailwater and Groundwater)

Tailwater: As part of dewatering of the dredge material, tailwater would be discharged from the bunded area within each land-based dredge material placement area (DMPA). While the discharge of tailwater would be strictly controlled to ensure it is maintained within acceptable quality standards, there is potential for this tailwater to impact upon near aquatic environment. The inherent risk with tailwater discharge is the potential for environment impacts to the receiving waterways if tailwater quality is not managed properly or as result of extreme weather conditions or infrastructure failures.

Further potential water quality impacts can arise from the pumping of dredge material in slurry form from the trailer suction hopper dredger (TSHD) coupling point to the land placement site.

This activity has the potential for spills/leakages causing sediment deposition and turbid plumes during pumping operations.

Groundwater: The groundwater test results satisfy the DoE potable water quality guidelines except Noakhali (GW8) and iron is pre-dominantly high in all locations.

Placement of dredge material on land has the potential to impact on underlying and/or adjacent groundwater resources. Impacts to groundwater could eventuate due to the weight of the dredge material compressing the underlying soil structure (affecting groundwater and surface water exchange), and also due to the large proportion of saline and potentially acidic water (if allowed to oxidize) within the pumped dredge material. Placement of dredge material on land could impact on groundwater resources in the following ways:

- Change groundwater levels – most likely raising groundwater levels temporarily during and immediately after the landfarm dewatering, due to the large volume of overlying water
- Change groundwater quality – potentially increasing the salinity of groundwater resources, and changing the chemical composition of groundwater due to a shift in the groundwater/surface water dynamic
- Effects on ecology– changes in groundwater levels and quality may impact on flora and fauna reliant on groundwater resources in close proximity to the placement site
- Effects on adjacent land use (e.g. agriculture) – changes in groundwater levels and quality may impact on adjacent land uses reliant on groundwater resources in close proximity to the placement site.

In placement sites which have intertidal zones, the groundwater resource is especially vulnerable. Groundwater and soil chemistry in intertidal environments is complex and highly dynamic over small spatial and temporal scales. In these areas, the groundwater resources are effectively subterranean estuaries with oscillating hydraulic gradients. There is dynamic exchange of groundwater with surface water where groundwater seepage would take place via surface-connected pores along the intertidal slope during the ebb tide.

On the other hand, land placement options which do not have intertidal areas are located in higher elevations, and therefore are likely to have lower groundwater tables. Notwithstanding the likely lower groundwater table are possibly groundwater users in this rural area which may potentially be affected by changes to groundwater levels and quality.

Habitat Values

Significant habitat values exist across the waterways. Also, there are several places beside the waterways known to be important habitat for threatened and migratory species. Potential impacts on these areas are discussed in the section 5.3.1. Figure 10-1, Figure 10-2 and Table 10-1 shows the environmental sensitive areas including location of dredging and disposal sites for dredged materials.

Air Quality impacts of on-land dredge material disposal

The air quality test results in Sadarghat (AAQ2) exceeded the World Bank EHS criteria. Therefore, the placement of dredge material on land is likely to generate emissions from a number of sources during the transport and placement of the material. The works are likely to generate particulate and dust emissions through vehicle movements on-site and to-site via haul roads, disturbance of soils, materials handling and wind erosion of exposed surfaces. When material is initially placed at site, it will be very wet and dust generation would be minimal. As it dries however over time, dust generation will increase and will be difficult to control as the material will be too soft for machinery to gain access. In windy conditions, a significant amount of dust may be generated. Once stabilised and treated, the contribution of dust to the surrounding environment should be significantly reduced. More detailed air quality modelling would be required to confirm the actual impact of air emissions on sensitive receivers and whether an exceedance of limits would occur.

Noise impacts of on-land dredge material disposal

The placement of dredge material is likely to generate noise emissions from a number of sources including pumping and dredge equipment, treatment equipment (e.g. booster pumps, lime dosing equipment, graders, bulldozers and trucks) and haulage of materials to site along public roads for duration of up to 12 months. Dredging is likely to occur over a 24-hour period, affecting sensitive receivers outside of working hours. However, the noise level in baseline environment satisfies the DoE noise measurement guidelines.

Legislative requirements with respect to construction noise impacts do exist in Bangladesh, with the exception of restrictions on the hours of work (6:00 am to 9:00 pm) of construction sites which produce audible noise at a noise sensitive receptor. Sensitive receptors, as defined in the Noise Pollution (Control) Rules, 2006, include dwellings, libraries and educational institutions, childcare centres and kindergartens, outdoor school playground areas, medical institutions, commercial and retail activities, protected areas, parks and gardens. Bangladesh Standard for Noise Level at Different Types of is given in Table 8-5

Table 8-5: Bangladesh Standard for Noise Level at Different Types of Areas (as per Noise Pollution (Control) Rules, 2006)

BD Noise Standard (2006)	Zone	Day	Night
	Silent areas	50	40
	Residential	55	45
	Mixed	60	50
	Commercial	70	60
	Industrial	75	70

As stated above, it is likely that material placement would occur beyond these standard hours. In the worst case scenario, excessive night time noise can cause human health impacts over a period of time. Because of the noise emissions; migratory birds which use this area could also be impacted and may avoid the area temporarily during works. Excessive noise at the dumping site

would cause disruption to businesses, tourism and nearby residence; this is likely to be considered an unacceptable impact for the area.

Odour and pest impacts of on-land dredge material disposal

The material to be disposed will be mostly anaerobic sediment, containing hydrogen sulphide. On exposure to air during drying processes this can cause temporary nuisance odour (duration of a few days). The extent of the odour impact will be dependent on the drying method and prevailing wind conditions at each site as well as the proximity of sensitive receptors.

Land-based placement of dredge material will involve large bunded areas where dredge material in slurry form will initially be placed. These placement areas would represent modified habitats and large areas of ponding water would be present during the dewatering and treatment of tailwater. There is a small chance that these areas may become attractive to pests or other species due to the modified nature of the placement areas and the exposed areas of water.. These pests include:

Birds attracted to areas containing open water bodies, including dredge disposal sites. This could be considered a positive impact overall if it occurs, except if dredge materials disposal sites are close to an airport, in which case it represents a safety risk to aircraft landing and taking off from the airport. Mosquitoes – due to the modified nature of the placement site, and areas of open water, additional mosquito breeding habitat could be unintentionally created. This impact is expected to be minor, given that only a small percentage of dredge material may eventually be disposed on land (with the rest being disposed in the river), and also given that on-land disposal if required will be done in confined disposal facilities designed to facilitate proper drainage of excess water to avoid ponding.

Traffic

Placement of dredge material on land would involve the transport of materials for treatment of the dredge material and for construction purposes. To provide an indication of potential traffic issues which may result from transport of this material, a high level estimate of heavy vehicle use has been determined for each land placement option. This high level traffic assessment is based on the concept designs of the land placement options, and includes consideration of the delivery of materials such as lime, clay, stone and geo-synthetic liner to the placement site. It should be noted that to accurately determine the full traffic impact associated with the use of each land placement option, a more detailed Road Impact Assessment would be required.

The potential impacts of heavy vehicle to the external traffic network from an operational and safety perspective include:

- Operation of existing road network – impacts on traffic volumes at intersections and pavement impacts
- Hazard and safety impacts from an increase in heavy vehicle traffic
- Amenity and nuisance, including noise and dust
- Environmental issues related to potential spillage of dredge material on roads

- This section outlines the potential traffic issues for each land placement option.

Community Benefit

Land-based placement of dredge material may potentially provide some benefit to the community in terms of valuable land use, depending on the final proposed end use for the placement site.

If the land-placement area can later be developed for residential, commercial or industrial uses, the land would represent an economic value to the community. This land would also provide social benefits to the community in the form of additional areas for housing and industry, or as public recreation areas.

Land placement areas used merely as placement areas would have limited economic value and would incur ongoing maintenance costs. These costs can include lost opportunity costs and costs to maintain infrastructure associated with the placement area, such as bunding, seepage control and public safety (e.g. fencing).

Visual Amenity Issue

Land placement of dredge material would potentially cause the greatest impact on visual amenity during the construction phase. For developed sites, the visual amenity impacts after ground treatment and development will likely to be somewhat reduced. For placement sites, visual amenity impacts would likely be more prolonged.

A DMPA would cause a significant temporary visual impact, as the placement of dredge material will require the employment of trucks and earthmoving equipment on a continual basis, with night lighting, thus impacting the rural landscape character of the site. In the longer term after placement is complete, the site will appear as a raised platform of rivers sediment and will appear largely incongruous within the surrounding landscape.

Mitigation Place the dredge material as nearer as possible. Since, with increasing pumping distance there is an associated increase in the water required to pump the material which could potentially double the volume of process water required for distant sites.

In case of hazardous and toxic dredged material to be stored separately, suitable site to be identified in consultation with public representative and community people before placement on the land.

- Pumped material would be delivered to site in a slurry form with moisture content of approximately 90 percent. It would need to be dewatered to a moisture content of approximately 40-60 percent to enable rehandling by machinery (excavators and trucks). Prior to filling commencing, the areas being filled will be subdivided into compartments by construction of temporary containment bunds of suitable material (e.g. dredged sand). Filling will be achieved by progressively pumping a slurry of sand and water into the bunded areas, allowing the surplus water to drain away to artificial and natural waterways in a controlled manner through the pipeline, without affecting floodplains.

- Control the discharge of site runoff, including excess dredge water, by the installation and correct use of containment walls, bunds and weirs.

8.3.4 Impacts from Dredgers and Associated Vessels

Noise

Water is an excellent medium for sound transmission. Sound travels more than four times faster underwater than in air and absorption is less compared to air. The sensory modalities of vision, touch, smell and taste are limited in range and/or the speed of signal transmission. As a consequence many aquatic organisms use sound as their primary mode of communication – to locate a mate, to search for prey, to avoid predators and hazards, and for short- and long-range navigation. Activities generating underwater sound can affect these functions and, since sound can be far ranging, the spatial scale of impacts can be quite large. Concerns for underwater sound impacts on marine mammals, fishes, and other forms of aquatic organisms have arisen primarily with the conduct of military operations, seismic exploration, dredging and various forms of construction in aquatic environments.

Short-term temporary increases to noise will occur in the vicinity of the dredging operations and staging/dewatering activities. Sources of noise include the dredging equipment, dewatering equipment, generators, loaders, and the trucks used to transport the dewatered material for placement. Noise levels generated by the dredging operation will vary according to the size and type of the equipment used, and more importantly, the size and type of the engines. For this project, the PBC contractor will use suitable dredger depending on type of sediment to be dredged. Generally speaking during dredging operations, there are three categories of sound sources that are associated with:

- Dredging excavation
- Dredging vessels during transport
- Dredged material placement.

Figure 8-7 gives an overview of the different types of dredging vessels and the sources of underwater sound for each type of vessel. Sound production is largely influence by sediment properties – to excavate hard, cohesive and consolidated soils, the dredger must apply greater force to dislodge the material. Sounds from dredges can be variable, depending on the phase of operation, and the type of dredge used, but typically occur at low frequencies (<500 Hz).

Noise from dredgers and associated vessels was not assessed under this EIA study. This information is gathered from various secondary sources. In few areas of the Project Influence Area noise level exceeded the guideline due to the unplanned urbazination and industrialization. Therefore, instrument and machinery should be controlled and maintained with manufacturer's recommendations especially the use within residentail and environmentally and socially sensitive areas. Some of these areas are Sadarghat, Chandpur Launch ghat, and Bhola. However, the dredgers produce minimum noises that are within the limit of prescribed guidelines. The following table shows the sources of the noise in a cutter and hopper suction dredgers.

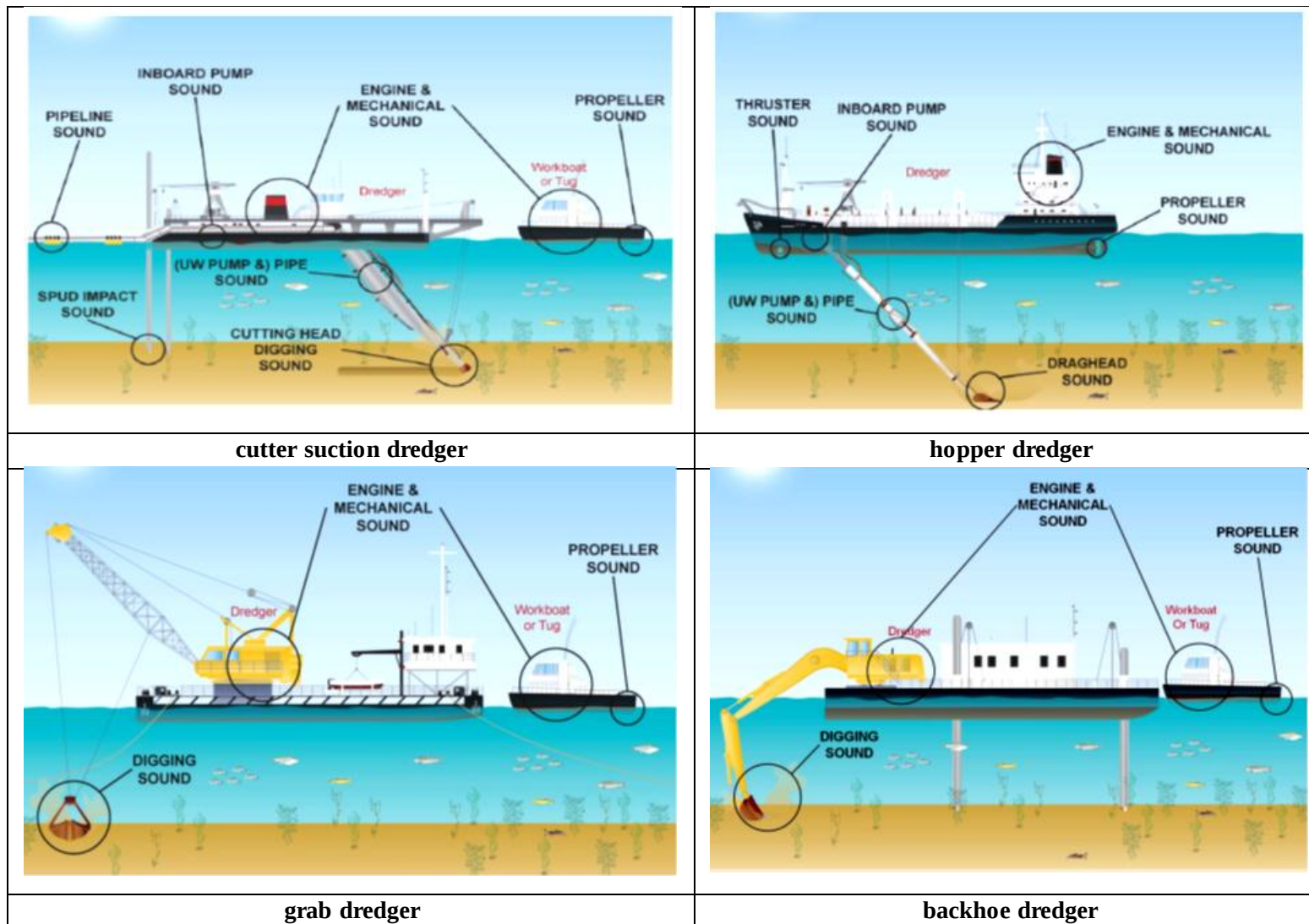


Figure 8-6: Sources of Noise from several types of dredgers and associated vessels

Hydraulic pipeline cutterhead dredges are commonly used for both new work and maintenance dredging operations. They are capable of removing most types of material and pumping the slurry through pipelines for several miles or longer with the use of booster pumps. The major processes contributing to hydraulic dredging sounds include: 1) dredge material collection sounds originating from the rotating cutterhead in contact with the bed and intake of the sediment-water slurry, 2) sounds generated by pumps and impellers driving the suction of material through the pipes, 3) transport sounds involving the movement of sediment through the pipes, and 4) ship and machinery sounds, including those associated with the lowering and lifting of spuds and moving of anchors by dredge tenders. Pipeline cutterhead dredges have a source level at 1 m of 172 dB – 185 dB re 1uPa rms, ranging from 100 – 500 Hz. However, cutterhead sounds might be peaked at 100-110 dB in the frequency range of 70-1,000 Hz and are inaudible at ~500 m from the source.

Hopper dredges hydraulically remove sediment from the seafloor through dragheads. Sediment is sucked upward through a pipe by means of centrifugal pumps, and the slurry is transferred to the hopper bin. Much of the sound is associated with propeller and engine noise with additional sounds emanating from pumps and generators. Similar to the cutterhead suction dredge, produce noise ranging from 70 to 1,000 Hz with peaks at 120 to 140 dB. Hopper dredges have a source level of 186 dB – 188 dB re 1uPa rms ranging from 100 – 500 Hz.

Grab or Bucket dredges produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying. The noise generated from a mechanical dredge entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the closed bucket up through the water column, and emptying the bucket into an adjacent barge. Once the barge is full, it would be towed by a tug offshore and emptied into the approved placement sites. The maximum noise spike with mechanical dredges is when the bucket hits the bottom. All other noises from this operation (i.e., winch motor, spuds, etc.) are insignificant. The sound of a bucket impact with the substrate is at the limit of detection by a low-noise hydrophone and hydrophone audio amplifier at 7 km from the impact point. These dredges are anticipated to be used in the lower harbor and in the entrance channel to dredge soft rock from the channel.

Backhoe dredgers require the use of transportation barges. Production of underwater sounds by this mechanical dredger depends on the dredging cycle, including the availability of barges. In general, this produce relatively low frequency sounds.

Sounds can have a variety of effects on aquatic life, ranging from subtle to strong behavioural reactions such as startle response or complete avoidance of an area. It is well documented that short and impulsive sounds such as those produced from pile driving strikes, seismic airguns and military sonar can cause behavioural reactions by fishes and cetaceans (whales, dolphins and porpoises for example) up to distances of several tens of kilometres from the sound sources.

Certain sounds can also mask biologically important signals such as communication calls between baleen whales or fish. If the level that the animals receive is high enough, sound can affect hearing either temporarily or permanently and extremes can lead to injury or even

death. The latter, however, usually occurs only in the case where animals are very close to very high intensity sounds, without having the opportunity to move away. Even when sound alone is not severe enough to affect the wellbeing of populations of concern, together with factors such as fishery by-catch, pollution and other stressors, sounds may create conditions that contribute to reduced productivity and effects on survival.

While there would be an increase in the ambient noise level during the dredging phase of the project, the source of noise is at a distance far enough away from any sensitive receptors that no significant impact is anticipated. The closest the dredging would be to any sensitive receptors would be along the river channel. Most of these communities are buffered from the river by the regular activities within these rivers. Since dredging does not occur in one position for any extended period of time, there will be no disproportionate impact on any communities.

Ganges River Dolphin: The Ganges-Brammaputra-Meghna River system is a favorable river dolphin habitat especially upper and lower Meghna of the Project area. Potential impacts of noise on dolphins include mortality, hearing damage, masking of communication and other biologically important sounds, and behavioural responses⁵. Mortality only occurs in the immediate vicinity of very high energy noise sources, such as blasting, and is unlikely to occur for the considered pump noise.

Behavioural response - Behavioural responses to noise include changes in vocalisation, resting, diving and breathing patterns, changes in mother-infant spatial relationships, and avoidance of the noise source⁶.

Southall *et al.* (2007)⁷ conducted a review of numerous studies into behavioural disturbance in high-frequency cetaceans from continuous man-made noise. Most of these studies concerned the effects on harbor porpoise. A ranking of behavioural response severity was adopted to emphasise that not all behavioural responses are equally significant. Behavioural changes may be relative minor and/or brief, have the potential to affect important behaviours such as foraging, breeding and resting, or are likely to affect these vital behaviours.

The review by Southall *et al.* (2007)⁸ concluded that harbor porpoise display behavioural response at very low noise exposures of SPL 90 to 120 dB re 1 μ Pa, at least for initial exposures. It is noted that for the majority of observations, the behavioural changes to levels below 120 dB re 1 μ Pa were relatively minor or brief. Significant and sustained avoidance behaviour was recorded when noise levels exceeded 140 dB re 1 μ Pa. Habituation to sound was noted in some but not all studies.

The United States (US) National Oceanic and Atmospheric Administration (NOAA) adopts interim noise exposure criteria for assessing behavioural disruption and injury in cetaceans

⁵ Richardson *et al.* (1995). *Marine Mammals and Noise*. San Diego: Academic Press.

⁶ Richardson *et al.* (1995). *Marine Mammals and Noise*. San Diego: Academic Press.

⁷ Southall *et al.* (2007). *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations*. *Aquatic Mammals*, 33(4).

⁸ Southall *et al.* (2007). *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations*. *Aquatic Mammals*, 33(4).

from underwater noise. An exposure criterion of SPL 120 dB re 1 μ Pa is conservatively adopted for behavioural disruption (NOAA 2011)⁹.

Whether the harbor porpoise data reviewed by Southall *et al.* (2007) can be extended to the Ganges River Dolphin is unknown. However, combining the conclusions of their review and the conservative interim criterion adopted by NOAA, it is assumed as a precautionary measure that noise levels above SPL 120 dB re 1 μ Pa may cause behavioural disturbance.

A study into the habitat use and distribution of the Ganges River Dolphin in the VGDS concluded that the number of motorised boats and boat noise were not significantly correlated with dolphin encounter rates (Kelkar, 2008)¹⁰. Small boats equipped with outboard engines can produce source levels in the order of 160 dB re 1 μ Pa at 1 m, or received levels of over 120 dB re 1 μ Pa at 1 m up to 500 m. Although the study results suggest that boat noise is not displacing dolphins, it is not conclusively showing that such noise levels do not impact on their behaviour.

Masking - Masking of biologically important sounds may interfere with communication and social interaction and cause changes in behaviour as well. The zone of masking impact will be highly variable and depends on many factors including the distance between the listener and sources of the signal and masking noise, the level of the signal and masking noise, and the propagation of noise from the signal and masking source to the listener (Richardson *et al.*, 1995).

It is important to note that masking of communication and echolocation signals naturally occurs by the ambient noise environment. Man-made noise causes additional masking of a signal only when it is of a higher level than the ambient environment within the species' critical hearing bandwidth at the signal's dominant frequencies. The critical bandwidth for dolphins is typically assumed to be one-third octave band wide (Richardson *et al.*, 1995).

Echolocation clicks produced by the Ganges River Dolphin have dominant energy around 65 kHz (Sugimatsu *et al.*, 2011)¹¹. This is well above the dominant frequency range of most man-made noise, including pump noise. Masking of echolocation signals is therefore not a significant issue for most man-made sources (Richardson *et al.*, 1995). In other words, **the dredge noise is not expected to significantly interfere with the echolocation ability of the Ganges River Dolphin.**

The Ganges River Dolphin is likely to produce communication signals, such as whistles, squeals or clicks, based on communication signals produced by other river dolphins. These signals generally have energy at much lower frequencies than the echolocation clicks, i.e., as

⁹ National Oceanic and Atmospheric Administration (NOAA 2011). Interim Sound Threshold Guidance for Marine Mammals. <http://www.nwr.noaa.gov/Marine-Mammals/MM-sound-thrshld.cfm>.

¹⁰ Kelkar, N. (2008). Patterns of habitat use and distribution of Ganges river dolphins *Platanista gangetica gangetica* in a human-dominated riverscape in Bihar, India. Master Thesis, Manipal University, Centre for Wildlife Studies, Bangalore.

¹¹ Sugimatsu *et al.* (2011). Annual Behavioral Changes of the Ganges River Dolphins (*Platanista gangetica*) Based on the Three Long-Term Monitoring Seasons using 6-Hydrophone Array System. IEEE Symposium on and 2011 Workshop on Scientific Use of Submarine Cables and Related Technologies, (pp. 1-7). Tokyo.

low as 1-6 kHz. Communication signals are therefore more likely masked by man-made noise than echolocation clicks.

Hearing damage - When the dolphin's auditory system is exposed to a high level of sound for a specific duration, the sensory hair cells begin to fatigue and do not immediately return to their normal shape (NRC 2005)¹². This causes a reduction in the hearing sensitivity, or an increase in hearing threshold. If the noise exposure is below some critical sound energy level, the hair cells will eventually return to their normal shape. This effect is called a temporary threshold shift (TTS) as the hearing loss is temporary. If the noise exposure exceeds the critical sound energy level, the hair cells become permanently damaged and the effect is called permanent threshold shift (PTS).

Noise exposure criteria for marine mammals were recommended by a group of experts based on a review of available data (Southall *et al.* 2007). An M-weighted exposure criterion of SEL 215 dB (M) re 1 $\mu\text{Pa}^2\text{s}$ is recommended for PTS from continuous noise. This is based on a TTS-onset level of SEL 195 dB (M) re 1 $\mu\text{Pa}^2\text{s}$ measured in mid-frequency cetaceans, and adding 20 dB to estimate PTS on-set (Southall *et al.* 2007).

The United States (US) National Oceanic and Atmospheric Administration (NOAA) adopts interim noise exposure criteria for assessing injury in cetaceans from underwater noise. An injury criterion of SPL 180 dB re 1 μPa is adopted for PTS conservatively based on available data for TTS (NOAA 2011).

Noise exposure criteria –Table 8-6 summarises the noise exposure criteria adopted for assessing hearing damage (PTS or TTS) and behavioural effects on the Ganges River Dolphin from pump noise. The noise exposure criteria are based on the review presented by Southall *et al.* (2007) and the current interim criteria adopted by the NOAA (2011), which were discussed above.

Table 8-6: Noise exposure criteria for physiological (PTS and TTS) and behavioural impacts from impact piling on cetaceans.

Impact	Noise exposure criteria
Permanent threshold shift	SEL 215 dB(M) re 1 $\mu\text{Pa}^2\text{s}$
Temporary threshold shift	SEL 195 dB(M) re 1 $\mu\text{Pa}^2\text{s}$
Behavioural response	SPL 120 dB re 1 μPa

¹² NRC. (2005). Marine Mammal Populations and Ocean Noise - Determining When Noise Causes Biologically Significant Effects. National Research Council, National Academies Press.

Air Pollution

Navigation channel maintenance dredging equipment needs to be mobile and capable of operation without an external power source, making diesel fuel the predominate choice. The combustion of diesel fuel releases pollutants into the atmosphere that can be quantified and compared between dredging crews to determine the lowest adverse environmental impacts for each type of equipment and scenario. These contaminants impact air quality and may add to global climate change considerations. However, air quality test results indicate that all test results are within the national standards.

Air pollution from ships causes a cumulative effect that contributes to the overall air quality problems on a local scale, particularly in coastal zones in the case of sulphur oxides (SO_x), nitrogen oxides (NO_x), particulate matter (PM), and on a global scale with CO₂ emissions contributing to climate change. Most of these airborne pollutants are produced when burning fuel oil.

Potential air quality impacts associated with the Project have been identified and assessed. As dredging activities of the Project are river based and no dusty activity is anticipated, negligible dust impact on nearby air sensitive receivers (ASRs) is expected during both the construction of the Project as well as for the maintenance dredging activities.

Waste (Solid and Liquid)

The marine-based construction activities also bilge water from ship and accidental spills during operation phase will result in the generation of a variety of wastes which can be divided into distinct categories based on their nature and ultimate method of disposal. The types of waste include:

- river sediments
- construction waste
- chemical waste; and
- general refuse

The definitions for each of these categories and the nature of their arising and potential impacts are discussed in the following section.

River Sediments: Dredged River and marine sediments will arise from the construction activities and it is estimated that a total of approximately 5-6 million m³ of dredged materials will be generated annually. The potential environmental effects of the removal and disposal of these sediments comprise water quality impacts and indirect adverse effects on aquatic biota, as discussed in detail in Section 8.3.2.

Construction Waste: During construction activities carried out by the contractor, wastes including materials packaging and equipment wrappings, may be generated. As the volume of construction waste generated will be dependent on the Contractors operating procedure and practices, it cannot be quantified.

Chemical Waste: Chemical wastes likely to be generated by construction activities will mainly arise from the maintenance of equipment. Waste arising from these activities may include cleaning fluids, solvents, lubrication oil and fuel. The cumulative effect of a

potentially large number of small spillages during maintenance operations by faulty equipment, accidents, and carelessness may be significant.

Chemical wastes arising during the construction phase may pose serious environmental, health and safety hazards if not stored and disposed of in an appropriate manner as outlined in the Chemical Waste Regulations. These hazards include:

- toxic effects to workers
- adverse impacts on water quality from spills and associated adverse impacts on aquatic biota and
- Fire hazard.

General Refuse: General refuse may include food wastes and packaging, waste paper, etc. and have the potential to cause impacts on water quality. Release of general refuse into river waters should not be permitted as introduction of these wastes is likely to have detrimental effects on aquatic biota in the area.

The amount of general refuse which is likely to arise cannot be quantified at this time as it will be largely dependent on the size of the workforce employed by the contractor and the implementation of practices on board the works vessels.

Mitigation

- Select appropriate dredger to minimize the noise as much as possible
- Regularly measure underwater noise level and avoid Ganges Dolphin movement area for dredging. Difficult to specify these areas however, during dry season location of scour holes, river confluences and river bends may be avoided. Under water noise may not exceed 145dB at 70kHz, which is also the maximum noise level to be used by the pingers to drive the dolphins away
- Minimize underwater noise impacts on nearby fauna by slowly ramping up equipment, using pingers etc to allow fauna to swim away in advance of dredging
- Regularly check and carry out maintenance work of dredgers and associated vessels to reduce air pollution from them
- Do not discharge liquid and solid waste into the river from vessels

8.3.5 Impacts from Disposal of Contaminated Dredged Material

Although generally not heavily contaminated, much dredged material is subject to some contamination. A variety of harmful substances, including heavy metals, oil, TBT, PCBs and pesticides, can be effectively 'locked into' the riverbed sediments. These contaminants can often be of historic origin and from distant sources. The dredging and disposal processes can release these contaminants into the water column, making them available to be taken up by animals and plants, with the potential to cause contamination and/or poisoning. The likelihood of this occurring depends upon the type and degree of sediment contamination; however, some remobilization of very low levels of pollutants would be expected during many dredging campaigns.

The highest levels of contaminants generally occur in silts dredged from industrialized estuaries. If low level contaminants are released into the water column during disposal, they may accumulate in marine animals and plants and transfer up the food chain to fish and sea mammals.

General effects of contaminants on marine life:

- When found in sufficient quantities in the food chain, contaminants may cause morphological or reproductive disorders in shellfish, fish and mammals.
- Generally young shellfish and crustaceans (oysters, shrimp, crab and lobsters) are much more susceptible to the toxicity of contaminants than adults.
- Concentrations of heavy metals in most estuaries are too low to cause adverse effects on eelgrass *Zostera* sp.

Years of point and non-point source discharges from industrial and municipal facilities, and urban and agricultural runoff to the rivers in Bangladesh and its distributaries/tributaries have contributed toxic substances into the ecosystem, resulting in major contamination issues. The occurrence of very contaminated sediments is certain in the river of Buriganga and in some locations of Meghna also.

Mitigation

- Test the dredged material to measure the level of contamination.
- In case of contaminated dredged material, it will be isolated and stored in confined trenches at designated location based on discussion with community people before disposal according to national or other applicable guidelines.
- Do not dispose the dredged material in the fish spawning or breeding areas.

8.3.6 Sediment Dispersion Modelling and Impact Assessment

There are a number of dredging locations in the Meghna estuary for the improvement of navigability along the Dhaka Chittagong corridor route. During dredging process the river bed will be disturbed and a small part of dredge material are very likely to be in suspension due to the fine sediment content of the bed material. High levels of fine suspended sediment over long periods may have an adverse environmental impact therefore a dredge dispersion modelling was commissioned to investigate these potential impacts. The dredging location along the Bhola Island and Sandwip Island were selected for sediment-dispersion modeling to investigate the extent and concentration of sediment dispersion considering 5% and 10% dispersion of dredge material due to dredging. During dredging the instantaneous suspended sediment concentration of the navigational channel results in a plume of fine sediment, which is dispersed upstream and downstream through ebb current and flood current.

The available Two-Dimensional Bay of Bengal model covers the whole coastline of Bangladesh. The modelling system used for the development of model is the MIKE21 FM, which is based on an unstructured flexible mesh consisting of linear triangular elements. The mesh enables to increase the resolution of grid around Islands, along coastline and other area of interest. It uses Finite Volume method for discretization of the flow and transport equations.

The upstream end of the model is extended up to non-tidal zone and the downstream end of the model area extends up to 16° Latitude in the Bay of Bengal. Three open boundaries are defined in the model, two in the north in the Upper Meghna River at Bhairab and in the Padma River at Baruria. Another one is in the south in the Southern Bay of Bengal at 16° latitude. The maximum depth along the southern open boundary of the model area is more than 2,000 m. The northern/ upstream boundaries measured discharge and southern boundary is tidal boundary generated from Global Tide Model. Bathymetric data have been collected from different sources and used for the generation of bathymetry. C-map provides the bathymetry data in the deep sea. In the estuary, different rivers and other areas, available recent surveyed bathymetry data has been used. The model domain for Bay of Bengal Model (BoB) is shown in Figure 8-7

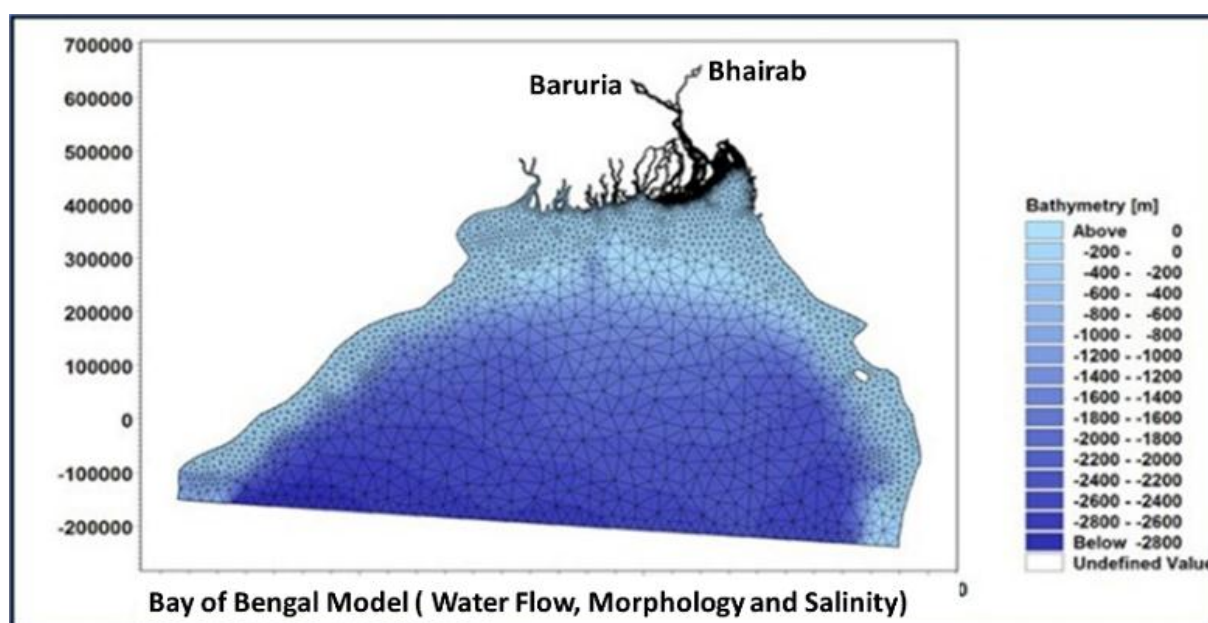


Figure 8-7. The domain of Bay of Bengal Model (BoB)

Hydrodynamics

The existing hydrodynamic model was used to provide a description of tidal current flows and water level variations based upon an unstructured triangular mesh. The water levels and flows are resolved on a flexible triangular mesh, when provided with the bathymetry, bed resistance, wind field, and hydrographic boundary conditions. The model is provided with additional functionality through application of a Mud Transport Module which extends the model capabilities to consider the transport, deposition, erosion and re-suspension of fine sediments. This module was applied to consider the potential impacts of the proposed dredging operations. Water level calibration plot is shown in Figure 8-8 and Figure 8-9

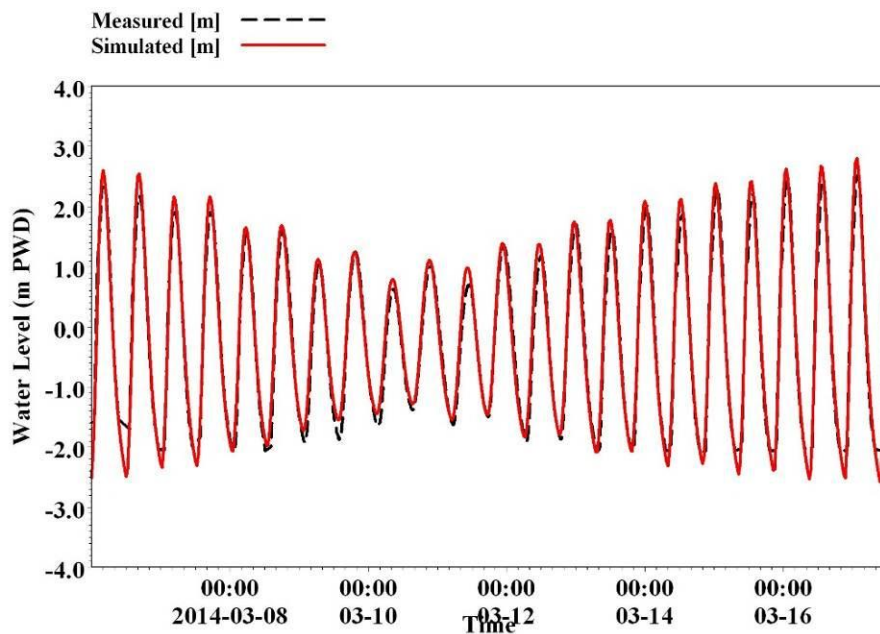


Figure 8-8: Comparison of simulated and measured water level Near Sandwip

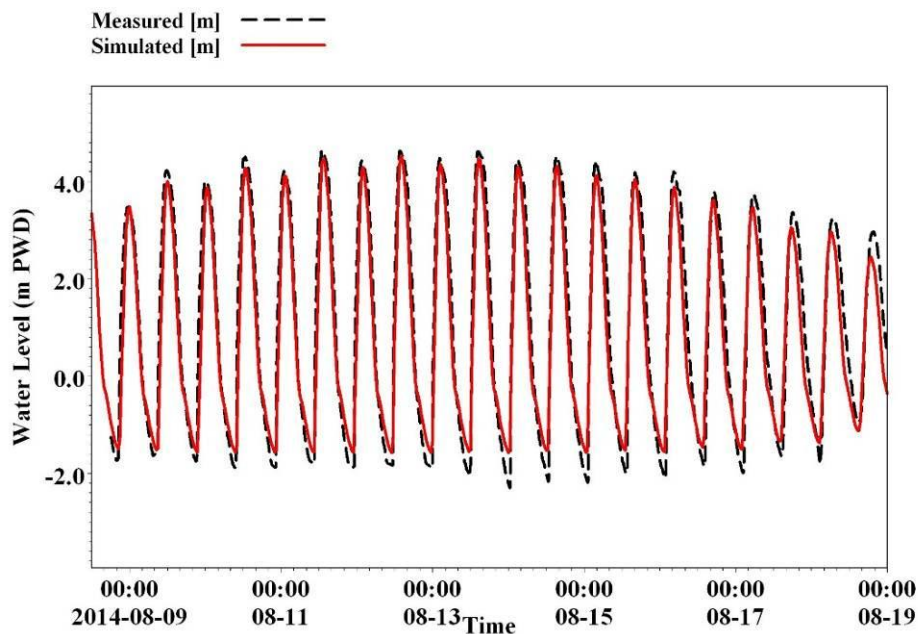


Figure 8-9: Comparison of simulated and measured water level Near Jahazer Char

Simulation of Sediment Dispersion

The hydrodynamic model was used to drive the mud transport model, which simulates the fate of fine sediment associated with dredging. The model results were extracted over the model domain for suspended sediment concentration and unconsolidated sediment accretion. Suspended sediment calibration plots are shown in Figure 8-10 and Figure 8-11

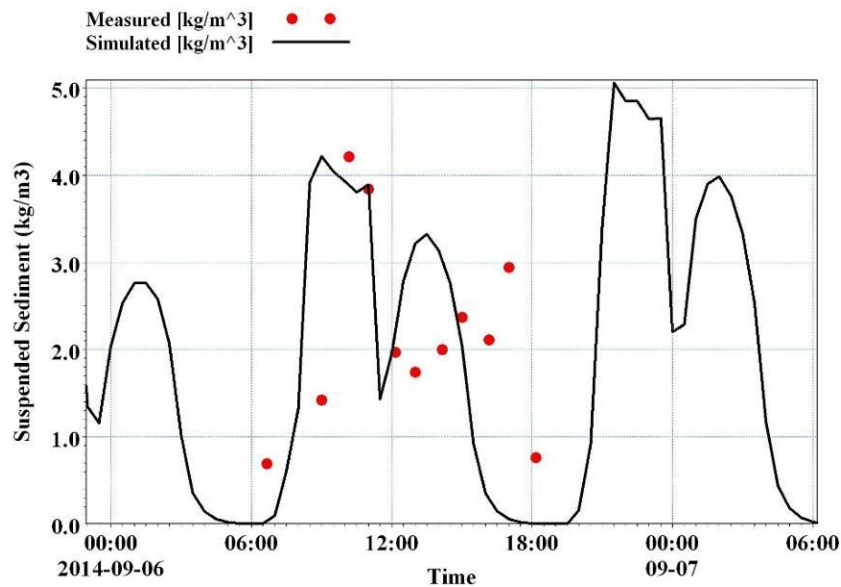


Figure 8-10: Comparison of simulated and measured suspended sediment concentration near

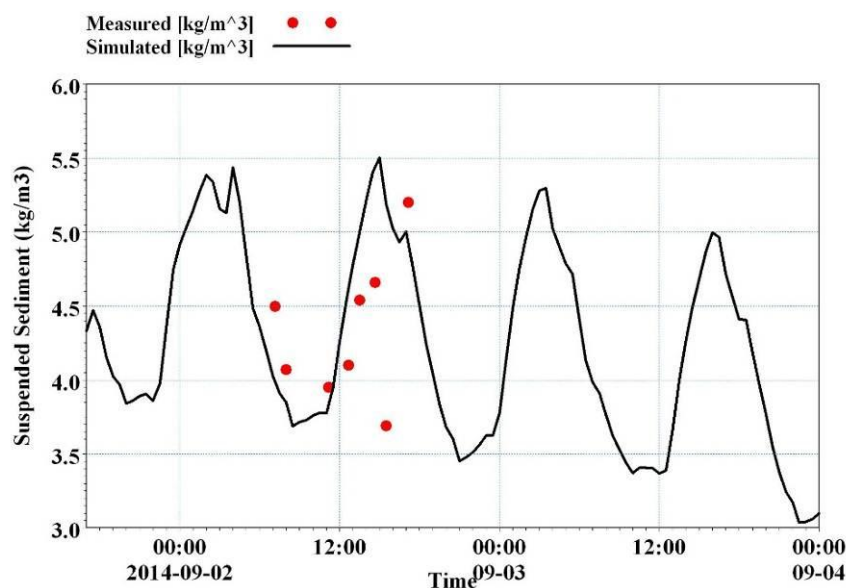


Figure 8-11: Comparison of simulated and measured suspended sediment concentration near Jahazer Char

Impact of dredging operation

The instantaneous suspended sediment concentration during dredging of the navigational channel results in a plume of fine sediment. This plume is dispersed over a significant distance by the strong tidal currents at the point of dredging, which also leads to increased sediment dispersion. During the ebb tide the plume is transported to the south. During periods of slack tide when the tidal currents change direction, an area of the dredge plume passes to the north. During neap tides, suspended sediment concentrations are slightly increased locally due to the reduced current speed, however the plumes follow a similar path and direction, but of reduced extent.

The time-step of the sediment dispersion model simulation was set at 600s (10 mins). At every time-step sediment is released into the water column based on the specific scenario. Sediment concentrations averaged over the entire water column are presented for each modelled scenario. At the end of each simulation (14 days), the maximum sediment concentration that occurs within each model element is calculated. The final maximum concentration results are therefore, not a representation of any point in time but are instead a time independent view of the sediment plume extent. In reality, the actual sediment concentration at any point in time is likely to be much lower.

The proposed dredging operation lasts for 14 days for the modelled section. The representative snapshots of the plume development (>5 mg/l) are shown in Figures 8.13 and 8.14 for two current directions. It can be seen that the sediment plumes generated during the dredging operation are confined to the alignment of the current directions. The sediment plume is created immediately after dredging works starts and disperses in the direction of the dominant current direction. The presence of the plume (>5 mg/l) can be expected to persist for entire dredging operation, after which it quickly dissipates within 4-6 hours after the dredging activity stops.

The model shows that sediments will migrate and distribute over a large area under the tidal currents. The spreading of sediment is confined in a smaller area under northerly currents due to the lower magnitude of the current speed compared to the southerly currents.

Figure 8-12 and Figure 8-13 illustrate the map plots of maximum depth averaged concentration over 14 days. The impact (excess concentration) in terms of the extent and area affected has been derived from the model results for four thresholds: 5 mg/l, 4 mg/l, 3 mg/l and 2 mg/l. These plots show the spreading of the suspended sediment. Table 8-7 summarizes the maximum affected area and distance from the dredging to the contour defined by a given threshold concentration.

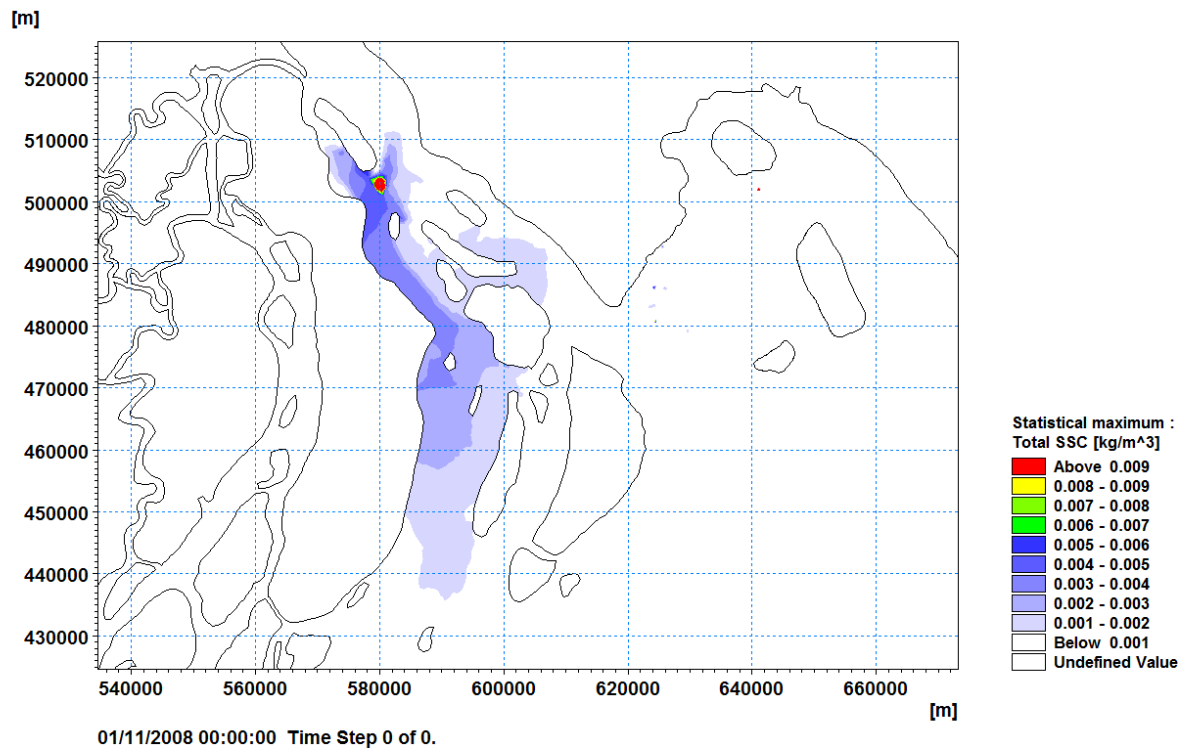


Figure 8-12: Extent of excess sediment concentration for 5% dispersion due to dredging at north of Bhola

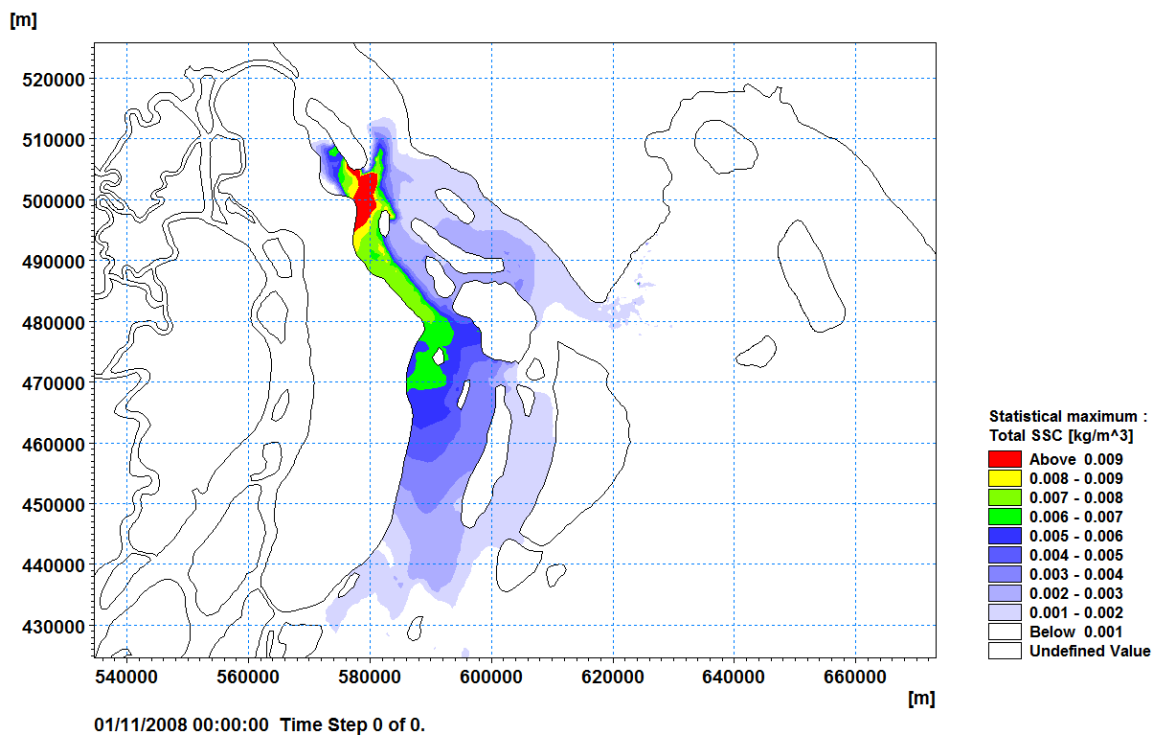


Figure 8-13: Extent of excess sediment concentration for 10% dispersion due to dredging at north of Bhola

Table 8-7: Distance and area affected by the excess sediment concentration

Sl No	Dispersion	Affected area/distance	≥5mg/l (0.005kg/m ³)	≥4mg/l (0.004kg/m ³)	≥3mg/l (0.003kg/m ³)	≥2mg/l (0.002kg/m ³)
1	5%	Distance (km)	13	41	57	80
		Area (km ²)	34	157	372	833
2	10%	Distance (km)	57	66	80	93
		Area (km ²)	375	553	868	1476

Sediment dispersion modelling shows that the maximum excess suspended sediment concentration due to dredging in the Lower Meghna River and Meghna estuary is 42mg/l within 100m from the centre of the dredging in addition to the base suspended sediment concentration. Beyond 100m the excess sediment concentration is very insignificant. The base sediment concentration during dry season in the Lower Meghna River and estuary is in the range 200mg/l to 300mg/l, whereas in the monsoon it varies from 300mg/l to 953mg/l as per field measurements of 2015 under this. The additional suspended sediment concentration is about 4.4 % increase if maximum sediment concentration is considered. If dry season is considered, then the percentage increase is about 14%. It implies insignificant impact of dredging in on the flora and fauna of the Lower Meghna River and Meghna Estuary. Feeding and socializing behavior of dolphins, turtles, some fishes may be temporarily affected with increased levels of turbidity.

8.3.7 Worker Health and Safety

Safety at water applies to all vessels and personnel working in the aquatic sector. Safety also extends to the protection of the aquatic environment, waterborne global trade and consequently in all these aspects to the dredging industry. Safety on dredging vessels and during dredging operations embraces an overall approach towards ensuring the safety and health of personnel, the safety of the ships and the quality of the environment.

Safety standards are applied during every phase of a dredging project, paying close attention to the safety of ships, crews and all other personnel as well as marine life. Ships, operations and offices must comply with the strictest of international standards regarding Quality, Health, Safety and Environment (QHSE).

Works on the water particularly near the coastal area is hazardous due to the hostile and sometimes unpredictable nature of the environment in which it is carried out. Additionally, a variety of potential hazards are believed associated with the project scope of work. The following Table 8-8 can be used to identify anticipated hazards for the project based on the project scope of work and site conditions.

Table 8-8: Anticipated hazards for the project based on the project scope of work and site conditions

Hazard	Control Measures
Cold Stress	Warm clothes, water proof outer layer, regular breaks as necessary.
Water Drowning	Personal Floatation Device (PFDs) will be worn at all times when in support boat
Vehicular Traffic	One person will be on watch for approaching vessels
Slips / Falls	Proper boating footwear must be worn when on board
Sun Exposure	Shaded glasses to be worn during sunny conditions.
Inclement Weather	Field activities will cease in the event of approaching storms or high winds/seas
Heavy Machinery Area	Be aware of machinery operations. Obey no-go-areas where machinery is operating
Physical/Back Injury	First aid will be applied as necessary. Team lifting when weight over 50 lbs.
High Crime Area	Lock all boats and equipment at the end of every day.
Flammable Materials	No smoking will be allowed during work activities. All flammable substances will be stored in appropriate fire-proof containers.
Chemical	PPE worn when there is a potential for sediment contamination
Biohazard	PPE worn if there is a potential for contact with sediment or water. Wash hands prior to eating/drinking.

Personal Protective Equipment (PPE) is a crucial part of worker safety and can include face shields, safety glasses, hard hats, and safety shoes. Additional PPE may also include high-visibility vests, high-visibility fleeces, and raincoats and trousers. This type of equipment has become standard for the dredging industry and has accounted for a significant reduction in accidents and incidents that could endanger a worker. In each case the type of PPE to be used is determined through a risk assessment.

8.4 Social Impacts from Maintenance (dredging) and Vessel Shelter Related Activities

The communities have very high expectation from the project regarding dredging of the river and construction of storm vessels shelters. They expect positive impact on livelihood through better transport and business opportunities. Although there will be some land acquisition due to the project but the project will mostly use government land therefore, the impact will be minimal. Some squatters, lease holders and private land owners might face negative impact due to the project, which can be specified during detailed design stage. Some positive and negative impacts according to respondents' observation are presented in Table 8-9.

Table 8-9: Some positive and negative impacts according to respondents' observation

Expected Positive impacts of the project	%
The project will enhance livelihood opportunities	29%
It will improve transport facility	27%
It will upgrade environment and play role in disaster management	20%
The project will enhance social development	5%

Expected Negative impacts of the project	%
The project will cause environmental degradation	30%
Transport cost will increase	19%
Negative impact on livelihood during construction	16%
The project will fail in maintenance	11%

8.4.1 Land Acquisition and Resettlement

The project will follow World Bank Operational Policy 4.12 and GoB policy to avoid, minimize and mitigate any adverse land acquisition and resettlement impacts to the communities to be affected by the project. Most of the terminals are on GoB land, but proposed launch terminal facilities will require approximately 2.093 ha land acquisition, which is minimal compared to the overall benefits and influence area of the project. The proposed 06 vessel shelters are planned to be constructed on public land to avoid any negative impacts on the population near project sites. The EIA study findings indicate that area wise land value is different in various regions based on access to service facility and transport-communication system. In case, where land acquisition is unavoidable, the project will ensure that replacement value in current market price of the affected land is provided to the legitimate owners. Also, structure value, compensation for trees, standing crops will be paid in current market price and business loss will be paid to the business owners for any interruptions caused by the project. The project will consider all possible options to avoid, minimize and mitigate resettlement impacts. For the situation, where land acquisition or displacement is unavoidable, a resettlement action plan will be designed based on policy matrix provided in the RPF to minimize and mitigate any negative impact caused by resettlement due to the project.

If required (i.e. if no suitable in river dumping location is available), Dumping points or stack yards for dredge materials will be identified in consultation with the project stakeholders and

community preference. In most cases, the dredge materials will be directly moved and sold to willing buyers. The project will consider all possible means to avoid soil contamination and degradation of top-soil to avoid adverse impacts on agricultural production.

The Project Implementation Unit (PIU) of the Bangladesh Inland Water Transport Authority (BIWTA) will arrange land for disposal of the dredged materials following GoB law i.e. Acquisition and Requisition of Immovable Property Ordinance 1982 (Ordinance No. 2) and subsequent amendment until 1994. The land will be requisitioned through the concerned Deputy Commissioners of the project districts. The PIU will pay the required amount to DC office as per law as required for renting/leasing for the particular land for the sand deposition. DC office will annually assess the rent for the land and claim fund from the PIU to disburse to the lessees.

In case, where land acquisition is unavoidable, the project will ensure that replacement value in current market price of the affected land is provided to the legitimate owners. Also, structure value, compensation for trees, standing crops will be paid in current market price and business loss will be paid to the business owners for any interruptions caused by the project. The project will consider all possible options to avoid, minimize and mitigate resettlement impacts. For the situation, where land acquisition or displacement is unavoidable, a resettlement action plan will be designed based on policy matrix provided in the Resettlement Policy Framework (RPF) to minimize and mitigate any negative impact caused by resettlement due to the project interventions.

A lease agreement would be signed between the PIU and the land owners according to the broad principles as under-

- DC will identify the actual owners of the proposed land taking into account of the record of rights to the property
- Rent would be paid through the DC office on yearly basis at the beginning of the year
- Land will be used for project purposes only (sand deposition)
- Land will be restored to original condition and returned to the land owners after agreed lease period.

The lease agreement will be based on requisition of land.

8.4.2 Impact on livelihood sources

The people of the area are looking forward to earn their livelihood by establishing shops, temporary and permanent businesses etc. after implementation of the project. It goes without saying that there will be a kind of dynamicity throughout the project. Some people will search out their livelihood by working in ferry ghats and proposed storm shelters. When it will be put into practiced all over the river way, a large number of people can get an opportunity to be appointed there. Ghats and terminals related markets are the hearts of economy of local population. If it is possible to expand the market place then a large numbers of peoples will reconcile their livelihood with new hope and they can enlarge it by investing more capital. Some of these markets play an active role in regional or even national economy.

In Harina ferry ghat approximately 500 fishermen are leading their lives by catching fishes. Chairman ghat (Boyar char) is providing livelihood opportunity to a large number of fishermen (about 15,000-20,000). The fishermen near Hatiya and some other char area have been enthusiastic about dredging as the fishermen community depend a lot on river transport system for fishing as well as transporting the fish to the markets. Some river sites lose navigation during low tide, which causes difficulties to the fishermen. On the other hand, some fishermen expressed their concern that dredging causes distortion to regular fish habitats and some fish might migrate to other spots due to dredging.

The population of Bangladesh depends on wild fish for food and the generation of income. A large portion rural family are engaged in part time fish capture from the rivers and beels. Until 70s, there was an abundance of fish in the natural waters of the country to well-satisfy the demand. In recent years, however, capture fish production has declined to about 50%, with a negative trend of 1.24 % per year (Ahmed, 1995). In spite of these in 2013-14, Bangladesh has produced 3548115 MT fish of which 83.22% and 16.78% comes from inland and marine fisheries respectively (FRSS, 2015).

Fishermen comprise a major portion of the inhabitants by the riverside in this project area. They catch fish all the year round. Although they have some modes of established system of their product transportation, this project will add a new dimension in the fish trade as it will develop the navigation as well as port management through vessel shelter construction. However, agriculture (excessive removal of surface water and abstraction of groundwater for irrigation), pollution (domestic and industrial), and unregulated discharge of untreated industrial and farm effluents, habitat destruction also have significant impact, as does the regular over flooding and lack of flooding rain in the last few decades (Hossain, 2014).

The present study has identified an ethnic community named *Bede* in Dakatia River (a tributary of Meghna River in Chandpur). They are living here for round 100-150 years following their ancestors. Their daily income is about BDT 300-500. Their main occupations are fish capture and selling. No proper sanitation system has been developed for them. Their children get no schooling facility. They drink river water by mixing with Alum. There is several floating net culture's evidence in the Dakatia River. Though it is under culture practice, some people are still making money out of it. Tilapia and carp species are mainly cultured in this system.

In Horinaghat, fishermen stated that, they usually eat the small fishes (Bacha, Dain, etc.) of the net and sell the big fishes (Hilsa, Pangus, etc.). Another important living source among the fishing communities is the net sewing. A consultation meeting with local residents of Choumohuni, Barisal revealed that, if vessel shelter is made here, a lot of people will earn money for their livelihood and will contribute in this area's economic status. Most of the fishermen near this area are in debt from different loan providers (ASA, Grameen Bank, BRAC, Podokkhep, etc). This same situation was observed in Daulatkhan, Bhola where some families were recorded to leave their home and fishing boat to escape from the loan supplier's reminder. This has become a common phenomenon in the fishermen's village. Katha fishery (a special type of fishing, practiced in Bangladesh to aggregate fish in a certain place of open water) is also a temporary subsistence option for some people around the area. This practices

were quite familiar in Dakatia river, Koroitola Khal (a tributary of Kirtonkhola river, Barisal), Shitalakhya river (less common than the previous two). One of the main problems was lack of capital for buying fishing gears and craft. Most of the fishermen are Muslim in religion but Hindu are another significant group. Fishermen are engaged in fish catching in the Meghna River throughout the year. January, February, March, April are almost dry season. At that time water level was very low and riverine environment is not suitable for the growth of fish. So, during this period fish were not available (Mia *et al.*, 2015). Fishermen basically change their income source then; to labor based other works at their locality. Almost all fishermen community is disadvantaged in social capital such as the networks, groups, trust, access to institutions etc. There was poor existence of social organizations in the surveyed areas. Lack of social capital has affected socio-economic condition of poor people in fishing communities (Mia *et al.*, 2015).

The government of Bangladesh has adopted a programme to protect *jatka* in 2003-04 to ensure sustainable *Hilsa* production. By this programme, *jatka* catch, sell, carry and transport has been prohibited during 1st November to 31st May (7 months). It is not unlikely that *jatka* fishers earn their livelihood by selling *jatka* and they do not have any alternate source of income. That's why the government has given special importance this year for alternate sources of income for *jatka* fishermen so that they can earn their livelihoods by some other means during the 'no catch period' of *jatka*. For the rehabilitation of *jatka* fishers there was a programme named '*Jatka* Protection and *Jatka* Fishers Rehabilitation Programme'. A total of Tk.2.00 crores/year has been allocated for rehabilitation of *jatka* fishermen during the years 2008-2010. Beside this programme a project named "*Jatka* Conservation, Alternate Income Generation for the *Jatka* Fishers and Research Project" has been implemented within *jatka* available and sanctuary surrounding *upazilas* for giving alternate income generation activities during the ban period. As this rehabilitation programme was implemented and it helped their livelihood, this made it comparatively easy to keep the fishermen away from catching *jatka*. This project covers 21 *upazilas* of 4 districts. Through this project the Government has allocated 10,000 Tk for each *jatka* fisheries to maintain their family during the *jatka* catch ban period since the project started.

The Government initiated to help the fishers affected by *Hilsa* ban which includes rice provision through VGF (vulnerable group feeding) per household for four months during the ban period in order to mitigate the sufferings of the fishermen. This programme has started since 2004-05. Programme has covered 85 *upazilas* of 15 districts for each year (Ahsan *et al.*, 2014).

According to Mondal *et al.* (2013) in Lakshmipur (Ramgati upazilla) of Lower Meghna a total of 82% of fishermen are professional and 18% are seasonal where 25500 fishermen in this area are dependent on the riverine fish for their livelihood and protein supply. The study also states that, two types of fish marketing channel exist in the study area. In first type (84%) involving fishermen to directly consumers and 2nd type (16%) involving three intermediaries (*aratdar*, *wholesaler* and *retailer*). During the peak season, the monthly incomes of fishermen were adequate and the range was 5000 to 30000 BDT. But during the lean period their income became low and even zero. 80% fishermen are fishing with boats (Consider as one

unit) and the rest without boats. This underprivileged group of people of our society is the basement of our national protein demand.

A large market of vegetables takes place in Chandpur Sadar launch ghat. There are more or less 1000 business shops located there. Most of the vegetables are coming from the chars by boat. The people of this area will get new hope to work in the new proposed river way. Better transportation always promotes business and industrialization and local traders and business owners are enthusiastic to the project for this opportunity.

Ashuganj, Mozu Chaudhuri Ghat, etc. have been playing a major role in transporting construction materials and receiving international goods. The project will create more opportunity for the people in terms of employment and income. From the consultation findings, in Ashuganj ferry ghat, about 1500-2000 labourers work in a day. In this case many employment opportunities can be generated there and the community will have new dimensions in terms of occupation. Many mobile vendors of vegetables, raw materials, fruits, etc. are dealing in these ghats, jetties and terminals. This opportunity will grow more when the project will be implemented. Therefore, developing the terminals by extending its capacity and efficiency will directly enhance local economy in each case. It means after implementation of the project, these terminals can attract a massive number of people for their livelihood. Here GoB will get more revenue from the ghats once business units are increased.

The operators/crews of water vessels advised the project to include improved river traffic system by inclusive development of signaling across the river routes. Safety is a major concern of the vessel operators and passengers. Better navigation system will remarkably improve safety and security of the vessel users. This may also create provision to divert some laborers to new occupational groups after implementation of the project. Vessel operators, country boatmen, fishing boat owners and operators, lessees of the terminals will continue livelihood with better pace after completion of the project. Some ghats, terminals, jetties, ferry crossing routes are in vulnerable state; these should be constructed as early as possible on priority basis. It is expected that a massive progress will come forward in their livelihood after completing the planned interventions. The project will promote advancement of the infrastructure in the river routes and proposed locations. Development of infrastructure will amplify the livelihood and increase the income as well as standard of living of local people.

So, colossal positive impacts will come to all walks of people in their daily livelihood through all along the river route. According to people's opinion there will be no negative impact of the project on livelihood. The proposed launch ghats /vessel shelters will offer fresh income and livelihood opportunities and can play a major role in economic development of the surroundings.

8.4.3 Impact on boat/ Vessel traffic

Floating pipe is the only means of discharging dredged materials followed in navigation dredging in Bangladesh. Deployment of dredger, ancillary crafts, placing of floating pipes and shore pipes disrupt uninterrupted traffic. These occupy most part of the channel and leave

a narrow lane for other vessels or boats to negotiate. Most of the cases, this lane is so narrow that allows a one-way traffic with caution. Such cases increase transportation time.

Again, some channels are so narrow where after deployment of dredger and placement of floating pipe lines leave no room for vessels to move. In such events, traffic remains closed during dredging. This happens in case of Bamnirchar in the Chandpur-Barisal route and in some ferry routes.

Deployment of dredger and placement of floating pipe lines is also a potential threat of accidents. There are instances of such accidents caused by dashing of vessels to dredger, ancillary crafts or pipe lines.

Mitigations

Prior consultation with the relevant stakeholders including notification, arrangement of safety measures to avoid accidental collision and proper planning as well as involvement of public representative shall be in place to avoid major disturbance to riverine traffic.

8.4.4 Public Health Impacts and Safety Issues

Construction phase activities associated with dredging and disposal activities may affect noise, air quality, safety of personnel and have the potential to increase disease vectors such as mosquito and biting midges. These Project variables may potentially affect the wellbeing of the surrounding community and each is discussed in more detail below and section references made where appropriate.

Noise Level Impacts

People have widely varying reactions to noise. The key areas of concern to the community in relation to noise pollution from dredging and disposal activities are as follows:

- Annoyance, reduced quality of life;
- Sleep disturbance;
- Performance and learning of school children;
- Cardiovascular disease;
- Mental health; and
- Neuro physiological stress.

Predicted noise levels generated from the construction of the Reclamation Area complies with site- specific noise criteria for all identified noise sensitive receivers and due to the distances between the site and any receivers, noise and vibration impacts will likely be insignificant.

Air Quality Impacts

The main air quality impacts from dredged material reclamation activities will be vehicle emissions consisting of nitrogen oxide (NO_x) compounds, dust and particulates due to vehicle movement on unsealed areas. Dredging will also result in exhaust emissions from the dredgers, however, these impacts will be transient and will not result in a permanent, long term change to air quality in a particular locality.

Particles are a broad class of chemically and physically diverse substances. They exist as discrete particles spanning several orders of magnitude in size, 0.005 to 100 µm. Epidemiological studies show a correlation between exposure to particles and adverse health effects. At this time there is no conclusive evidence regarding the role of particle size and health effects, however different sizes may be important for different health outcomes. There is no threshold concentration established for particulates or different size ranges amongst particulates below which adverse health effects will not be observed.

Dust impacts to the sensitive receiver during construction of the reclamation area are unlikely to be of concern due to separation distances and the moist nature of the dredged material being used for the reclamation. Exposure to nitrogen dioxide (NO₂) has been associated with increases in daily mortality, hospital admissions and emergency room attendances for cardiovascular and respiratory disease, increases in respiratory illness and symptoms and decreases in lung function. The elderly, asthmatics, children and people with existing disease are particularly susceptible to the effects of NO₂. Material which has been dredged and relocated to the reclamation area may release odours. Hydrogen sulfide (H₂S) generated by the decay of organic material within the dredged material is the principal cause of potential odours. The nature of the material to be dredged and the proximity of the reclamation to populated areas and exposure of construction workers are the main aspects that will determine if odour is an issue for this project.

Mitigations

- Inspect and maintain equipment in good working condition. Proper maintenance of engines ensures full combustion with low soot emissions.
- Use low-sulphur heavy fuels to reduce noxious emissions.
- Provide exhaust filtering.
- Gaseous emissions to be monitored monthly (visual monitoring daily) and emissions should be within limits as prescribed in the DOE air quality standards

Impacts of Reclamation Construction

As a result of the filthy environment brought about by unplanned disposal of dredged materials and indiscriminate refuse dumping at reclamation sites, there could be an increase in the prevalence of communicable diseases. These refuse collections could contaminate surface soil and underground water, attract breeding of houseflies and act as sources of occurrences of diarrhoeal diseases such as Typhoid and Cholera. The waste heaps can also serve as breeding sites for mosquitoes and consequently increase the prevalence of vector borne diseases. Such breeding sites would have both indirect and direct impact on the epidemiology of malaria in the city and the health systems.

Though dredging brings about an improvement in flow of water and its speed, it may lead to an increase and change in pattern of the epidemiology of diseases associated with fast flowing rivers such as Meghna.

Mitigations:

Dredge material management plant is prepared and implemented and OHS plan will be implemented by contractors on the basis of the WBG EHS Guidelines (2007) and ECoPs.

Impacts from Contaminated Disposal

The conceptual model defines individual risk scenarios. For chemical risk assessment, the only scenario to consider is the ingestion of contaminated fish or shellfish.

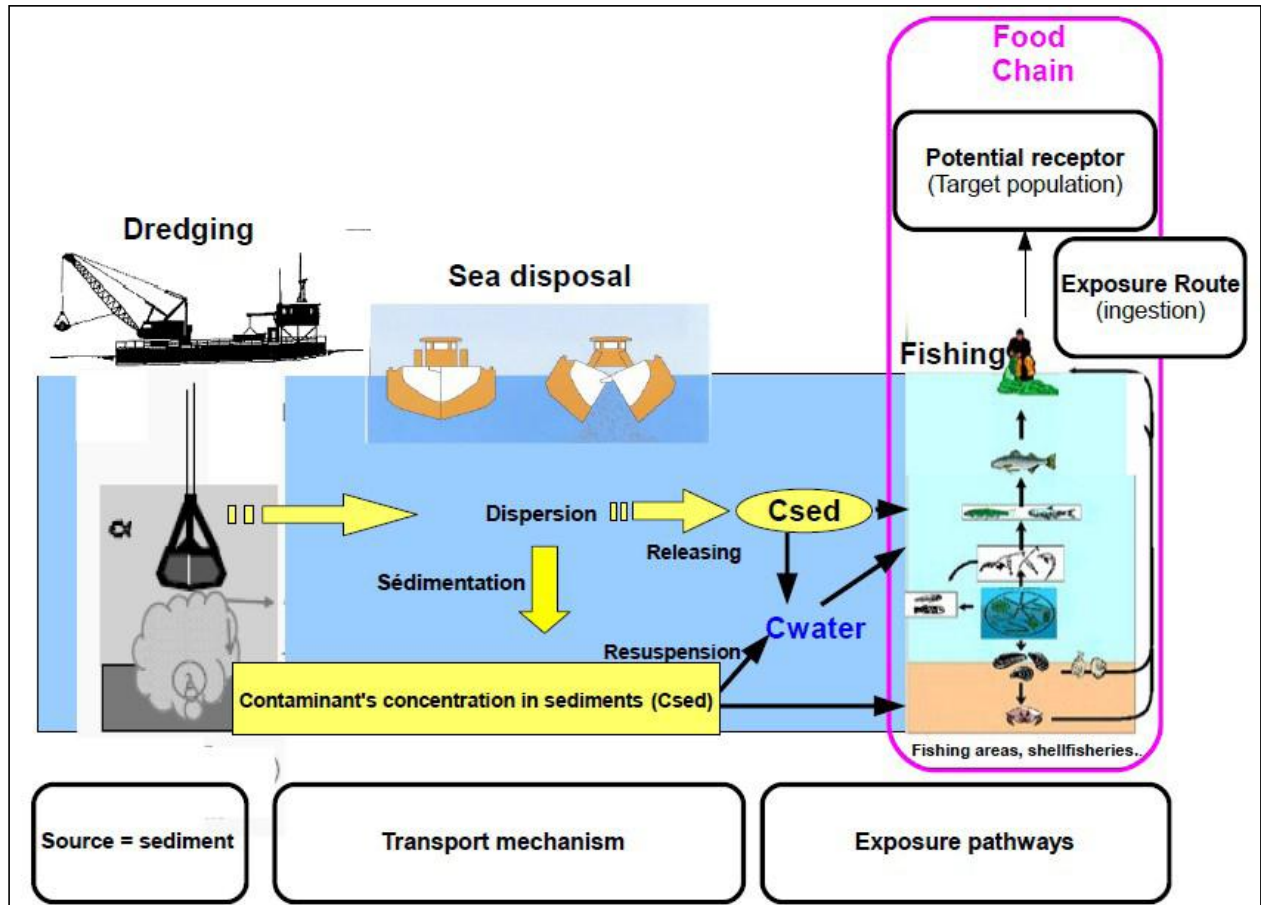


Figure 8-14: Exposure of contaminated river bed sediment due to Dredging

Mitigation

- Always maintain the noise level within the national standard during construction period.
- To reduce the noise impact contractor should not work at night time near the settlement area.
- Air emission from construction activities should comply with the national guidelines as stipulated in Table 5.18.
- Regularly check and repair the faulty equipment if found to minimize the noise and air pollution.
- Dredge material is not likely to be contaminated; if contaminated then it will be disposed in-river. Only in exceptional circumstances, if in-river locations are not available, would contaminated dredge material be brought onshore. In such cases, it will be isolated and disposed at proper site to be identified in consultation with relevant stakeholders to be used for land reclamation.
- Reclamation site should be restricted for local people until it is declared to use for general people.
- Observance of ECoPs, OHS Plan and dredge materials management plan.
- Continue liaison and provide information to relevant community leaders, stakeholders and potentially affected communities.
- Provide adequate training to staff to operate equipment, to carry out dredging, and to transport dredged material

8.5 Impacts from Inland Water Transport

8.5.1 Development of Efficient and Environmentally Friendly Transport

Inland water transport (IWT) is a competitive alternative and addition to road and rail transport, offering a sustainable and environment-friendly mode of transport in terms of energy consumption, noise and gas emissions. IWT is also often the most economical inland transport mode due to low infrastructure and external costs – a characteristic of crucial importance. However, IWT is often still under-used and suffers from infrastructure, institutional, legal and technical barriers, which call for pro-active policies by Governments and international bodies.

Almost 100% respondents have willingly welcomed the project considering it's magnitude and ultimate result. Majority of them stated during consultation and survey that there will be no negative impact due to the project. Participants from Ashuganj, Shadarghat, Munsiganj, are enthusiastic about the project as it will improve transport system across the country and international river transport channels including playing a major role in transporting goods from India and other cross border countries. Project will also facilitate better transportation among three sea ports. Some of them were concern about unplanned dredging, which may cause erosion at some locations and therefore homesteads and agricultural field may become victim of unpredictable erosion.

The rivers of Bangladesh have played a major role in overall development of the country. Each river has offered biodiversity to its connecting region, enriched the topsoil for cultivation and many other direct and indirect benefits in addition to providing complete livelihood for the contiguous communities. There are potentials that have improved various industrial hubs along the neighboring areas. A profusion of industries have been constructed bordering the rivers, which have become intimidating to the environment. For example, fertilizer, cement, dyeing factories along the major rivers have contributed to environmental hazards through unrefined disposal of chemical directly to river, noise and air pollution, etc.

The river ports and terminals possess employment and livelihood opportunities for thousands of households. For example, the Mozu Choudhuri ghat itself has 500-600 shops focusing on the inbounds and transport facilities of the ghat. Local produces like coconut, areca nuts (*'Shupari'*) and other agricultural products along with construction materials are transported through the ghat. Therefore, developing the terminals by extending its capacity and efficiency will directly enhance local economy in each case.

Shatnal, Dakatia (Boro Stationtek) launch terminals can promote great tourist spots in the surrounding for national and international tourists based on barely the natural resources and scenic beauty of the adjacent rivers. River routes can assure ultimate comfort packages that the tourists would admire without the hustle of traffic congestion through road transportation.

Previous studies comparing road, railway and water way indicates that the water based transport system produce lowest amount of greenhouse gas, makes least noise pollution and is the cheapest way of traveling throughout Bangladesh. Therefore, the proposed project initiatives can play a major role in promoting an eco-friendly transport system in the country. However, the project should take account of potential environmental hazards through awareness raising and minimizing any possible negative impacts. Project scopes may also be extended through involving other government agencies like fisheries, agriculture, etc departments and developing a collective panel to ensure environmental sustainability of our rivers. The environment team will elaborately scrutinize these issues.

8.5.2 Environmental Impacts of the Inland Water Transport

Transport has several impacts on the environment. Emissions contribute to air pollution and climate change, noise causes nuisance and health risks and infrastructure has serious impacts on landscape and ecosystems. In addition to these impacts on the environment, transport has also other severe impacts on society. Every year hundred thousands of people are killed and injured in accidents and in various densely populated areas; high congestion levels result in time losses.

Technical and economic developments during the last decades have significantly increased the mobility of people and goods. As a result, the transport sector has undergone dramatic expansion during this period. In order to achieve long-term sustainable development, new demands are placed on transport sector actors to promote greater environmental compatibility both individually and jointly.

The distribution between various transport modes has a considerable bearing on the sector's environmental impact. Comparative assessment of the environmental impact from different

transport alternatives is complicated, due to the fact that environmental problems from different modes of transport are of differing dimensions, and most of these effects are difficult to quantify.

In the next subsections we briefly explain the main environmental impacts of transport:

- Impacts from greenhouse gas emissions on climate change.
- Impacts from pollutant emissions on various problems related to air quality.
- Health and nuisance impacts from noise.
- Impacts on landscape from infrastructure.
- Impacts on biodiversity and ecosystems because of infrastructure fragmenting natural habitats.
- Impacts on water quality.
- Impacts on soil quality.

Climate Change

Climate change is one of the great challenges of current society, a global environmental problem. In the last decades there has come more and more evidence that the emission of greenhouse gases contributes to the effect of global warming. Transport makes a considerable contribution to the greenhouse effect. For the transport sector, the greenhouse gas emissions are dominated by the carbon-dioxide (CO₂) emissions from burning fossil fuels. Carbon-dioxide emissions from transport are increasing, and are expected to increase in the future. Emissions of greenhouse gases are an extremely relevant issue when it comes to our choice of transport means.

The Intergovernmental Panel on Climate Change (IPCC) has examined a range of future climate change scenarios and found that the globally averaged surface air temperature is projected by models to warm 1.1 to 6.4°C by 2100 relative to 2000, and globally averaged sea level is projected by models to rise 18 to 59 cm by 2100. The warming is expected to vary by region, and to be accompanied by changes in precipitation, changes in the variability of climate, and changes in the frequency and intensity of some extreme climate phenomena (drought, flooding) as well as impacts on ecosystems, and diseases.

The amount of CO₂ emissions, which are particularly relevant for climate change, can be directly derived from the amount of energy consumption. These emissions result from burning of fuel by motors of trucks, diesel locomotives and vessels. For electrical locomotives, emissions are caused by corresponding power generation. The lowest CO₂ emissions per unit of energy occur with electrical trains. Their future development depends on the structure of primary energy used for electricity generation. As regards trucks and inland ships, future emissions depend on the development of specific fuel input.

In case of water transport, the main load derives from the vessel's engine. This is used mainly to provide power to drive the vessel, to cool the products, to operate the ship's equipment, and to ensure the needs of the staff. The engines of the vessels keep running while mooring,

providing power for loading and material handling. Air pollution also derives from the internal material handling at the ports, as well as from the energy use connected to the operation of the port, e.g. heating.

Calculations have been prepared for selected origin-destination (OD) pairs (routes). Clearly, the highest specific CO₂ emissions are caused by road trucks. This remains valid if the additional collection and distribution transport by trucks is considered for containers carried by railways or ships on their main route section. For five of eight analysed bulk freight transport cases, inland shipping causes lower CO₂ emissions than railways. As regards container transport in the Dhaka-Chitagong corridor, the CO₂ emission per TEU (twenty-foot equivalent unit, a measure used for capacity in container transportation) of inland shipping is by 19% to 55% lower than for railways.

Air Pollution

Transport-related air pollution causes damages to humans, biosphere, soil, water, buildings and materials. The most important pollutants are the following:

- Particulate matter (PM_{2.5}, PM₁₀);
- Nitrogen oxides (NO_x);
- Sulphur oxide (SO₂);
- Ozone (O₃);
- Volatile organic compounds (VOC).

The emissions of pollutants give rise to health costs, building/material damages, crop losses and costs for further damages for the ecosystem (biosphere, soil, water). Each impact is related to one or more type of pollutants:

- *Health impacts:* Impacts on human health due to the aspiration of fine particles (PM_{2.5}/PM₁₀, other air pollutants). Exhaust emission particles are hereby considered as the most important pollutant. In addition, ozone (O₃) has impacts on human health. The main health impacts are increased health problems for people who suffer aspiration diseases and a higher risk for anyone to get such a disease.
- *Building and material damages:* Impacts on buildings and materials from air pollutants. Mainly two effects are of importance: soiling of building surfaces/facades primarily through particles and dust. The second, more important impact on facades and materials is the degradation through corrosive processes, due to acid air pollutants like NO_x and SO₂.
- *Crop losses in agriculture and impacts on the biosphere:* crops as well as forests and other ecosystems are damaged by acid deposition, ozone exposition and SO₂.

The main impacts are the health impacts mainly caused by particulate matter (PM) from exhaust emissions or transformation of other pollutants. There is increasing evidence that in particular ultra-fine particles have severe health risks.

Unlike the climate impacts of CO₂, the impacts from air pollutant emissions depend on the location. Air pollutants that are emitted in densely populated areas cause considerably more harm than pollutants emitted in remote areas.

Numerous studies have prepared extensive estimates of pollution caused by road and railway transport. Inland shipping gained less attention, and related estimates are based on highly aggregated figures. Such calculations referring to the aggregated vessel fleet do not allow reliable conclusions.

The level of exhaust emissions by trucks depends largely on the traffic situation. With growing level of traffic disturbances, exhaust emissions per vehicle-km increase significantly. Exhaust emissions of electricity-powered railways depends on the structure of primary energy used for electricity generation.

Electricity-powered railway transport causes clearly lower pollutive emissions than road and ship transport. Accordingly, the external costs of air pollution caused by railway transport are significantly lower than those of competing modes. When comparing inland shipping with road transport, there is a clear advantage for ship transport¹³.

Waterborne transport contributes significantly to the emission of air pollutants, both locally and globally. The local effect primarily occurs in port areas. The sources are the same as the CO₂ sources responsible for climate change; however, the amount of emitted pollutants - mainly SO_x, and diesel particulate matter - depends heavily on the quality of the fuel used. The bunker fuel that is mainly used in shipping causes a much greater environmental impact than the diesel used in trucks and trains.

Concerning the local effects, the onward transport of goods is an important issue, i.e. the land transport (road, rail) connections of the port. The distance of the port and the transport routes from the residential or other sensitive areas is also an important question.

Noise Impacts

Traffic noise has a variety of adverse impacts on human health. The World Health Organization (WHO) has recognized community noise, including traffic noise, as a serious public health problem. The effects are often indirect and combined in a pattern of interacting factors. The most widespread effect is simply annoyance. In addition, there is substantial evidence for serious health problems caused by traffic noise. The main problem is disturbance of sleep patterns, which affects cognitive functioning (especially in children) and contributes to certain cardiovascular diseases. There is also increasing evidence for an impact of noise raising blood pressure.

The degree of noise from different modes of transport differs. The frequency of the noise, the location of the source and variations in the level of noise all affect the experience of it. Sensitivity to disturbance varies considerably from person to person. Disturbance depends on the sound level at the time and the number of noise events, their duration, the time and the situation of the individual when exposed to noise.

The difference of noise emissions per unit of freight, between road and rail, measured along road/railway lines is only small. However, noise from rail transport has a lower subjective nuisance level of the same average level of physical emission compared to noise from road

¹³ BFG & PLANCO Consulting GmbH (2007), Economical and Ecological Comparison of Transport Modes: Road, Railways, Inland Waterways

traffic. Inland shipping causes only lower emissions, with a difference of -10 dB(A). This difference represents 50% lower emission loads as perceived by people¹⁴. Inland shipping is not seen as a relevant noise polluter, because emission factors are comparably low and most of the activities occur outside densely populated areas. Marginal noise costs due to maritime shipping and inland waterway transport are assumed to be negligible¹⁵.

Noise emission from shipping has an impact both on human population and wildlife. The impact on wildlife is dominant near the waterways, as these often lead close to protected natural areas. The impact on the population mainly appears in the vicinity of ports, connected partly to road and rail connections, and to internal material handling. The noise emission of the engines of mooring vessels has to be considered as well.

The noise emissions of ships can be reduced by using modern engines. The optimal choices of speed, traffic management reducing acceleration and deceleration also have a positive impact on this load.

Noise emission within ports and near access roads can also be reduced by measures used to mitigate the emissions of CO₂ and other pollutants. Construction of bypass roads or noise barriers can in some cases also lower the noise impact of access roads.

The time and location of noise emission is an important issue. Emission during the day has a different effect than the same emission during the night, or over the weekend. This has to be considered when designing the operational regulations of the port and it should be enforced at the rail and road links of the port as well. The activities with higher noise pollution and the cargo operations during the night should be carried out at more remote areas of the port from the populated areas.

Mitigation:

- Reduce the dredger noise at source by isolation of exhaust systems, by keeping engine room doors shut and by additional measures such as shielding.
- Limit the noisy dredging to daylight hours, where possible, rather than at sunrise or sunset (significant for wildlife) or during night time hours. Where unavoidable, the contractor should ramp up the levels of engines or other noise producing sources, so that the noise slowly increases. This will encourage riverine and terrestrial fauna to move away from the source area prior to significant noise emissions.
- Inspect and maintain equipment in good working condition.
- The noise emissions of ships can be reduced by using modern engines. The optimal choice of speed, traffic management reducing acceleration and deceleration also have a positive impact on this load.

¹⁴ BFG & PLANCO Consulting GmbH (2007), Economical and Ecological Comparison of Transport Modes: Road, Railways, Inland Waterways

¹⁵ Maibach, M., et al. (2008), Handbook on estimation of external costs in the transport sector - Produced within the study Internalisation Measures and Policies for All external Cost of Transport (IMPACT), CE Delft, Delft, the Netherlands.

Water Quality

Transport activities have an impact on hydrological conditions. Fuel, chemical and other hazardous particulates discarded from aircraft, cars, trucks and trains or from port and airport terminal operations can contaminate groundwater, rivers, lakes, wetlands and oceans. Water transport emissions represent the most important segment of water quality inventory of the transportation sector. The main effects of water transport operations on water quality predominantly arise from dredging, waste, ballast waters and oil spills¹⁶.

Waste generated by the operations of vessels at sea/river or at ports cause serious environmental problems, since they can contain a very high level of bacteria that can be hazardous for public health as well as aquatic ecosystems when discharged in waters. Besides, various types of garbage containing metals and plastic are not easily biodegradable. They can persist on the water surface for long periods of time and can be a serious impediment for navigation in inland waterways and at sea and affecting as well berthing operations.

Major oil spills from oil cargo vessel accidents are one of the most serious problems of pollution from inland water transport activities.

Mitigation:

- Select dredging equipment and methodology with low risk of sediment dispersal.
- Monitor local suspended sediment concentration by sediment sampling and laboratory.
- Regularly inspect and maintain equipment in order to prevent leaks. Develop and implement a Spill Prevention Plan to prevent and contain accidental spills, monitor sediment spill.

Operational Oil Pollution

Ships are designed to move safely through the water when they are filled with cargo. When empty, they fill their tanks with ballast water in order to weigh them down and so stabilize them as they cross the ocean. Before entering the port where they are to load up, they discharge the ballast water, whose weight will be replaced with freight. The water discharged is typically somewhat unclean, being contaminated with oil and possibly other wastes within the ballast tanks. Its discharge is therefore a source of water pollution. It should be noted, however, that segregated ballast tanks, which are required on newer tank vessels, reduce or eliminate the oily ballast problem. A similar source of pollution is bilge water; this is seepage which collects in the hold of a ship and must be discharged regularly. On oil tankers the bilge water is typically contaminated with oil which seeps out of the cargo tanks; thus this is also a source of oil pollution. Such discharges are referred to as “operational” pollution because they have long been considered a part of the normal operating procedures both of oil tankers and of other ships managing their fuel.

¹⁶ Rodrigue, J-P, C. Comtois and B. Slack (2009), *The Geography of Transport Systems*, Second Edition, New York: Routledge.

Mitigation:

- Refuel of barges and boats with a proper care to avoid any spills.
- Make available spill kits and other absorbent material at refuelling points on the barges
- Develop and implement spill contingency plans for pipeline and hull leakages. Ensure that emergency response equipment, e.g. floating booms, are serviceable and available to deal with any oil spills or leakages.

Solid Waste Disposal

The disposal of plastics at sea is a significant source of environmental harm, since the materials are both buoyant and persistent. Debris is generally of several types. Fishing boats discard old nets and lines, frequently made of plastic. Freighters accumulate and sometimes discharge materials used to pack break bulk freight to keep it from shifting as the boat moves. This material, called dunnage, is typically either wood or plastic.

Discarded plastics pose a threat both to rivers species and to coastal regions. Discarded nets carry out so-called "ghost fishing", continuing to trap animals as they drift through the water. Bands shaped packing materials can encircle aquatic mammals, fish, or birds, forming a girdle which tightens as the animal grows. Aquatic organisms also ingest plastics, which can kill them or reduce the nutritional value of their food intake. Wood used for dunnage, if not grated or pulped can damage small boats which run into it.

Mitigation

- Enforcement of national and international regulations e.g. Management Regulations on Preventing Vessels from Polluting Marine Environment.
- Solid waste are forbidden to be discharged into the rivers, and must be unloaded to the nearby waste treatment facilities for treatment.
- Protocol to be developed by the contractor and approved by the BIWTA and DOE for waste management.

Impact of increased waving

Waterborne traffic increases surf, which causes problems primarily on the bank. Surf threatens the wildlife of the riparian zone, especially invertebrates and juvenile fish. The coastal vegetation may be affected as well, as reeds do not tolerate continued strong waving.

Mitigation

Limit speed of water borne traffic at sensitive locations by less than 10 Knots/hour.

Introduction of foreign species

Waterborne transport can result in the introduction of foreign species to new territories, a part of these travels on board, or within the cargo, and spread to the area. Thus, parasites, bacteria, or other organisms can appear in a particular area, infecting or expelling native species, weakening biodiversity. This process can be controlled by quarantine rules, but their effectiveness is questionable.

Other foreign species are carried to new territories stuck to the hull or in ballast water, causing environmental problems there. This problem is related specifically to waterborne transport.

Mitigation:

- Strict observance of national and international rules related to disposal of ballast and bilge water.
- Biological/chemical/mechanical control of introduced foreign/invasive species.
- Regular monitoring of water quality including analyses of planktons and Benthos.

8.5.3 Risk of Accidents and Collisions

Accidental Spills

Spills from waterborne vessels are one of the major sources of water pollution from shipping. They are of several types. Cargo spills frequently occur while loading or unloading in port, due to handling errors or equipment problems. Such spills are typically relatively small in volume. They may be of any kind of cargo, though petroleum products (primarily cargo rather than fuel) and other chemicals are most common. Spills of non-hazardous cargo are more common than spills of toxics or flammable materials, because the precautions taken in handling dangerous products tend to promote much greater vigilance and far fewer careless spills.

Much less common, but potentially more dangerous, are cargo spills which occur when a boat runs aground or breaks up in bad weather. Such disasters typically occur when boats are moving into or out of ports or in other restricted areas, where there is little or no room for maneuvering or going off course in case of bad weather. In comparison, in the open ocean, boats can handle storms or high winds with little risk of accident, because if they are blown off course they are unlikely to run into anything.

Collisions of Ships

Inland waterway traffic records an ever increasing traffic density. Consequently, new channels are being built and new solutions are being found in order to enlarge inland waterways, etc.

The safety of waterways is considered satisfactory if they are regularly maintained, if they possess accurate necessary signs, if they possess the means to facilitate navigation such as, for example, River Information System - RIS, Vessel Tracing System - VTS, Electronic Charts Display Information System - ECDIS, Automatic Information System – AIS etc. Apart from the abovementioned factors, the accident statistics done for waterways with satisfactory level of safety and observed through a longer time period should provide data on accidents that occur rarely.

Despite the vastness of the IWT network, it has many problems associated with safety and navigability. Natural obstacles cause a lot to inadequate navigability, as well as to marine disasters. It is a painstaking job to find the permissible routes for navigation, as routes vary in a wide range with the change in seasons. During the monsoon, the navigable inland waterways are approximately 5,968 km in length, which however, decrease to 3,600 km in

dry seasons¹⁷. The problem gets intensified due to alluvial deposition, which is profoundly caused by geographical position of the country, deforestation and unplanned construction of dikes and embankments in the coastal region.

As the country is located in the vicinity of the nadir of the Himalayas, which is comparatively young and vulnerable to soil losses due to both natural and man-made causes, high rate of sediment transport is prevalent here. Since the river gradient within Bangladesh is very low, a significant amount of that sediment load cannot be naturally transported to the Bay of Bengal and is deposited on the river beds, as well as flood plains, each year. The Ganges River mobilizes a total of 729 megatons of sediments annually through a narrow zone within its river valley. Under the present hydro-geological conditions, the river sedimentation is climatically controlled and is predicted to produce a 2000 km long, 2 to 40 km wide and 25 to 50 m thick ribbonshaped, well-sorted symmetrically skewed fine sand body. The river Ganges is marked by its second highest siltation rate in the world. The current situation of the waterways demands for a prominent dredging service. Annual dredging demand in core waterways network is estimated as 18 million cubic meters, while the annual productivity of the dredgers, currently in work, is 6.36 million cubic meters only. This is due to the dearth of dredgers as well as the aged state of most of the dredgers, resulting in reduced efficiency. Due to low budget allocation, hydrographic surveys to all classified waterways remain impossible. Only a limited number of navigation routes of 965 km, 16% of the total, were surveyed in 2006-07 according to a need-based priority. Thus, due to all the shortcomings stated above, the current classification system of inland waterways is believed to outlive its usefulness. Navigational aids like beacons, lighted & unlighted buoys, iron & bamboo marks etc. are used to mark shoals, while channel bends, shallow patches etc. are used in waterway routes for the vessel safety. Observation at various river ports exposed that the intense traffic density in the ports prevent the vessels to berth alongside the pontoon and persuade them to resort to nose berthing. Due to acute congestion, the vessels keep colliding with each other recurrently, causing damage to the fender as well as the hull. These collision events are often ignored as long as these do not result in human death or severe hull damage. Other hazardous effects such as crack formation and propagation, metal fatigue and so on, leading to ultimate hull damage, often seem to be underrated¹⁸.

Mitigation

- A direct investigation of accidents through an interactive system may serve the purpose of both developing an authentic and reliable accident database and updating the current fault trees.
- Regular hydrographic survey on the waterway should be carried out and the navigation aid service should be provided appropriately.
- For improved hydro-meteorological forecasting a modern station could be developed in appropriate place like Chandpur to avoid collision and accidents.

¹⁷ Huq, N.A. & Dewan, A.M. (2003). Lauch Disaster in Bangladesh: A Geographical Study, Geografia, Vol.1, Issue 2 (14-25), ISSN 0126-7000.

¹⁸ Hossain, M. T., Awal, Z. Ibn., Das, S., (2014). A Study on the Accidents of Inland Water Transport in Bangladesh: The Transportation System and Contact Type Accidents, Journal of Transport System Engineering volume 1, Issue 1, p 23-32.

8.6 Impact Assessment Matrix

Impact assessment matrix is prepared for all three project components (**Component 1:** Dredging, **Component 2:** construction of vessel shelter, cargo/passenger terminal and landing ghat, **Component 3:** Institutional Capacity Building)

For each project activity, several parameters are identified which will be directly affected or hampered. At each project activity site the parameters are ranked from -5 to +5. If activity of project component hampers, deteriorates or degrades the parameter (like water quality, noise, benthos, etc.) then it will be ranked from (-1 to -5) depending on the vitality of the degradation. If certain parameters (like navigability, ecosystem and livelihood, etc.) is improved then it will be ranked from (+1 to +5) depending on the anticipated benefits.

Now for explanation of impact assessment, dredging operation (Table 8-10) will degrade water quality temporarily due to, accidental oil spill from dredger, turbidity at the time dredging, therefore at all dredged river this parameter is ranked as “-1”. Noise level will increase temporarily during dredging operation. Navigability (enhanced as available water will increase and submerged sandbars will be dredged), fisheries resources (will enrich due to flow augmentation), livelihood (will increase as opportunities of fishermen in harvesting fishing resources will increase) and ecosystem (aquatic ecosystem will enhance as flow and exchange of nutrients will increase) will be improved therefore, these parameters are ranked positive.

Now for Component-2 (Construction of Cargo/Passenger Terminal and Landing ghat) parameter have positive impact in most of the cases (Table 8-11) such as industrialization, work opportunity, economic development, etc., because employment opportunity will enhance as economic activity will increase. However, water quality will deteriorate as numbers of vessels will increase, which increases the possibility of accidental oil spill. Sound pollution will occur as, more noise from water vessels and crowding of hawkers, passengers and other people.

Now for Component-3 (Institutional Capacity Building) all parameters are related to human resource development, therefore overall impact will be positive (Table 8-12).

Table 8-10: Impact Assessment Matrix (Component-1: Dredging)

Activity	Parameters	Aquatic Environment					Kirtankhola
		Buriganga	Dhaleswari	Sitalakhya	Upper Meghna	Lower Meghna	
Component -01 Dredging	Water Quality	-1	-1	-1	-1	-1	-1
	Air Quality	-1	-1	-1	-1	-1	-1
	Noise Quality	-1	-1	-1	-1	-1	-1
	Benthic Environment	-2	-2	-2	-2	-2	-2
	Turbidity	-1	-1	-2	-2	-2	-2
	Navigability	+4	+4	+4	+5	+5	+4
	Fisheries	+2	+3	+3	-1	+3	+3
	Fish Spawning Area	+2	+2	+2	-2	-2	+2
	Erosion and Sedimentation	+1	+1	+1	-1	-1	+2
	Agriculture	+1	+1	+1	+2	+2	+1
	Floodplain Ecosystem	+2	+2	+2	+1	+2	+2
	Charland Ecosystem	*	*	*	+2	+1	*
	Estuarine Ecosystem	*	*	*	+1	+2	+2
	Coastal Ecosystem	*	*	*	+2	+2	+2
	Livelihood	+2	+2	+2	+4	+2	+4

Table 8-11: Impact Assessment Matrix (Component-2: Construction of vessel shelter, terminal and launch ghat)

Activity	Parameters	Upper Meghna	Buriganga	Shitalakhya	Lower Meghna	Kirtonkhola	Ilisha	East Shahbazzpur	West Shahbazzpur	Sandwip Ipland
Component -02 Construction of Cargo/Passenger Terminal and Landg ghat	Industrialization	+3	+4	+3	+2	+3	+1	+2	+2	+1
	Work Opportunity	+3	+4	+3	+3	+3	+3	+2	+3	+2
	Transportation	+3	+4	+3	+2	+2	+2	+2	+2	+2
	Land price	+3	+4	+3	+2	+3	+1	+2	+2	+1
	Economic development	+3	+4	+3	+3	+3	+3	+2	+3	+2
	Urbanization	+3	+4	+3	+2	+2	+2	+2	+2	+2

Activity	Parameters	Upper Meghna	Buriganga	Shitalakhya	Lower Meghna	Kirtonkhola	Ilisha	East Shahbazzpur	West Shahbazzpur	Sandwip Ipland
	Income	+3	+4	+3	+2	+2	+2	+2	+2	+2
	Livelihood	+3	+4	+3	+3	+2	+2	+2	+3	+2
	Noise	-1	-1	-1	-1	-1	-1	-1	-1	-1
	Water Quality	-1	-1	-1	-1	-1	-1	-1	-1	-1

Table 8-12: Impact Assessment Matrix (Component-3: Institutional Capacity Development)

Activity	Parameters	Ranking
Component -03 Institutional Capacity Development	Development of River Information system	+4
	Human resource development	+4
	Enhancement of Management system	+4
	Modernization of training facility	+4
	Environmental Monitoring System	+4

Legends

+1 = Insignificant beneficial Impact	-1 = Insignificant Adverse impact
+2 = Slight beneficial Impact	-2 = Slight Adverse impact
+3 = Moderate beneficial Impact	-3 = Moderate Adverse impact
+4 = Significant beneficial Impact	-4 = Significant Adverse impact
+5 = Very Significant beneficial Impact	-5 = Very Significant Adverse impact
0 = No Impact	

9 CUMULATIVE IMPACT ASSESSMENT

This Chapter discusses the cumulative and induced impacts of the Dhaka-Chittagong Inland Water Transport Projects.

9.1 Overview

The Government has prioritized the improved development and maintenance of the Class I routes and linked Class II and III routes along the Dhaka-Chittagong Inland Waterway corridor. The main trunk route is about 300km, of which it is initially estimated that about 40km currently require dredging and channelization to maintain the advertised depth for the existing traffic. Another 110-130km of linked routes is part of this corridor, of which about 33-50km requires constant maintenance. The objective of the current cumulative impact assessment is to evaluate the combined effects of proposed developments along the proposed IWT corridor. The most significant valued environmental components (VECs) related to the proposed developments are identified as aquatic biodiversity from river environment, spawning areas from coastal environment, and flood affected areas from floodplain environment. These VECs are considered from the national stakeholder consultation and also from survey findings described in Baseline Environment chapter of this EIA report. Significance of these VECs is described later in the Chapter.

9.1.1 Study Boundary

The study boundary of for CIIA has been considered based on the full lengths of the waterways themselves (including islands, chars and shoals within the waterways as well as riverbed and banks), the river basins/catchments upstream and downstream of the waterways, floodplain and drainage areas and patterns, areas of potential influence of existing and planned river ports, landings, terminals, vessel shelters, ferry crossings, and dredge spoil dumping locations along the waterways (including roads leading to on-land spoil dumping sites that would be used by locals to haul spoils to secondary markets), areas of ecological importance along the waterways such as any parks/reserves/forests, current and planned areas being irrigated by or otherwise using waters from the waterways, roads leading to the spoil disposal sites, etc. According to GoB development plans, inland water transport, third sea port in Tentulia River in Rabnabad channel, construction of embankments and river training works along the bank of major rivers, development of a road network on the embankment, integrated river management program, economic zone and fish processing zone on the proposed corridor, mega power plants and defense training camps are considered as future major developments in next 20 years; and hence these projects are considered for CIIA study. Brief summary of these developments along the tentative locations are presented below.

9.2 Current and Future Development Projects in Context of CIIA

Inland Water Transport and Integrated River Management Program: The GoB has an ambitious plan of undertaking about \$100 billion ‘Performance Based Capital Dredging Project’ in all major rivers including the Padma, Meghna, and Jamuna for sustainable river management. The objective of the project is control of river bed siltation and aggradation, land reclamation, and develop inland navigation through extensive dredging programs.

Payra Sea Port in Tentulia River: Development of the Payra Sea Port at the Rabnabad Channel in the Patuakhali District is under active consideration of the Government of the People's Republic of Bangladesh (GOB). Economic and social development would be enhanced rapidly in this zone if a sea port is established. International sea borne trade of Bangladesh has been using two existing sea ports, with about 92% passing through Chittagong Port. The coast line of Bangladesh is about 710km and coastal area is characterized by many tidal rivers, which can be utilized in development work for enhancement of economic growth of the country and creating employment opportunity of growing population of Bangladesh. The objective of the project is to build a sea port in the central coastal zone for economic, business, industrial and social development of the country. With the increasing population, demand of development for sea port in the central coastal zone is crucial for creating employment opportunity and social development of the country.

Construction of Embankments, Development of a Road Network on the Embankment and River Training Works along the Bank of Major Rivers: The future development projects under RMIP, FREMIP, and other development projects includes (i) construction of and rehabilitation of 150 km embankments and development of a two lane highway along the embankment under RMIP Project, which would subsequently be expanded to 4 lanes, (ii) construction of about 32 km of additional new riverbank protection works and rehabilitation of about 13km of existing revetments, six spurs, one hard point and one groyne under RMIP project, (iii) rehabilitation of about 40km length of BRE from downstream of Jamuna Bridge to Chandpur along with necessary river training works.

Economic Zone and Fish Processing Zone: An economic zone and a fish processing zone are under implementation stage of the Government of Bangladesh near Sandwip Island which is close from the project area. The objective of this development projects are to bring industrial growth of the country and will use IWT as major means of transport for both national and international purpose.

Sandwip is close to Bay of Bengal and an ideal place for fish catch. Government of Bangladesh with the help of lending agencies is planning to establish a fish processing zone in Sandwip area.

Proposed Mega Power Plants: Supercritical Coal Based mega power plant is currently under consideration to be built in Sandwip area. The objective of this project is to import coal from overseas through water channel. Mother vessels will use Dhaka – Chittagong IWT corridor for carrying coals not only to deliver in proposed Sandwip power plant but also other coal based power plants in Ahsuganj areas.

Defense Training Camps: Bangladesh Army is planning to develop the Jahizzar Char, an island in the Bay of Bengal, to use for advance defense training centre. The future development of the Charland will include (i) a number of infrastructure, (ii) cyclone shelters, (iii) power plant, (iv) polder for embankment purpose, and (v) harbour development. The objective of this exclusive project is to operate amphibian tanks and navy ships in that area mainly for security patrolling and training purpose.

9.2.1 Current and future development projects and plan

At present six development projects are under implementation by BIWTA in the Dhaka-Chittagong corridor and adjoining routes. 13 projects are in planned status. Feasibility study of one project is underway, investment projects of which will be implemented on PPP basis. Table 9.1 will illustrate the situation:

Table 9-1: Project List in the Dhaka-Chittagong IWT Corridor and Adjoining Routes

Sl	Name of the Project	Project Cost (in million BDT)	Project period	Status
Project under Annual Development Programme (ADP) :				
1.	Capital Dredging of 53 River-routes in Inland Waterways (1st Phase: 24 River Routes).	18736.4	July 2012–June 2018	Under implementation
2.	Dredging on 12 (twelve) Important River Routes.	5084.6	October 2011 – June 2016	Do
3.	Development of launch ghats and way side ghats in rural areas of Bangladesh.	806.3	July 2013 – June 2016	Do
4.	Establishment of Inland Container River Port at Ashuganj.	2457.5	January 2011- June 2016(Proposed)	Do
5.	Procurement of 10 Dredgers, Crane Boats, Tug, Officers' House Boat and Crew House Boat with other accessories (1 st Revised).	7456.022	July 2011-June 2016	Do
6.	Procurement of 2 dredgers, Crane Boats, Crew House Boat and Tug Boat with other accessories for maintaining the navigability of inland waterways (2 nd Revised).	1512.893	January 2009 – June 2015 (Proposed)	Do
7.	Capital Dredging on 53 Rivers Routes in Inland Waterways (2nd phase: 29 River Routes).			Planned
8.	Removal of garbage from the Rivers of Buriganga, Shitalakhaya and Turag (partly) and decontamination of water.			Do
9.	Establishment of 2 nd Terminal Facilities at Shashanghat area under Dhaka River Port.			Do
10.	Procurement of Different Types of Service Vessels for BIWTA.			Do
11.	Construction & placement of special type terminal Pontoons with allied facilities.			Do
12.	Dredging of different River Routes under Protocol.			Do
13.	Construction of Walkway and Bank Protection on Evicted Foreshore Land of the river Buriganga, Shitalakhaya and Turag (partly).			Do
14.	Construction of 10 River Ports 8 ferry ghats.			Do

15.	Modernization of 9 River Ports and 6 ferry ghats.			Do
16.	Establishment of 3(three) new Training Institutions and Modernization of 1(one) old Training Institution.			Do
Self-financed Project:				
17.	Extension of Sadarghat terminal building at Dhaka port.	191.051	March 2014 - June 2016	Under implementation
18.	Development of Sadarghat to Shasanghat road under Dhaka river port.	199.09	January 2015 - June 2016	Do
19.	Development of port facilities at different landing stations of the southern region.	321.8	March 2014 – June 2016	Do
Under Public Private Partnership (PPP):				
20.	Construction & Operation of Inland Container Terminal (ICT) at Khanpur, Narayanganj.			Do (Feasibility Study)

Source: BIWTA

9.3 Valued Environmental Components

The following valued environmental components (VECs) are identified from river environment, coastal environment, and floodplain environment for the CIIA study that is based on the rationale explained below. These VECs and their significance are:

Based on the baseline condition of river environment of the project influence area, a number of VECs have been identified which are not limited to hilsa, dolphins, migratory birds, other identified key species, sediments, water quality, char lands, aquatic biodiversity, and etc. Out of these for the CIIA, aquatic biodiversity has been considered

Based on the baseline condition of coastal environment of the project influence area, a number of VECs have been identified which are not limited to coastal sedimentation, sanctuaries, spawning areas, and etc. Out of these for the CIIA, spawning area has been considered.

Based on the baseline condition of floodplain environment of the project influence area, a number of VECs have been identified which are not limited to agriculture, beels, water pockets, low lands, and etc. Out of these for the CIIA, flood affected area has been considered.

VECs selected for CIIA identified during national stakeholder consultation, field survey, secondary data courses, three significant VECs are considered that are Aquatic Biodiversity (including hilsa and dolphin), Spawning Areas, inland navigation.

9.4 Aquatic Biodiversity

9.4.1 Background and Trends

The baseline on aquatic biodiversity of the Dhaka-Chittagong IWT corridor is extensively discussed in baseline chapter of this EIA report. Upper Meghna, Lower Meghna, Padma, Tentulia, Arial Khan rivers are within the corridor of IWT project and its floodplains are the important source of both capture and culture fresh water fish in Bangladesh. Major habitats of capture fisheries are main river channels, khals and beels. These beels, khals and the Jamuna are naturally connected during floods and will act as migratory routes for the carp's fishes, which migrates to floodplains during flooding season for spawning.

The dredging and its associated activities may disturb the sanctuaries and spawning areas of fishes specially hilsa, dolphins and other aquatic species. Moreover, the fisheries in the floodplains have been declining significantly since the construction of flood control embankments, which have blocked the migratory routes of carp fishes from the river to floodplains. The fish production in the proposed corridor has been declining due to increased fishing pressure. The trend analysis of the Department of Fisheries time series data 1984-2012 shows the decrease of annual fish production in the Meghna River is approximately 2,700 tonnes in last 30 years.

9.4.2 Cumulative Effects

The sedimentation load in the Lowe Meghna is about one billion m³ per year. Out of which one third is deposited in river bed consequently decreased river depth over time. The shallow depth of these rivers increased the frequency of the flooding on the banks of the rivers and also decreased fish population. Number and type of fish species are also decreasing over time as few species require depth on the river to breed. The proposed dredging activity under IWT project and other future projects will restore the type of species due to restoration of the original depth of these rivers.

The proposed project will also improve and maintain navigation channels and land reclamation that will have some impacts on the aquatic biodiversity. Dredging activities will disturb the benthic habitat and the bottom fish feeders that depend on the benthic habitat. The sediments generated from the dredging activity will affect the water quality and in turn the quality of the entire river habitat. The water quality of the river will also be affected due to risk of oil spills from the barges and disposal of bilge water. There will be a risk of collision of dolphins with the barges and ships.

To address the cumulative impacts associated with the future dredging activities and also with induced environmental impacts, fish and dolphin sanctuaries need to be established in the corridor. Detailed ecological baseline studies are recommended for the entire CIIA study area to be carried out prior to commence the dredging and to identify suitable areas of sanctuaries and spawning areas.

9.5 Spawning Areas

9.5.1 Background and Trends

Habitat changing pattern due to this intervention may prove as a risk. Along with this, if the dredged sites are breeding ground for any unknown or unidentified species, the whole system can be collapsed as well. It will change the species composition of the water area and the fishermen depended on the fishes will not be able to catch them frequently and gradual effect on livelihood may be experienced. Fish sanctuaries which are built to facilitate the sound breeding of fish should be avoided from dredging demarcation. Otherwise, it can cause negative impact on the population size as well as fish catch of the fishermen.

On the other hand, if a fish population is aware of the new way that has been created by dredging; they may use it in the consecutive years for both migration and feeding. Some dredging sites create artificial scour that can also be used as habitat and hiding place for fishes like Boal (*Wallago attu*) or Chital (*Chitala chitala*) who prefer low temperature and lying in deep water bed for a certain period of their lifespan. Nutrient cycling is another key objective that can be taken under consideration as positive impact.

River dolphins are among the world's most threatened mammal species. They inhabit some of the largest river systems of southern Asia, and their environmental requirements link them to food and water security issues in the world's most densely populated human environments. Populations of river cetaceans have declined dramatically in recent years and much of their range has been lost. River cetaceans are threatened in many ways. Overharvesting of fish and crustaceans reduces the availability of their prey. Deforestation and intensive floodplain farming increase the sediment load of river channels and degrade cetacean habitat. Industrial effluents, human sewage, mining waste, and agricultural runoff contaminate water. Dolphins die from accidental entanglement in gill nets, and mortality rates increase as the use of these nets spreads. Possibly the most significant threat to river cetaceans is the construction of large water development structures, most notably dams, barrages, and levees.

The environmental consequences of water development projects are significant and far reaching. These structures fragment populations and reduce the environmental complexity that makes rivers suitable for aquatic species. Water development proceeds, however, with little understanding or concern about the effects on cetaceans, or on the assemblage of other life that shares their habitat.

The Ganges or Asian Freshwater Dolphin (locally known as shushuk or susu) occurs in the inland waters of Bangladesh, India, and Nepal. Its traditional strongholds have been the Ganges, Brahmaputra, Meghna, and Karnaphuli river systems. Gangetic dolphins still occur in these rivers and, at least seasonally, in many of their tributaries. There are at least a few hundred dolphins in both the Ganges and Brahmaputra systems, and their total abundance may be in the low thousands. However, with the extensive development of irrigation, flood control, the dolphin's metapopulation has become increasingly fragmented. Groups of dolphins upstream of dams and barrages have either disappeared or declined with little prospect of recovery. Dolphins are caught either incidentally in fisheries and are also hunted

deliberately in portions of their range in both India and Bangladesh. There is a strong localized demand for their oil to be used as a fish attractant and as medicine or liniment.

9.5.2 Current Threats

The trend for this species is towards a shrinking range, as dolphins are eliminated from smaller tributaries, and a declining population, as animals are killed in fishing gear and directed hunts, and as they compete unsuccessfully with humans for shrinking water and prey resources.

Accidental capture in fishing gear is among the most critical threats facing river dolphins. The absence of systematic effort to investigate the problem, however, makes it difficult to quantify its magnitude or to establish priorities for regulating fishing activities. Information on dolphin bycatch is particularly difficult to obtain. In some cases, there is a strong disincentive for fishermen to report by-catch because they can be prosecuted for causing the death of a dolphin. In other cases, fishermen keep the carcass for oil, or sell it or use the carcass or parts of the decomposing dolphin in pile fishing to attract fishes.

Small-mesh monofilament plastic nets cause the greatest damage because of their extensive use and because dolphins cannot break free of them once entangled. Dolphins also become entangled in large-mesh nets but, apparently, often manage to escape.

Very little is known about the effects of vessel traffic on river dolphins and porpoises. Ferry crossings, commercial ports, and primary fishing grounds in rivers are generally located downstream of convergent channels or sharp meanders, which are also the preferred habitat of river dolphins. River dolphins are often observed swimming in areas with high vessel traffic, that includes small boats, motorized ferries, and in some locations large container ships and oil tankers, with no visible damaging effects. Mortality from propeller collisions, however, has been reported for baiji and finless porpoises, particularly in the lower reaches of the Yangtze River, where waterways contain high levels of large commercial vessel traffic (Zhou 1992). A single susu was also reported by fishermen to have been killed by the propeller of a cargo boat in the Brahmaputra river near the India/Bangladesh border (Mohan 1996). Dolphins may be more vulnerable to collisions during calving and nursing periods.

9.5.3 Cumulative Effects

Dredging and disposal processes cause temporary increase in the level of suspended solids and turbidity, thereby influencing the positive variation in other physico-chemical parameters. The potential environmental effects of dredging arise due to the excavation of sediments at the estuary/sea bed, loss of material during transport to the disposal site and during disposal. Dredging has a strong impact on marine water environment, especially to the suspended solids and turbidity. Usually turbidity has a positive correlation with total suspended solid. Maintenance dredging usually has near-field and temporary effects and lasting as long as dredging operation takes place (Sangita *et al.* 2014).

Usually the release of organic rich sediments during dredging or disposal results in localized oxygen depletion. Higher values of nutrient and total suspended solids also cause low Dissolved Oxygen. River runoff and sediment transport are the main sources of nutrients in the estuarine region. Re-suspension of sediments during dredging and disposal result in an

increase of the levels of organic matter and nutrients available to marine organisms. The values of nutrients such as phosphates and nitrates are higher in the surface water due to increase in suspended sediment loads in water which releases nutrients to the water column due to dredging.

9.6 Inland navigation

9.6.1 Inland navigation and Trends

Bangladesh is crisscrossed by a network of about 24,000 km. of inland waterways. It provides cheaper transit of passenger and goods and most important in case of Bangladesh is that about 25.1 percent of rural population has only access to rivers for the purpose of transport. A World Bank Report on Revival of Inland Water Transport: Options and Strategies revealed that modal share of IWT registered a gradual declining trend during last decades and estimated at 8.9% in passenger and 16% in freight movement in 2005; while in 1975 IWT modal share of passenger traffic was 16% and freight traffic 37%.

One of the main causes of declining trend of IWT identified by many studies is the deteriorating condition of the river system in Bangladesh caused by both morphological, natural processes and withdrawal of water beyond the border and within the country. Length of navigable waterways determined by a survey in 1989 was about 6,000 km in the wet season which reduced to about 3,600 km in the lean period. Inland waterways were divided according to LAD in to four hierarchical classes in 1989 and which were found to be inappropriate now with the change of navigability and of transport pattern and type over the years. But no comprehensive survey has been conducted since 1989. However a Core Waterways Network of 1,822 km was recommended in the IWT Masterplan 2009.

So far BIWTA has established 21 inland river ports and 380 landing stations in the country. Infrastructures and facilities now available in these ports and landing stations are very much marginal and primitive in nature to such extent that head-load remains the general means of loading and unloading of cargo. BIWTA does not have details traffic data of passenger and freight movement in inland waterways. In 2013-2014 BIWTA recorded 87.40 million of passenger and 35.18 million tons of cargo throughputs at 9 major river ports. IWT is mainly used for transport of bulk, dry bulk and liquid bulk of construction materials, food grains, fertilizer, clinker, petroleum product etc. A large fleet of about 10,000 inland vessels are engaged in the carriage of goods and passengers. Besides there are approximately 750,000 country boats powered by the pump engines operate mainly in the rural waterways.

A Protocol on Inland Water Transit and Trade between Bangladesh and India has been in force since 1972 without any disruption for commerce between two countries and for passage of goods between mainland India and the land-locked north-east through the waterways of Bangladesh. A total volume of more than 19.33 million tons of cargo was transported under this Protocol in 2013-2014 of which more than 98% were transported by Bangladesh vessels despite the provision of sharing the carriage of cargo on equal tonnage basis. In this regard IWT trade is dependent on only fly ash required by the cement manufacturing factories. One of the main factors for revival of IWT would be container traffic in inland waterways. To meet the growing demand of transporting containers between Dhaka and maritime ports, utilization of inland waterways has become inevitable. Railway suffers from capacity constraint and the road does not have bearing capacity to accommodate trailers, so all the

studies conducted recently recommended for inland waterways. An Inland Container Terminal has already been developed through a joint venture project of BIWTA and CPA with an annual handling capacity of 116,000 TEUs which is to be followed by another 4 inland container terminals under construction by private sector. The length of navigable IWT network in Bangladesh (seasonal and perennial) was determined by the DHV Consultants, the Netherlands back in 1989 is yet to be surveyed to determine the updated length. Due to deteriorating condition of rivers and information gathered from the actual field it is very much reasonable to assume that the length reduced significantly over the years. It is also evident from the River Notices published monthly by BIWTA. Maintenance of a network of 6,000 km may not be cost effective and dredging or human intervention otherwise may not result any benefit. Economic justification is there where large or medium inland vessels navigate. No rationale exists to augment the navigability in thousands of kilometer used exclusively by mechanized boats and the smallest size of inland vessels. The rural waterways are being used by country boats and smaller inland vessels under existing condition. The Inland Water Transport Master Plan Study, 2009 limited public responsibilities of maintaining navigability to the following routes termed as Core Waterways Network. It is evident from the chart table of distance, the length mentioned above (BIWTA) were not accurate. However according to traffic and economic importance almost all routes were included in the recommended network. The waterways linking two maritime ports and Dhaka/N'Ganj area and routes under Bangladesh-India Protocol on IWT were marked as priority routes. With the above the following should be included:

- Raimangal-Khulna-Noapara 165 km as route under Protocol
- Rajshahi-Daulatdia, 173 km, this could be an important domestic route and a route for transit traffic,
- Tongi-Narayanganj, 35 km, this route may contribute modal shift of passenger of greater Dhaka to remove congestion on road.

Table 9-2: Core Waterways Network Recommended in the Master Plan, 2009

IWT Route	Length (km)
1. Dhaka-N'Ganj-Chittagong	306
2. Dhaka-Barisal-Mongla	418
3. Chandpur-BhairabBazaar/Ashuganj	102
4. Mohonpur-Daikhawa	385
5. Bhairab-Chatak	228
6. Jamuna/Hurasagar-Baghabari	15
7. Dilalpur-Fenchuganj	191
8. Chatak-Sylhet	53
9. Mongla-Khulna-Noapara	80
10. Dhaka-Tongi	40
11. Barisal-Patuakhali	85
12. Barisal-Barguna	97
13. N'Ganj-Narsingdi	77
14. N'Ganj-Meghnaghat	42
Total	1,822

Source: IWT Master Plan, Final Report, 2009

Passenger and Freight Movement

Modal share of IWT in respect of passengers is gradually declining. This trend will continue further as time is valued more than before. With the completion of Padma Bridge, IWT modal share in respect of passenger will be decreased to a significant volume as the present principal passenger corridors between Dhaka and districts in the southern region will inevitably experience of large modal shift. But in respect of cost IWT will remain the first option of thousands of poor people. Savings of BDT 100 will be more valued than increase of traveling time by two hours.

On the contrary, freight movement will certainly experience a significant increasing trend. IWT will emerge as the principal modal option for the carriage bulk, break bulk and liquid bulk. Pacific Consultants International, Japan in its Report on Techno-Economic Feasibility Study on Deep Sea Port projected traffic volume of general cargo at the ports of Bangladesh at 12 million ton in 2020, 35.66 million ton in 2035 and about 50 million in 2055. And IWT will share 38% of the modal split.

Container Transport

Container traffic to and from the maritime ports in Bangladesh is growing by 12% per year. Due to the growth of international trade container traffic must continue. Major problem of container movement is the inefficient hinterland connectivity. Due to inherent weaknesses and limitations of road and rail transport, river transport is given importance by all concerned. Significantly, the private sector has come up in a big way in this trade. Constructions of four river side terminals are underway. The Pacific International, Japan estimated container traffic volume in the ports of Bangladesh at 3.33 million TEU, 8.52 million and 19.60 million respectively in 2020, 2035 and 2055 while modal split in IWT will be 38%. The number of inland container vessels will be 55 in the short term, 152 in the mid term and 305 in long term. Number of container terminal will be 5 in the short term, 10 mid term and 24 in long term.

The World Bank in the KCT Pre-Feasibility Study, 2014 under the Bangladesh Trade and Transport Facilitation Program projected as follows;

Table 9-3: Projection of IWT Container Traffic (000TEU)

Year	Setting sail	The world wears Bangla
2021	1,299	1,588
2022	1,402	1,763
2023	1,514	1,958
2024	1,635	2,175
2025	1,766	2,415
2030	2,469	3,790

Source: *The World Bank Study on Chittagong Port Efficiency, 2014*

Setting sail assumes growth potential of inland waterway is unlocked and modal share of IWT (containers in TEU) rises from 5 to 45% over the period 2014-2018 and maintains share at that level. **The World Wears Bangla** allows for GDP growth to accelerate over previous trends but is below the Government of Bangladesh target of 8-10 percent.

9.6.2 Cumulative Impacts

Possible impacts for dredging on environment of wild life and mitigation measures are illustrated in Table 9.4. Impacts and mitigation measures on biological resources is presented in Table 9.5. Impact matrix for dredging activities is mentioned in Table 9.6

Table 9-4: Possible impacts for dredging on wildlife and their mitigation measures.

Activities	Possible Impacts	Impacts on Wildlife	Mitigation Measures
Dredging	- Enhancement of fresh water flow due to dredging of Shitalakya and Upper Meghna River (page: 60) - Erosion and sedimentation - Deterioration of water quality by disposal of liquid and solid waste -Increased turbidity in water caused by the discharge process - Nuisance from dredger - Noise, dust, exhaust gas emissions from dredging equipment	Positive: -Opportunistic Species - Due to increased fresh water flow fish bio diversity will be improved. Negative: -Damage, disturbance or modification to aquatic life or stream habitat -Disturbance of aquatic (plankton & benthos) organisms in the river bed - Disturbance of fish and mammals in the river - Increased water turbidity. -Degradation of wildlife habitat - Loss of aquatic vegetation	- Examine alternatives to proposal especially if the area is sensitive or a breeding area -Ensure all activities are well managed to reduce runoff and water quality reduction -Provision of sewage and waste treatment facilities, cleaning of the water -Continuously monitor water turbidity. - Likely to have significant impact on aquatic life and vegetation -Restrict dredging only to the area where required - Limit the dredgeing activity during Hilsha breeding season. - Minimize habitat loss by applying careful control of cutter head, restrict digging to specified boundaries -Dredging area should be checked every day prior to commencement of dredging work. All dredging activities should be stopped at sight of aquatic mammals. -
Deposition of Sediments	-Filling low lying areas of wildlife resources - Change of landscape - Nuisance from stockpiling of spoils -Soil pollution	Positive: -Reintroduction of wildlife in some case - Opportunistic species Negative: -Alteration and disturbance of wildlife habitat -Aquatic life may adversely affected by deterioration of water quality due to deposition of sediments -Reduction of photosynthesis	- A plan for the deposit of dredged material will be implemented -It is recommended to avoid exceeding said concentration in the smallest area possible - Properly baseline environmental conditions for site specific proposals to ensure no impact on wildlife habitat

Activities	Possible Impacts	Impacts on Wildlife	Mitigation Measures
		Processes	
Occupying land for vessel shelter & ferry terminal	-Degradation of wildlife habitat -Loss of scenery and landscape -Alteration and natural habitat	- Clearance, disturbance, modification or destruction of vegetation & natural habitat of wildlife	- Restore native vegetation to riverbanks -Examine alternatives to proposal especially if the area is sensitive or a breeding area
Constructional activities of vessel shelter & ferry crossing	- Nuisance from dredger & construction equipment - Noise, dust, exhaust gas emissions & other pollutants from equipment	-Direct or indirect adverse effects on the feeding, breeding and migration of wildlife -Hampers of photosynthesis	-Ensure machinery is well serviced and in good working order -Have to take efficient efforts to mitigate the pollution
Movement of heavy equipment	-Occupying a large area -Erosion of river bank -Air, water & sound pollution	-Distraction of natural habitat of wildlife -Natural life of both flora & fauna hampered adversely	-Constant maintenance of dredging equipment and other machineries - Ensure the minimum impact code, and that special care is taken during bird nesting periods -Ensure water vehicles reduce speed where wildlife may be present
Longtime presence of workers & project developers	- Generation of sanitary wastes and debris in general wastes from dredge activities -Temporary housing in natural habitat -Occurrence of different type pollution	-Direct killing and disturbance to wildlife -Introduce several challenges to the natural environment of wildlife	-All wastes arising from the activities must be disposed of in accordance with the current regulations -Provision of sewage and waste treatment facilities, cleaning of the water - Ensure human waste is buried at least 50m from all water sources

Table 9-5: Impacts and mitigation measures on biological resources.

Ecosystem/ Biodiversity – related Factors	Predicted Impacts		Mitigation Measures
	During Dredging	Post-Dredging	
Aquatic Habitat alteration: Water quality, benthic environment, transportation of dredged materials	Increase in turbidity, suspended materials, transparency hindering sunlight penetration and affecting phytoplanktons	Localized effect, recovery in a short time	Curtains placed on dredge, or other mitigation measures, to trap sediments and therefore limit the lateral movement of turbid water; Spoil dispersion outfall characteristics to be evaluated by collecting grab water samples during dredging operations and operations modified accordingly; Avoidance of sensitive locations (mudflats, reedlands, etc.) for dredge material depositing on land Keep increased turbidity and suspended solid levels at dredging site to no more than 20% increase over baseline conditions during the dredging activity. In order to do so, some methods to explore may include for example, avoiding dredging in periods of rapid water movements, for example, in the afternoon when trade winds are strong, or during the rainy season when large influxes of fresh water could move significant volumes of sediment laden waters to the Bay of Bengal; The connection of a conical reflective shield to the outlet as silt suppression and dispersion control mechanism; Preventative maintenance of equipment to mitigate negative environmental impacts such as leakages and spillages.
Benthic fauna	Changes in species composition Fluctuation in population	Changes in species composition	

	Habitat alteration due to increase in depth	Changes in vertical depths May impact livelihood of some people	
Aquatic Species Affected (Dolphins, turtles, etc)	Noise and disturbance-changes in movement routes and pattern	May recover over time	
Terrestrial Habitats: Chars, Mudflats, Reeds & Grasslands	Sediment deposition	Sediments may render mudflats unsuitable for migratory birds	
Terrestrial Species	Localized disturbances due to presence of labourers, other activities	Recovery over time	
Cumulative impacts: Aquatic Habitat	Expected	-	
Cumulative Impact on Species	Expected		
Impact on fisheries			
Predicted Impacts	During dredging	Post dredging	Mitigation measures
Habitat degradation of Hilsa, Catfish and other fin-fishes	The nursery and rearing ground of diverse fishes may be damaged due to the operational activities i.e. cutter head circulation, flat open scraper movement, etc.	Turbidity increases, as a result some fishes, bivalves and gastropods loss their natural habitat due to the excess alteration of optimum water quality.	To avoid this scenario, the suction pump can controlled through pressure diminishing where efficient data is available to trace organisms like crab, catfishes and other scavenging aquatic species. Some bathymetric reports also provide these kinds of evidence. Pre and post dredging sampling of mud of the 12 dredging points can be utilized to identify its success.
Habitat and feeding ground destruction of shellfishes	During this whole process the bottom dwelling crabs and other benthic community are compelled to shift their scavenging route and eventually affect their feeding and subsequent breeding.	The dredging may leave them scattered and misplace the populations to some extent. After the extraction of sand and mud carrying pipelines, some artificial depressions may	Avoid starting set up dredging and additional supplementary instruments close or near to the habitat and feeding ground of the species.

		be created to inhabit some new organisms.	
Disruption in feeding and breeding migration	Agitating water throughout the dredging period may confuse the fish school and interrupt their migration	The new environment in the topography of water after dredging may misdirect the fish migration which will result in the unwanted dispersal of fish/fishes out of its/their natural navigation area.	Raw data on pre dredging water quality assessment of the project area should be available to the dredging authority and need to compare them with the during-dredging to measure whether it is optimum for maximum freshwater riverine fishes or not.
Physiological deformities in fishes	Elevated temperatures during dredging increase the metabolism, respiration and oxygen demand of fish and other aquatic life, approximately doubling the respiration for a 10° C.	The physiological changes may lead to long term deformities in fish body which ultimately can somehow affect their copulation, swimming and associated movements.	This impact is not expected to be significant due to project activities.
Impacts & Mitigation Measures of dredging activities (both Hopper & Cutter dredging)			
Activities	Impacts	Mitigation Measures	
Lifting	Life of aquatic fauna (like, dolphin, turtle, mollusks, crabs etc.) will hamper greatly. Due to turbidity aquatic fauna have to face several challenges (like, scarcity of food, hampering of respiration & breeding etc.) to survive. Photosynthesis process of aquatic flora will be reduced adversely.	-Suitability of lifting on the proposed spots has to be evaluated carefully. -Have to take proper efforts to sustain the determination level as low as possible. -restrictions on sediment suspension during dredging and dredge disposal, to be monitored on an ongoing basis by contractor and consultant.	
Transportation	• Pathway may be polluted and dirty due to leakage during carrying of sediments. • Great disturbance may be occurred to the terrestrial fauna. • Flora of influenced areas may be damaged.	-Carrying equipment should be well designed. -Have to make appropriate plan for transportation of sediments. Follow ECoPs	

		outlined in the EMP. -Priority should be given to the safety of wildlife during transportation.
Disposal	-Habitat of terrestrial flora and fauna may be occupied in a broad scale. -Natural activities of fauna (both terrestrial & aquatic) like, movement, feeding, breeding etc. may face several adverse effects. -Existence of wildlife species of the affected area may be threatened.	-Disposal of sediments should be well planned and should follow EMP requirements. -Activities should be performed through maintaining the natural environment of wildlife. -Proposed sites have to be justified for the protection & safety of wildlife.
Impact on Benthic communities		
	Impacts	Mitigation measures
Depth of Overburden at Disposal Sites	Some benthic organisms such as burrowing polychaetes, amphipods and molluscs can colonize newly deposited sediments through vertical migration, therefore, if dredged material depths are limited to within the vertical migration capacity of these organisms (20-30 cm), recovery rates may be quicker than if colonization is dependent upon the lateral migration of juveniles and adults from adjacent areas and larval settlement.	Placement of dredged material in the tidal river shall not be made during High Water and Low Water slack time of a tidal cycle when velocity is very less. Specific restrictions on dredge material placement and management are outlined in the EMP. Management actions for the disposal site following unfavourable monitoring results may include, but are not limited to: additional confirmatory monitoring to delineate the extent of the problem, capping to isolate the sediments from potential biological receptors, and/or closure of the site.
Habitat Type (disturbance history)	Shallow benthic habitats (<20 m depth, Hall 1994) experience relatively frequent wave, wind, and current induced disturbances and thus are typically inhabited by low-diversity, selected benthic assemblages that can readily re-establish themselves under conditions of high frequency disturbances (Dauer 1984, Clarke and Miller-Way 1992, Ray and Clarke 1999). These communities are naturally held in early succession stages and therefore, are able to recover more rapidly than	

	communities in deeper, more stable environments (Newell <i>et al.</i> 1998, Bolam and Rees 2003).	
Sediment Type	Rapid recolonization of soft-bottom benthic habitats is frequently associated with either unconsolidated fine grain sediments (Cruz-Motta and Collins 2004) or the rapid dispersion of fine-grained dredged material by currents (Van Dolah <i>et al.</i> 1984). Newell <i>et al.</i> (1998) characterized typical recovery times at 6-8 months for mud habitats and 2-3 years for sand and gravel substrata.	
Spatial Scale of Disturbance	The spatial scale of the dredged or disposal area may be proportional to recovery times (Zajac <i>et al.</i> 1998, Guerra-Garcia <i>et al.</i> 2003). For small-scale disturbances, the edge/surface area ratio of the disturbed area is larger than for larger disturbances, therefore colonization through adult immigration from surrounding undisturbed areas may facilitate recovery. With larger disturbed areas, the central portion of the disturbed areas is reliant upon settlement from the water column for colonization, which is very dependent on seasonal recruitment patterns and local hydrodynamics.	
Timing and Frequency of Disturbance	Greater monitoring efforts of dredging after seasonal larval recruitment periods are a common practice when possible. Deposition of sediments in several smaller units rather than one deep deposit also may be less detrimental to the benthos. In a microcosm study, sediment deposited in a single event caused more severe changes to nematode assemblages than the same amount of sediment deposited in smaller doses (Schratzberger <i>et al.</i> 2000).	

Table 9-6: Impact matrix for the dredging works

Phase	System affected	Potential positive impact	Potential neutral or negative impact
During dredging Works	Impact on Resource System (physical, biological and	-	• Disturbance of aquatic (plankton & benthos) organisms in the river bed. • Risk of pollution of surface water from oil spills and leaks. • Deterioration of water quality by

Phase	System affected	Potential positive impact	Potential neutral or negative impact
	ecological)		disposal of liquid and solid waste. • Disturbance of fish and mammals in the river. • Increased water turbidity. • Loss of aquatic vegetation. • Risk of pollution of air, surface water and contamination of disposal site.
	Impact on User System (socio-economic and cultural aspects)	• Employment opportunities • Improved navigable depth.	Noise, dust, exhaust gas emission, oil spill from dredging equipments. Obstacle to navigation traffic. Occupational health and safety risk. • Obstruction to fishing.
Post Dredging Works	Impact on Resource System	• Improved waterway traffic. • Biodiversity.	Hydro-morphological adjustment. Erosion and sedimentation. Biodiversity composition and abundance
	Impact on User System	• Navigation traffic. • Employment. • Socio-economic development. • Attraction of tourists.	Erosion and accretion. Need maintenance dredging.

9.7 Hilsa

9.7.1 Background and Trends

Overview

The Government has prioritized the improved development and maintenance of the Class I routes and linked Class II and III routes along the Dhaka-Chittagong Inland Waterway corridor. The main trunk route is about 300km, of which it is initially estimated that about 40km currently require dredging and channelization to maintain the advertised depth for the existing traffic. Another 110-130 km of linked routes is part of this corridor, of which about 33-50km requires constant maintenance. The objective of the current cumulative impact assessment is to evaluate the combined effects of proposed developments along the proposed IWT corridor. The most significant valued environmental components (VECs) related to the proposed developments are identified as aquatic biodiversity from river environment, spawning areas from coastal environment, and flood affected areas from floodplain

environment. These VECs are considered from the national stakeholder consultation and also from survey findings described in Baseline Environment chapter of this EIA report. Significance of these VECs is described later in the Chapter.

Study Boundary

The study boundary of for CIIA has been considered based on the full lengths of the waterways themselves (including islands, chars and shoals within the waterways as well as riverbed and banks), the river basins/catchments upstream and downstream of the waterways, floodplain and drainage areas and patterns, areas of potential influence of existing and planned river ports, landings, terminals, vessel shelters, ferry crossings, and dredge spoil dumping locations along the waterways (including roads leading to on-land spoil dumping sites that would be used by locals to haul spoils to secondary markets), areas of ecological importance along the waterways such as any parks/reserves/forests, current and planned areas being irrigated by or otherwise using waters from the waterways, roads leading to the spoil disposal sites, etc. According to GoB development plans, inland water transport, third sea port in Tentulia River in Rabnabad channel, construction of embankments and river training works along the bank of major rivers, development of a road network on the embankment, integrated river management program, economic zone and fish processing zone on the proposed corridor, mega power plants and defence training camps are considered as future major developments in next 20 years; and hence these projects are considered for CIIA study. Brief summary of these developments along the tentative locations are presented below.

Inland Water Transport and Integrated River Management Program: The GoB has an ambitious plan of undertaking about \$100 billion ‘Performance Based Capital Dredging Project’ in all major rivers including the Padma, Meghna, and Jamuna for sustainable river management. The objective of the project is control of river bed siltation and aggradation, land reclamation, and develop inland navigation through extensive dredging programs.

Payra Sea Port in Tentulia River: Development of the Payra Sea Port at the Rabnabad Channel in the Patuakhali District is under active consideration of the Government of the People’s Republic of Bangladesh (GOB). Economic and social development would be enhanced rapidly in this zone if a sea port is established. International sea borne trade of Bangladesh has been using two existing sea ports, with about 92% passing through Chittagong Port. The coast line of Bangladesh is about 710km and coastal area is characterized by many tidal rivers, which can be utilized in development work for enhancement of economic growth of the country and creating employment opportunity of growing population of Bangladesh. The objective of the project is to build a sea port in the central coastal zone for economic, business, industrial and social development of the country. With the increasing population, demand of development for sea port in the central coastal zone is crucial for creating employment opportunity and social development of the country.

Construction of Embankments, Development of a Road Network on the Embankment and River Training Works along the Bank of Major Rivers: The future development projects under RMIP, FREMIP, and other development projects includes (i) construction of and rehabilitation of 150 km embankments and development of a two lane highway along the embankment under RMIP Project, which would subsequently be expanded to 4 lanes, (ii)

construction of about 32 km of additional new riverbank protection works and rehabilitation of about 13 km of existing revetments, six spurs, one hard point and one groyne under RMIP project, (iii) rehabilitation of about 40 km length of BRE from downstream of Jamuna Bridge to Chandpur along with necessary river training works.

Economic Zone and Fish Processing Zone: An economic zone and a fish processing zone are under implementation stage of the Government of Bangladesh near Sandwip Island which is close from the project area. The objective of this development projects are to bring industrial growth of the country and will use IWT as major means of transport for both national and international purpose.

Sandwip is close to Bay of Bengal and an ideal place for fish catch. Government of Bangladesh with the help of lending agencies is planning to establish a fish processing zone in Sandwip area.

Proposed Mega Power Plants: Supercritical Coal Based mega power plant is currently under consideration to be built in Sandwip area. The objective of this project is to import coal from overseas through water channel. Mother vessels will use Dhaka – Chittagong IWT corridor for carrying coals not only to deliver in proposed Sandwip power plant but also other coal based power plants in Ahsuganj areas.

Defence Training Camps: Bangladesh Army is planning to develop the Jahizzar Char, an island in the Bay of Bengal, to use for advance defence training centre. The future development of the Charland will include (i) a number of infrastructure, (ii) cyclone shelters, (iii) power plant, (iv) polder for embankment purpose, and (v) harbour development. The objective of this exclusive project is to operate amphibian tanks and navy ships in that area mainly for security patrolling and training purpose.

Impacts at Dredging Sites

Although in the past decade technological developments, research activities and operational experiences, have led to an enormous expansion of knowledge about good dredging practices around the world, in Bangladesh the existing constraint is still the same; the soil management after dredging. If the soil is disposed near the dredging site, it will be of no good use rather than causing harm to the ecosystem and food chain the aquatic biodiversity. Even though sediments are natural elements in any river basin, alteration or misplacement is regarded as a threat to the existing ecosystem. If the slope is so upward, the tertiary consumer may easily reach the secondary and primary consumer which may bring about a reduction in their number as the zonation is not maintained properly. Habitat changing pattern due to this intervention may prove as a risk. Along with this, if the dredged sites are breeding ground for any unknown or unidentified species, the whole system can be collapsed as well. It will change the species composition of the water area and the fishermen depended on the fishes will not be able to catch them frequently and gradual effect on livelihood may be experienced. Due to such potential impacts, which might be unavoidable in the locations of required dredging, the project will support a biodiversity conservation program which aims to contribute towards enhancing the management of hilsha and dolphin sanctuaries and improve the aquatic ecosystem environment for key species.

On the other hand, if a fish population is aware of the new way that has been created by dredging; they may use it in the consecutive years for both migration and feeding. Some dredging sites create artificial scour that can also be used as habitat and hiding place for fishes like Boal (*Wallago attu*) or Chital (*Chitala chitala*) who prefer low temperature and lying in deep water bed for a certain period of their lifespan. Nutrient cycling is another key objective that can be taken under consideration as positive impact.

Change in trench and Scour

Trench and scour are shallow or narrow depression or ditches that are used by many riverine and floodplain fishes for multidimensional purposes. Destruction of these specific sites may be proved as habitat alteration and unwanted movement of fishes. It possibly will change the food and feeding behavior of fishes due to unavailability of proper nutritional elements around the new living grounds. Fish catch prototype will change as well as the living of the local fish depended people will be hampered, which needs a very good insight.

Change in water velocity

Change in water velocity is another impact that can occur at the dredging spots leaving the biodiversity interrupted. High water velocity results in turbidity in the riverbed. Some fishes don't like too much velocity and some are very akin to the same. For example, hilsa requires high water velocity for their gonadal development and maturation while carp fishes cannot tolerate soaring water velocity. As the width of the river is not going to expand during this project implementation period (except natural river bank erosion), this possible impact can be considered negligible. On the contrary, this water velocity can carry nutrient from Upper Meghna to Lower Meghna and vice versa which allows nutrient cycling and availability spreading out to new species. Some freshwater fishes can move to the new habitat to avail the macronutrients.

Impacts at Disposal Sites

The dredged soil can create an artificial barrier between the movement channels of fish. Consequently, it can destroy fish passing and food intake. The dredged material produces turbidity due to the increased water velocity in adjacent areas and compels fishes to move which are not generally reared in turbid condition. While considering the Ganges floodplain fishes, it is to be kept in mind that, these fishes are not much familiar with turbid water; as a result their healthy population may be hampered in some extent. Fishes get isolated and it inhibits breeding and subsequent reproduction cycles.

Other external factors

Navigational vibration is sometime horrifying to brood and juveniles of surface water. This trembling also results in less catchment in artisanal and marine fish near the Meghna estuary. However, the water close to the estuary (Noakhali, Hatiya, Bhola region) is not static and sometime not that harmful to marine species. Oil spillage, causes plankton destruction and bio-safety of natural riverine water. This very situation creates obstruction in food chain mainly in primary and secondary consumer level.

Recommendations

1. Proper Soil Management is a prerequisite to this project. The soil management plan should include recommendations/suggestions to ensure the proper use of the dredged soil.
2. Dykes that disconnect river and floodplain should be avoided to protect the regular fish movements.
3. Although the hilsa breeding ground consist of a wide range of area, the dredging and navigation should be done as less as possible. It will save the maximum gravid fish and juveniles as well.
4. Using the concept of setback distance can be utilized. It will facilitate required amount of water flow through the corridors.

9.8 Dolphin

9.8.1 Background and Trends

Ganges Dolphin and its habitat

The Ganges River Dolphin (*Platanista g. gangetica*) or ‘shishu/shushuk/shush’ (in Bangla) is found in most of the areas of the Ganges-Brahmaputra-Meghna river system including Nepal, India and Bangladesh. This species is categorized as ‘Endangered’ by the International Union for Conservation of Nature (IUCN) Red List (2015) with the wild populations decreasing drastically within the range countries. These dolphins share the same ranks as the tigers and great apes that are listed as a species endangered by trade on Appendix I of Convention on International Trade of Endangered Species of Flora & Fauna (CITES). The species is listed as a ‘flagship species’ by World Wide Fund for Nature (WWF).

Ganges River dolphins are generally concentrated in counter-current pools below channel convergences and sharp meanders (Kasuya and Haque 1972, Smith 1993, Smith *et al.* 1998) and above and below mid-channel islands, bridge pilings, and other engineering structures that cause scouring. Dolphins could potentially be negatively affected by dumping in the scour holes because scour holes are used as a refuge by the dolphins and other aquatic animals during dry season when water levels are low in the rivers. Their fidelity to counter-current pools is probably greatest in fast-flowing channels (Smith *et al.* 1998). Annual monsoon-driven floods cause great variability in the dolphins’ access to large parts of their range. Isolation in seasonal lakes sometimes occurs (especially in the Brahmaputra basin), as does "escapement" from the river channels into artificial water bodies such as canals and reservoirs. Deltaic (brackish) waters are a major component of the total range, but Ganges River dolphins are not generally known to occur in salinities greater than 10 ppt, although they have been recorded in waters as saline as 23 ppt.

Water abstraction upstream decrease river depth and the appearance of sand bars during winter season cause danger to the dolphins as the river is divided into small segments, causing a segregation of populations in deeper pools, narrowing of the gene pool, increase in the intensity of fishing, river traffic, pollution due to release of untreated effluents from industries, incidental and/or intentional capturing for oil extraction for use as fish attractant, liniment and aphrodisiac, etc., have become the major threats for its survival.

The significance of water depth as an important factor for determining the distribution pattern and habitat selection of marine dolphins is well documented (Ross *et al.* 1987, Hastie *et al.* 2005). It is perceived that the same applies for the Ganges River dolphin. Earlier studies in the Brahmaputra in India indicated certain depth range preferences of the Ganges River dolphin between 8 and 10 meters (Mohan *et al.* 1997); however in a recent study Wakid (2009) showed that the preferred water depth for the dolphins is between 4.1 – 6 meters for the same river. This variation may be due to the physical changes in sedimentation that might have happened over the years and other anthropogenic reasons for reduced water flow in the Brahmaputra River. In another study in the Chambal River in India the optimum water depth for dolphins was reported as 10 meters (Hussain *et al.* 2009). Rashid *et al.* (2015) also observed the maximum numbers of dolphins preferred areas between 6 – 10 meters deep during the dry season and between 10 – 16 meters during the wet monsoon season in the Padma and Jamuna Rivers.

Seasonality, food availability and environmental conditions of the water are the main factors of the Ganges River dolphin for its habitat use/preference (Hussain *et al.* 2011). Depth of water and also water turbidity in the Padma, Jamuna and Meghna Rivers vary greatly due to changes of seasons, physical characteristics and other anthropogenic reasons. Water depth increases during the monsoon months and decreases during the winter and summer months in the rivers. During the winter and summer months, dolphins were found to remain concentrated in the deeper sections (*kums*) of both the rivers. Optimum water depth preferred by the Ganges River dolphin throughout the year is mostly available in sections where scours in the river exist. Secondly, most river fishes occur or should have occurred in the scours of the rivers during the winter and summer months (Hussain 2010). The dolphins feed on fishes hence distribution, composition and abundance of their prey may also play an important role in the distribution and abundance of dolphins and consequently habitat utilization.

Current Threats

Accidental killing of dolphin in the form of by-catch in net fishing is one of the main threats for dolphins in the rivers. It was reported that accidental killing of dolphins in the project and surrounding areas through getting trapped or entangled in fishing nets were higher in the past but reported less during the survey period. Other threats for dolphins in the rivers included oil spill from boats and ships, river erosion, low water depth during winter, use of harmful fishing gears (especially current net) and making cross dam of bamboos across some sections of the rivers/tributaries/distributaries for fishing. As reported by local people, the practice of intentionally trapping and/or killing of dolphins in the rivers for commercial reasons is gradually gaining momentum for oil extraction. Remains of the dolphin body, particularly the head, are used in the brush pile fishery – certain sections of the river close to the banks is fenced using bamboos and piles of tree branches are used to provide a temporary refuge for the fish during the dry season when water level gets low. During dry season the fenced area is netted and fishes are caught. By putting the remains of the dolphin body and head together with the tree branches fishes are attracted by the smell as they decompose.

Very little is known about the effects of vessel traffic on river dolphins and porpoises. Ferry crossings, commercial ports, and primary fishing grounds in rivers are generally located downstream of convergent channels or sharp meanders, which are also the preferred habitat

of river dolphins. River dolphins are often observed swimming in areas with high vessel traffic, that includes small boats, motorized ferries, and in some locations large container ships and oil tankers, with no visible damaging effects. Mortality from propeller collisions, however, has been reported for baiji and finless porpoises, particularly in the lower reaches of the Yangtze River, where waterways contain high levels of large commercial vessel traffic (Zhou 1992). A single susu was also reported by fishermen to have been killed by the propeller of a cargo boat in the Brahmaputra river near the India/Bangladesh border (Mohan 1996). Dolphins may be more vulnerable to collisions during calving and nursing periods.

The direct risks associated with the current project dolphin and dolphin habitat includes: (a) generation of underwater noise levels from the dredging equipment, and (b) impacts on dolphin habitat due to disposal of dredged material in scour holes.

With respect to (a): For dolphins, sound serves three main functions: (i) it provides information about their environment, (ii) it is used for communication and (iii) it enables the remote detection of prey. The sounds generated by dolphins often extend beyond the range audible to the human ear. Vocalizations of dolphins will be in range of 125-173 (dB at 1m) for whistles and 218-228 (dB at 1m) for clicks. Underwater noise levels generated by dredging activities are expected to be below 175 dB. The threshold peak impulse source pressure for direct physical trauma in aquatic mammals is generally considered to be more than 200 dB and hence dolphins would not be expected to experience permanent hearing impairment from sound pressures generated by the dredging. However, effects on behavior are more likely. Behavioural studies conducted elsewhere on the impact of similar activities like pile driving on dolphin indicated a temporary displacement from the area where pile drivers are operating and they returned close to normal once pile driving had ceased. Whilst for fish, adverse behavioural aspects occur at a noise level of 150 dB and physical injury may occur at 206 dB. The indirect impacts on the dolphin from dredging activities would be impact on its prey, the fish.

With respect to (b), this impact can be effectively minimized by prohibiting deposition of dredged material in deep scour holes (greater than 5m depth), which are the preferred habitat for dolphins. Only shallower scour holes will be permitted for use by contractors for depositing dredged material in river.

The cumulative impacts associated with various activities in the watershed include risk of water pollution from accidental spillage of fuels, hazardous material and bilge water from the various types of vessels used in the river for various purposes, and risk of collision of dolphins with vessels. Motor boats will be extensively used for transport of personnel, material and fuel. There is a risk of water pollution from these activities through accidental spillage of fuels, hazardous material and bilge water. Any such pollution events will seriously impact the downstream dolphin and fish habitat. Further, there is a risk collision between dolphins and motor boats.

The impacts on the dolphin from the project activities can be minimized by the contractor by taking utmost care to prevent such risks and will prepare an emergency preparedness plan to address these risks. The contractor will make booms, absorbents and skimmers available on site along with trained personnel to recover spilled oils from water surface. The contractor shall include training in the use of this equipment within his training plan and carryout

regular drills in the deployment of this equipment. All waterborne plant/equipment shall be regularly serviced as per the manufacturer's guidelines and be inspected daily prior to operation.

Dredging work will adopt a 'soft start'; using a low energy start to the piling operations to give dolphins an opportunity to leave the area, gradually ramp up the sound levels to scare the dolphins and other cetaceans away before dredging commences. Contractor will also use pingers to chase away dolphins from the construction areas. Given that monsoon period coincides with in the dolphins' main calving period, which is July to August, the impacts on dolphins during this critical period will naturally be minimized, since little dredging is expected to be required during monsoon months. In addition, Pingers, set at 145dB at 70 kHz, may be used to drive away the dolphins, if necessary. Under component 2 of the project, the facilities will be established at the river ports to collect the bilge water from the various transport vessels. During the dredging activities under the current component, the contractor shall be prohibited from bailing or pumping this water into the river, but instead shall be required to collect the bilge water, treat it by separation and dispose of the separated oil and fuel as hazardous waste. Refuelling of dredgers and boats will be properly carried out to avoid any spills.

10 ENVIRONMENTAL MANAGEMENT PLAN

10.1 Objective

This section aims to provide methodology used to prepare the environmental management plan (EMP) for the Project to mitigate any potential negative environmental and social impacts which may occur as a result of Project activities. This chapter also specifies the Contractor's environmental obligations in performing the works to be carried out under the project.

The methodology followed for preparing the EMP consists of the following steps:

- Deriving mitigation/protection measures for identified impacts for each of the project activity and environmental component,
- Recommend mitigation, compensation and enhancement measures for each identified impacts and risks,
- Developing a mechanism for monitoring the proposed mitigation measures
- Estimating budget requirements for implementation of mitigation and monitoring measures, and
- Identifying responsibilities of various agencies involved in the Project for implementation and
- Monitoring of mitigation measures.

10.2 Components of EMP

The key components of EMP are summarized below and each of these components is explained in detail in the following subsections:

- Mitigation Measures
- Monitoring Measures
- Institutional Arrangement
- EMP Budget
- Reporting Requirements

10.3 Mitigation Measures

10.3.1 Key Impacts from the project activities and mitigation measures

The dredging and dredged material placement activities are expected to cause several negative impacts on the aquatic habitat and fauna due to generation of high sediment flows, disturbance of benthic habitat, noise and emissions from construction machinery, and accidental spillage of fuels. Various stages of the dredging and potential impacts from each of these stages are summarized below:

- **Excavation:** Excavation is the process of physical removal of the material from its in situ location on the bed of a water body. This will be done either hydraulically or mechanically by dredger heads. The physical changes that can take place during excavation are the generation of suspended sediments (causing an increase in turbidity), mixing of soil layers, and noise and air pollution from the equipment. Major potential impacts of these changes on the human and natural environment include but are not

limited to: impacts to aquatic and benthic flora and fauna; changes to bioavailability of contaminants in the sediment due to its re-suspension; temporary impacts to navigation, fishing and other river uses; disturbances to local communities and riverine species; among others. The changes to river morphology resulting from excavation can also impact riverbank erosion patterns.

- Before project implementation a pre-dredging survey will be carried out along the specified dredging location. From pre-dredging survey, dredging alignment will be delineated. Dredging alignment will be fixed again, considering the safe distance from river bank level. The safe distance from the river bank will be determined from hydrographic (distance of thalweg from river bank, alignment of river thalweg) and soil characteristics of river bank. **Hence, there is no risk of bank erosion.**
- Lifting: Lifting is the vertical transportation of the excavated material from the bed. Similar to excavation, this will also be done either hydraulically or mechanically. The physical changes that occur during lifting are the release of suspended sediments, for example as overflow losses during loading. Sediment re-suspended in the water column in high concentrations can directly lead to physical abrasion of, for example, filter-feeding organs or gill membranes of fish and shellfish. If the sediments are rich in nutrients and metals; the resuspension of sediments may release nutrients, organic matter and toxic chemicals into the water. Other impacts noted above related to excavation are also applicable to the lifting process.
- Transportation: Transportation is the process of transferring the excavated material to the placement location. In most cases, this will be done hydraulically through a pipeline. The potential impacts during transportation are spillage and safety in relation to other transport users of the river.
- Placement: Placement is the final stage, where the excavated material will be placed at designated sites in the rivers or on the land. Potential impacts during this stage are dispersion of deposited material and release of sediment laden runoff.

A detailed summary of these impacts and the mitigation measures for each of these impacts are given in Table 10-1. In addition, general construction related impacts and best management address practices to address these impacts are given in Environmental Code of Practices. The contractor shall comply with the mitigation measures proposed in Table 10.1 and in ECoPs. Contractor will be required to prepare the dredging plan with the help of Table 10.1 and ECoPs obtain approval from the Project Director of BIWTA to ensure that no critical habitat (dolphin, turtles, hilsa fish) exists at/near such dredging location. The Contractor should select the dredging methods to minimize suspension of sediments, minimize destruction of benthic habitat, and increase the accuracy of the operation. Inspection and monitoring of dredging activities should be conducted to evaluate the effectiveness of impact prevention strategies, and re-adjusted where necessary.

EMP guidelines (Table 10-1) clearly mention the procedures and standards which must be followed during implementation phase. **There may be some temporary disruption of food chain due to river bed excavation and dredge material transport. However, if EMP instructions are properly followed during implementation work, the impact would be minimal with possibilities of quick recovery and oil spill management.** Most of the

potential impacts would be short-term that can be avoided or mitigated by adopting mitigation measures and relevant ECoPs.

10.3.2 Location of Environmentally Sensitive Areas

Locations of known environmentally sensitive areas, including reed lands, mud flats, mangrove forests, migratory bird habitat, and hilsa sanctuaries and spawning grounds are shown in Figure 10-2. The locations of expected dredging locations (based on 2015 hydrographic surveys undertaken by BIWTA) and pre-identified appropriate dredge material placement locations are also shown in Figure 10.1. In addition, the river banks and chars also act as breeding areas for several aquatic species including fish and turtles, as well as birds. The Contractor shall take utmost care to prevent any harm to these environmentally sensitive areas.

The contractor shall not carry out any dredging activities within 100 m from the river banks and char lands. The contractor shall also maintain a minimum of 100 m distance from all reedlands, mudflats, mangroves and migratory bird habitats. The dredging has to be limited during all seasons in the hilsa sanctuaries and spawning areas, particularly during the hilsa migration period. The contractor is required to undertake intense monitoring and reporting on all activities in these areas, particularly during the months of October to November, and March to April, to ensure that there are minimum impacts on the water quality and hilsa habitat in these areas.

On the floodplains, the contractor shall also maintain a minimum 100 m distance in establishing offices or workers camps from the environmentally sensitive areas shown in Figure 10.1.

Location of Ecological critical Area

Recently Balu, Buriganga, Shitalakhya, Tongi, Turag are declared as ecologically critical area (ECA) by Bangladesh Government. The location of ECA area is shown in Figure 10-1. However, dredging operation will only be carried out at Shitalakhya River. The dredging operation will not disrupt the existing eco-system if Environmental management plan (Table 10-1) is properly followed. Dredging operation will enhance the water availability, water flow thus improve overall ecological system of the riverine ecosystem.

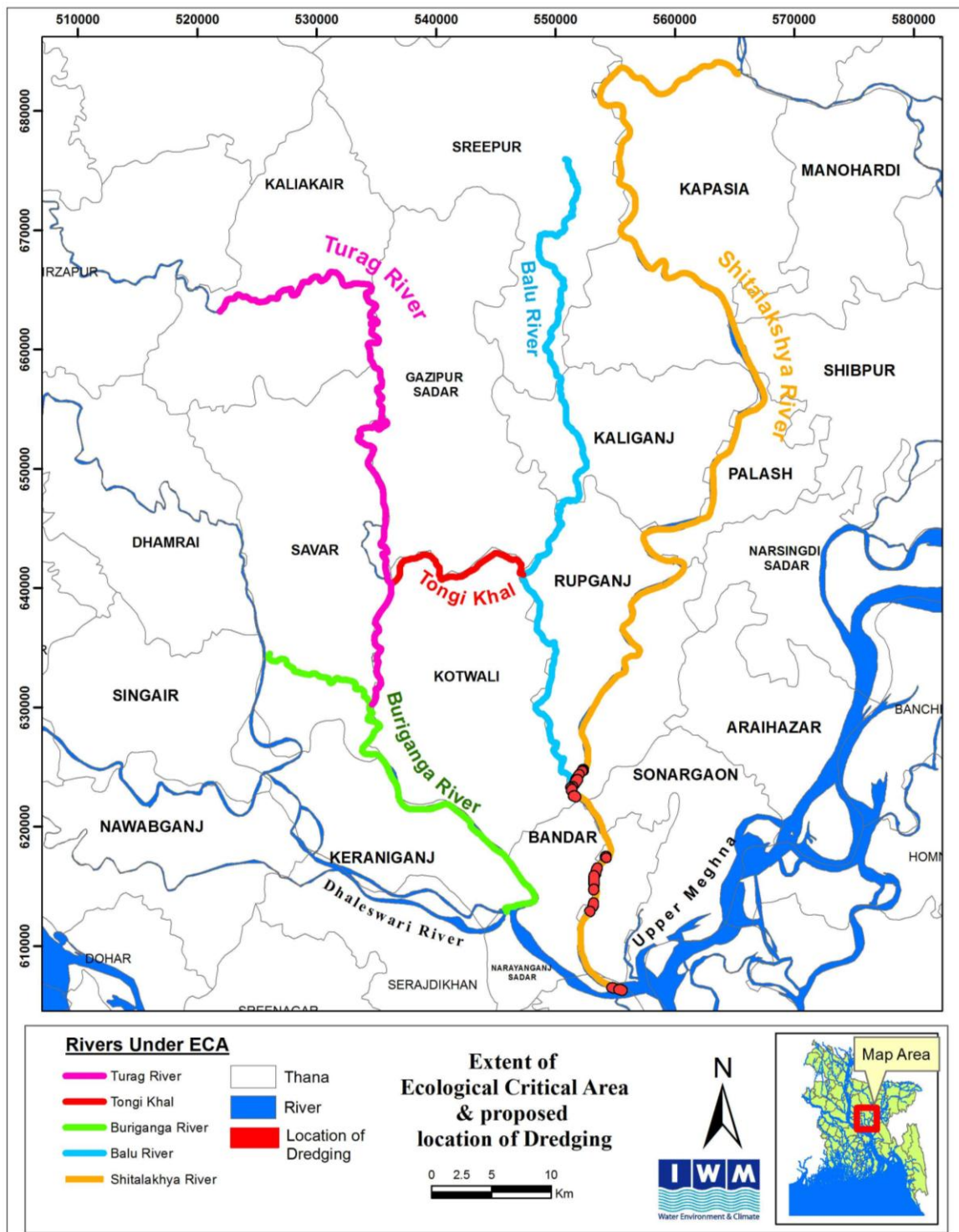


Figure 10-1: Ecologically Critical Area (source: Department of Environment)

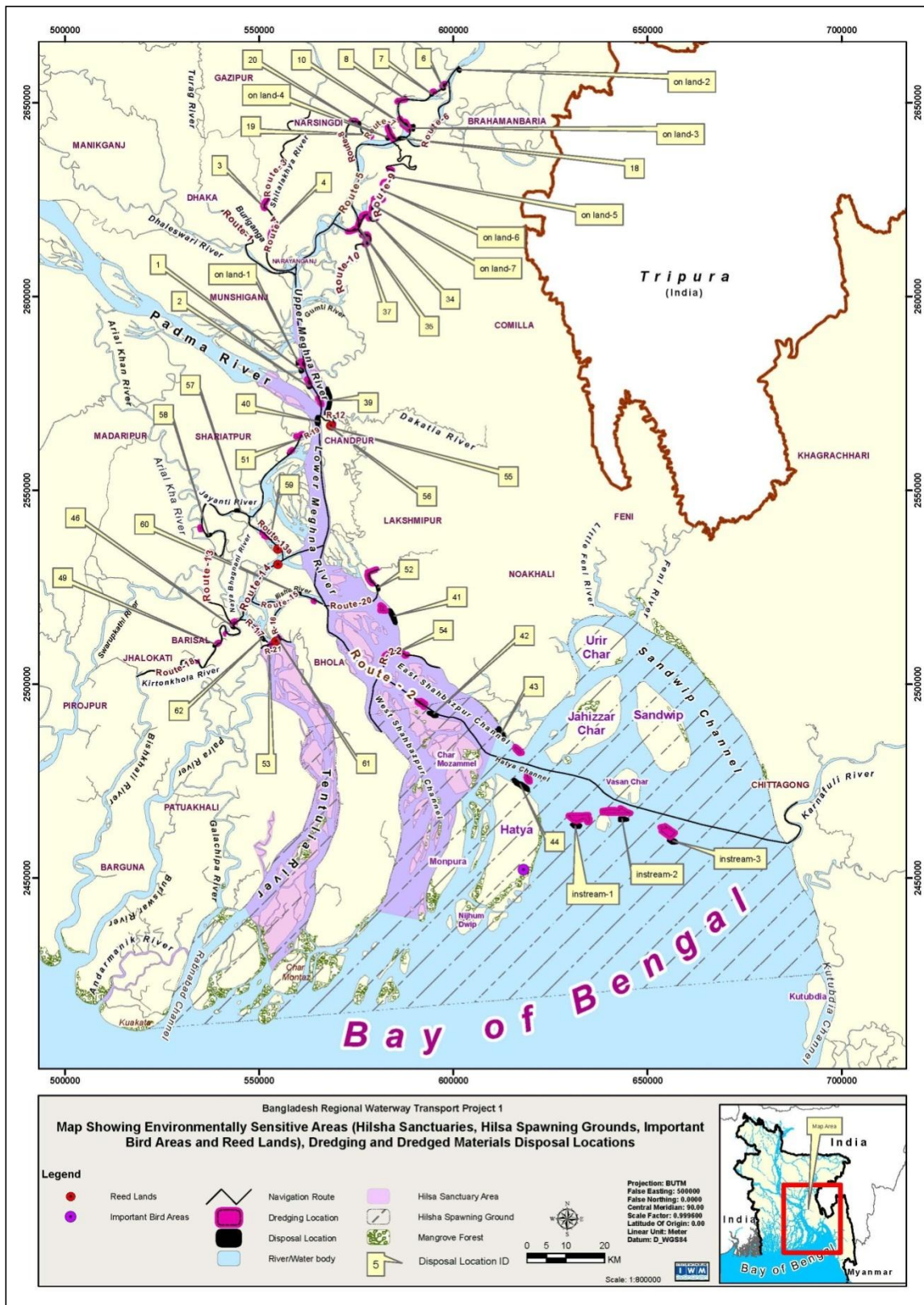


Figure 10-2: Locations of Environmentally Sensitive Areas, Dredging and Dredge Material Placement Locations

Table 10-1 : Environmental Management Plan: Mitigation Measures

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Pre-Dredging:Navigation Routes and Ferry Crossings					
Engagement of Environmental and other Technical staff	Without adequate technical staff, it would be difficult to implement EMP as prescribed.	Contractors and BIWTA should hire all technical staff as described in institutional arrangement Section for effectiveimplementation of the EMP. Contractor’s staff: Aquatic Biologist Occupational Health and Safety Specialists, Environmental Technicians, and Community Liaison Officers, BIWTA staff: Environment Management Specialist, DSC, Resettlement specialist, GRM officer, Environment Monitoring Specialist.	Contractors	PIU/ BIWTA	Included in Table 10.13 as contractor’s budget
Preparation of guidelines for effective handling of dredged materials	Without proper guidelines for management of dredged materials, there will be social and environmental problems.	Prior to the mobilization of Contractors, BIWTA will ensure that for selection of sites for temporary storage of dredged materials before subsequent beneficial use or permanent on land disposal, arrangement is made for such sites in consultation with local public representatives and concerned land owners. Site-specific Dredged Material Management Plan with proper containment compartment and drainage provision Refer Table 10.4 and Figure 10.3 for the dredging and disposal sites.	Contractors	BIWTA/ PIU/ DSC DSC / DOE	Included in Table 10.13 as contractors’ budget
Plan for sediment sampling to be carried out	Sediment may be contaminated posing threat at disposal sites and community.	Toxicity levels should be tested before dredging and verification to be carried out according to section 10.3.6 of EMP. Contaminated/ Toxic Dredged Material Management Plan.	Contractors	PIU/ DSC DOE	Included in Table 10.13 as contractors’ budget
Verification of dredging area	The projected dredge volume to be re-assessed through verification prior to commencement of dredging.	A bathymetry survey and analysis should be conducted jointly by Contractor and BIWTA or by independent monitoring agency for verification of dredging alignment in the selected routes.	Contractors and the independent monitoring and Evaluation Consultants	PIU and DSC	Included in Table 10.13 as contractors’ budget

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Land acquisition	The dredging operation will involve land acquisition/requisition and structure losses for the temporary storage and disposal of dredged materials on land.	All affected people of private land and structures should be compensated according to national and World Bank guidelines. RPF to be fully implemented prior to initiation of project activities.		BIWTA / PIU DC office	Included in Table 10.13
Safety of river traffic	Dredging location and activities in the waterways may result in traffic congestion or accidents or disturbance to fishermen and water vessels.	Notification to communities and river users prior to initiation of dredging. Erection of buoys in the area to alert river vessels passing the dredging site.	Contractors	BIWTA / PIU Ministry of Shipping	Included in Table 10.13
Inclusion of environmental Clauses in Construction Contracts	Compliance by the Contractor to requirements defined in the EIA, EMP and BMP.	Specific environmental and biodiversity conservation clauses will be added to contract specifications and a separate environmental bill-of-quantities section will be prepared.	BIWTA / PIU	BIWTA / PIU	-
Affects on biological resources, endangered species	Changes in aquatic/benthic species composition; hindrances in movements of aquatic animals, increase in turbidity, etc.	Specific clauses to mitigate the impacts and monitoring and reporting on a regular basis (weekly / monthly, as the case may be) will be added to the contract specifications. Collect / document relevant/detailed information on the key threatened species within the project influence area Make the field staffs/labourers aware of the biodiversity conservation issues	BIWTA PIU and NGOs or BDM Consultants BIWTA Contractor	PIU/ Department of Fisheries/, DoE / FD	Included in Table 10.13
Pre Construction Phase: Vessel Shelters					
Survey and design of Vessel Shelter sites	May cause temporary disturbance to traffic and businessmen during survey and investigation works by design Consultants	Adopt proper planning and take adequate precaution to carryout the survey with minimal disturbance to traffic and people.	Design Consultant	PIU /DSC	-
Land acquisition and resettlement	Potential impacts on aquaculture farmers at locations of Shatnal, Chandpur, Char Bhairabi, Mehendiganj, Nolchira and Sarikait.	Preparation of Resettlement Plan in accordance with the national and World Bank policies.	PIU, consultant	PIU, DSC	Included in Table 10.13

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Camp and storage facilities	Construction of camp and stockyards for materials can cause dust nuisance and gaseous emissions from equipment and vehicles to local residents and traffic.	Follow standard code of .construction practice and watering dry earthen surface to control dust emission, maintenance of equipment in good working condition and control of movement of vehicle, particularly on weekly market days and school timings.	Contractor	PIU, DSC	Included in Table 10.13 as contractors' budget
Siting of Vessel shelters	May affect environmentally sensitive areas, i.e. mangroves, reed lands, fish sanctuary, religious institutions	Site selection shall avoid such environmentally sensitive areas and social institutions.	Contractor	BIWTA/PIU,	-
Water and Sanitation facilities at Camps	Inadequate provision of drinking water supply, toilet facilities including solid and liquid waste management may cause poor health to workers and nuisance to public.	Ensure potable drinking water supply by installing tubewells and constructing sanitary latrineat camp sites. Provision of facility to put solid waste and adequate drainage provision for safe disposal of liquid and solid wastes. Also arrangement of first aid kit at camp sites to be ensured.	Contractor	PIU, DSC	Included in Table 10.13 as contractors' budget
Dredging Phase:Navigation Routes and Ferry Crossings					
Locations of dredging sites	Impacts on river morphology and bathymetric changes. Impact on habitats of sensitive species such as dolphins, migratory birds, and fish habitats	Restrict dredging to design section only where required by avoiding sensitive areas (dolphin and bird habitats, reeds and char lands) identified in the EIA (Refer Fig. 10.2). Regular monitorin will be ensured during dredging operation.	Contractor	PIU, DSC	Included in contractors' costs
		The impacts from dredging can be minimized by avoiding the sensitive habitats of fish and other important species during their breeding and spawning period.			
		During dry season no dumping of dredged materials in the scour holes in the Upper Meghna (Refer to Fig. 10.1 for location of scour holes). Scour holes are used as a refuge by some large fishes, dolphins and aquatic animals during dry season/winter.	Contractor	DSC, PIU	
		Dredging in Lower Meghna River and estuary should be avoided in the hilsa sanctuaries during	Contractor	DSC, PIU	

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		the months of March and April, and during 11 days in the hilsa spawning season in the month of October and November (see Table 10.2, Fig. 10.1). Hilsa usually take the deeper channels (preferably >10m) for migration. While dredging the contractor should maintain reasonable distance (≥ 100 m) from the deeper channels. Dredging to be done in blocks with prior information of the dredging locations to the relevant authorities.	Contractor Contractor		
Dredging: Excavation	Impacts of river morphology and bathymetric changes. Increased turbidity, loss of transparency and increased suspended sediment concentrations. Impact on benthic habitats,	Select dredging equipment with low risk of sediment dispersal. The Contractor should select the dredging methods to minimize suspension of sediments, minimize destruction of benthic habitat, and increase the accuracy of the operation. Suspended sediment concentrations due to dredging activities should not exceed 4,000 mg/l near the dredger (a threshold value being followed in other projects in Bangladesh) Dredging to be done in intervals giving some time for the habitat to recuperate during the hilsa breeding and migration period Monitor the dredging operation and, if necessary, change the dredge location to minimise the amount of material being dredged (or the number of dredgers allowed to operate) at	Contractor Contractor Contractor	PIU, DSC DSC/PIU DSC/PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		any one time. In ecologically sensitive locations – scours, reedlands, IBAs, fish sanctuaries - (see Fig. 10.1), the Contractor will additionally keep TSS levels below 20% over baseline levels. Inspection and monitoring of dredging activities should be conducted to evaluate the effectiveness of impact prevention strategies, and re-adjusted where necessary. An ongoing ecological monitoring will be in place to evaluate the impacts of the dredging and develop additional mitigation measures as required.	Contractor Biodiversity Management Consultant	DSC/PIU DSC/PIU	
Dredging: Lifting	The release of suspended sediments during lifting can cause mortality to fishes. Increase in turbidity, due to sediment re-suspension, also reduces light penetration in to the water thus resulting in to reduction in primary productivity for phytoplanktons.	Select dredging equipment with low risk of sediment releases from lifting.	Contractor	PIU, DSC	Included in contractors' costs
River Traffic	The presence of barges and associated vessels and discharge pipelines will pose a risk to local river traffic. There is also risk of collision of construction boats with dolphins.	Provide proper navigational lighting and navigation aids for the barges and associated vessels Provide appropriate lighting to all floating pipelines and buoys Check all navigational lights routinely to ensure that they are working properly. Limit the motor boat speed to ≤ 15 km/h in	Contractor	DSC/ PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		accordance with the best international practices and to avoid any collision with dolphins. Pingers set at 145dB at 70kHz (maximum) to be used to chase away dolphins from the construction and dredging areas thus minimizing the chances of any collision with dolphins. Pingers should be operated intermittently under supervision of experienced operators and if operated continuously for longer periods may harm or drive away other aquatic fauna, particularly fishes.			
Noise from dredging activities	Noise and vibration under water: Disruption to fish migration and disturbance to dolphins Noise and vibration above water: Nuisance to local community, disturbance to birds	Reduce the dredger noise at source by isolation of exhaust systems, by keeping engine room doors shut and by additional measures such as shielding. Limit the noisy dredging to daylight hours, where possible, rather than at sunrise or sunset (significant for wildlife) or during night time hours. Where unavoidable, the contractor should ramp up the levels of engines or other noise producing sources, so that the noise slowly increases. This will encourage riverine and terrestrial fauna to move away from the source area prior to significant noise emissions. Inspect and maintain equipment in good working condition.	Contractor	DSC/PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Exhaust emissions	Air pollution and release of greenhouse gases from construction equipment	Inspect and maintain equipment in good working condition. Proper maintenance of engines ensures full combustion with low soot emissions. Use low-sulphur heavy fuels to reduce noxious emissions. Provide exhaust filtering. Gaseous emissions to be monitored daily and emissions should be within limits as prescribed in the DOE air quality standards	Contractor	DSC/PIU	Included in contractors' costs
Oil spills	Oil spill will cover large area from a specific point location through tidal and wave action at Meghna estuary and lower Meghna river.	Contractor should follow the guideline of "National Oil Spill & Chemical Contingency Plan" prepared by Ministry of Environment, Forest and Climate change.	Contractor	DSC/PIU	Included in contractors' costs
Bilge water	Waste water disposal from the barges and associated vessels	Properly collect, treat and dispose on land the bilge water from the barge and boats. Empty barge or hopper from rest load by washing or mechanical cleaning before moving between different dredging areas, particularly between the ecologically sensitive areas (fish sanctuaries, important bird areas – Fig. 10.1) to prevent distribution of contaminated material through residual loads.	Contractor	DSC/PIU	Included in contractors' costs
River Water Quality	Increased suspended sediment concentrations	Select dredging equipment and methodology with low risk of sediment dispersal. Monitor local suspended sediment concentration by sediment sampling and laboratory analysis and sedimentation at the proposed dredge channel and adjacent area including disposal site and prepare a monitoring response plan to modify dredging and placement operations should threshold levels be exceeded under the	Contractor	DSC/PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		prevailing hydrodynamic and wave conditions. Regularly inspect and maintain equipment in order to prevent leaks. Should a pipeline leak occur, the pipe or joint should be repaired or replaced immediately. Develop and implement a Spill Prevention Plan to prevent and contain accidental spills, monitor sediment spill. Monitor the dredging operation and, if necessary, change the dredge location to minimise finesediment. Select placement methodology for bulk filling to ensure limited spread of sediments. Suspended sediment concentrations due to dredging activities should not exceed 4,000 mg/l near the dredger (a threshold value being followed in other projects in Bangladesh)			
	Increased turbidity and reduced transparency	Dredge cuts and lifts should be designed so as to prevent undercutting of material and hence a collapse of material locally at the cutter head, leading to an increase in the sediment being disturbed by dredging. If water quality standards are not met, modify operations, e.g. restrict the amount of material being dredged (or the number of dredgers allowed to operate) at any one time. Quality Control system shall be developed by the dredging contractor before commencement of work and get approval from DSC/EMS. Suspended sediment concentrations due to	Contractor	DSC/PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		dredging activities should not exceed 4,000 mg/l near the dredger (a threshold value being followed in other projects in Bangladesh).			
	Spillage of oils and fuels	Develop and implement spill contingency plans for pipeline and hull leakages. Ensure that emergency response equipment, e.g. floating booms, are serviceable and available to deal with any oil spills or leakages. If water quality standards are not met, modify operations, e.g. restrict the amount of material being dredged (or the number of dredgers allowed to operate) at any one time.	Contractor	DSC/PIU	Included in contractors' costs
	Site runoff	Control the discharge of site runoff, including excess dredge water, by the installation and correct use of containment walls, bunds and weirs. Monitor the quality of water (e.g. sediment content) in site runoff to confirm that the design and operation of the bunds and weirs, and the retention time for dredge waters which facilitates the settlement out of fine sediments prior to discharge off site, is adequate. If not, take appropriate remedial action. Water quality monitoring/laboratory test results should be shared every two weeks. Water quality parameters should not exceed DOE standards Also refer to suspended sediment concentration section above.	Contractor	DSC/PIU	Included in contractors' costs
Waste from ships	Oil containing wastewater, solid waste from ships, if discharged into water, will cause adverse impact on	Enforcement of national and international regulations e.g. Management Regulations on Preventing Vessels from Polluting Marine	Contractor, DSC	DSC/PIU, DOE	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	aquatic ecology and water quality.	Environment. Wastewater and solid waste are forbidden to be discharged into the rivers, and must be unloaded to the nearby waste treatment facilities for treatment. Protocol to be developed by the contractor and approved by the BIWTA and DOE for waste management including oil.			
Benthic biota	Loss of aquatic community's especially benthic biota. Changes in habitat characteristics, species composition and biomass production.	Restrict dredging only to the areas where required. Minimize habitat loss by applying careful control of cutter head, restrict digging to specified boundaries. Disposing dredged material in fast flowing and deep river sections.	Contractor	DSC, PIU	Included in contractors' costs
Aquatic Fauna	Disturbance to aquatic mammals	Information on the distribution of aquatic animals to be mentioned in the dredging plan and checked prior to initiation of dredging Dredging area should be checked every day prior to commencement of dredging work. Dolphin pingers to be activated to drive away any dolphins or other aquatic animals prior to commencement of dredging.	Contractor	DSC, PIU	Included in contractors' costs
Fisheries	Disturbance of fish and damage of aquatic vegetation.	See biodiversity management plan (in Annex E) for biodiversity enhancement activities Information on fish sanctuaries, breeding/ spawning period to be mentioned in the dredging plan.	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		Dredging to be done keeping in mind the fish breeding/ spawning period.			
Geo-morphology and Bathymetry	Erosion and accretion of the river bed and bank.	Ensure adequate measure through proper design and construction of training works. Before project implementation a pre-dredging survey will be carried out along the specified dredging location. From pre-dredging survey, dredging alignment will be delineated. Dredging alignment will be fixed again, considering the safe distance from river bank level. The safe distance from the river bank will determined from hydrographic (distance of thalweg from river bank, alignment of river thalweg) and soil characteristics of river bank. Hence, there is no risk of bank erosion.	Contractor	DSC, PIU	Included in contractors' costs
Transportation of dredged materials	Leakages and spillage from the hydraulic pipeline, dust emission affecting air quality during transportation by trucks.	Ensure regular inspection and maintenance of delivery pipes and accessories to prevent leaks. Develop emergency or contingency plan to prevent and contain accidental spills, fire or any other natural or man-made incident. The transportation of the dredged materials (dredged sediment and bulk refuse materials) using watertight dump trucks should not exceed the truck capacity to avoid spillage on the road and to be carried out night (e.g. 21.00 hrs to 05.00 hrs) to prevent road traffic congestion. Provide notification about the dredging activities at the dredging locations to minimize risks. Assigning a traffic officer at each dredging location.	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		Appropriate placement and maintenance of heavy equipment. Maintain cleanliness of trucks for transporting dredged materials. Provide adequate training to staff at dredging site to operate heavy equipment. Carry out dredging and transportation of the dredged materials during evening and night. Coordination with relevant stakeholders, including district and upazilla levels, throughout the dredging period.			
Placement of dredged materials	Dispersion of sediments and release of high sediment laden runoff from the placement sites.	For direct placement of sediment on land the area will be subdivided into compartments by dredged materials. Filling will be achieved by progressively pumping slurry of sand and water into the bunded areas, allowing the surplus water to drain away to artificial and natural waterways in a controlled manner through the pipeline, without affecting floodplains. Control the discharge of site runoff, including excess dredge water, by the installation and correct use of containment walls, bunds and weirs. Monitor the quality of water (e.g., sediment content) in site runoff following the dredged management plan and relevant Environmental Code of Practice. No agricultural land, grassland, mudflat will be used for permanent or temporary filling. If	Contractor,	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		temporary filling is required, only government owned khas lands will be used or will be directly sold to the willing-sand buyers.			
Waste Management	Generation of dredged materials that are unsuitable for use as fill / do not meet specification.	Minimize waste arising through the effective use of quality control system and waste management plan. Adopt appropriate waste confinement and storage arrangements. Waste management contractors to have the relevant approvals and permits from appropriate authority.	Contractor	DSC, PIU	Included in contractors' costs
Drainage Congestion	Drainage can be blocked in case of land disposal in the Upper Meghna basin.	Deploy silt screens in front of drainage pipes to prevent sedimentation on surrounding lands of the disposal areas. Ensure proper monitoring so that natural drainage is not blocked. Apply measures to minimize sediment dispersion.	Contractor	DSC, PIU	Included in contractors' costs
Worker's Health and Safety	Health impact from the exposure to hazardous and chemical materials and casualty from drowning or criminal attack.	OHS plan will be prepared, followed and implemented by contractors on the basis of the WBG EHS Guidelines (2007), ECoPs, and other relevant standards including fuels and hazardous substances management plan, drinking water management plan, spill control arrangements for fuels, firefighting equipment availability at the work station and safety precautions will be taken to transport, handle and store hazardous substances, such as fuel.	Contractor	DSC, PIU	Included in contractors' costs
Public Health	Workers mobilization, heavy equipment handling, dredging, transporting dredged materials and	Observance of ECoPs, OHS Plan and relevant dredged materials management plan by the Contractor.	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	placement of dredged materials can affect local people's health	Continue liaison and provide information to relevant community leaders, stakeholders and potentially affected communities throughout the dredging period in order to maintain community support. Provide adequate training to staff to operate equipment, to carry out dredging, and to transport dredged material.			
Institutional Responsibilities for spoil management	Identification of institutional responsibilities for spoil management, ownership of the dredge disposal facilities, contaminated spoil handling and re-use of the spoil will be critical issue with out proper institutional arrangement.	Contractor should take the responsibility to construct dyke and contaminated facilities (contained) using internationally approved method for construction of these facilities. After construction of these facilities, contractor should use them for spoil disposal and will also ensure their proper functioning and maintenance until PBC is over. According to the information of spoil demand, most of the clean spoil may be re-used for construction of rural roads, improvement of yards of community facilities, commercial use, etc. However, BIWTA will ensure long-term safety of the end users. After completion of the project, these facilities will be under the custody of Office of Chief Engineer – Dredging, BIWTA.	Contractor Contractor BIWTA	BIWTA, PIU DSC, PIU BIWTA/PIU	Included in contractors' costs
Construction Phase: Vessel Shelters					
Locations of dredging	Impacts of river morphology and bathymetric changes. Impact on habitats of sensitive species such as dolphin and migratory birds and fish habitats	Avoid sensitive areas (dolphin, otter and bird habitats incl. mudflats, reed lands, and charlands) identified in the EIA. No dredging will be carried out within one hundred meter from these sensitive areas (see Table 10.2, Fig. 10.1).	Contractor	PIU, DSC	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		Select the shallow sand bars along the river banks for dredging. Obtain approval from DSC (dredging supervision consultant) before starting dredging from any location.			
Dredging - Excavation	Impacts of river morphology and bathymetric changes. Increased turbidity, loss of transparency and increased suspended sediment concentrations. Impact on benthic habitats. The physical changes that can take place during excavation are the generation of suspended sediments (causing an increase in turbidity, destruction of benthic environment, and changes to river morphology), mixing of soil layers and noise and air pollution from the equipment	Select dredging equipment having low risk of sediment dispersal. Monitor the dredging operation and, if necessary, change the dredging alignment to minimise fines. Maintain record of all (quantities, location shown on map, timing, any sighting of key species)	Contractor	DSC, PIU	Included in contractors' costs
Lifting dredged materials	The release of suspended sediments during lifting can cause mortality to fish. There-suspension of sediments can also release toxic chemicals or nutrients such as phosphates and nitrates, which may increase the eutrophic status of the system. Release of anaerobic sediment and organic matter in high concentrations may in some cases deplete the dissolved oxygen.	Select dredging equipment with a low risk of sediment released from lifting. Reduce the suspended material released into the water column by adjusting the ratio of cutter revolutions to pump velocity. Monitor the lifting operations. Use of pingers to drive away aquatic animals, including fishes prior to dredging and lifting of dredged materials	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Soil erosion and soil and water contamination	Impacts of river morphology and bathymetric changes. Increase turbidity and discharge of contamination from dredging activities	Efficient waste management and monitoring protocols. Reporting and changing plans, if necessary.	Contractor	DSC, PIU	Included in contractors' costs
River Traffic	The presence of barges and associated vessels and discharge pipelines will pose a risk to local river traffic. There is also risk of collision of construction boats with dolphins.	Provide proper navigational lighting for the barges and associated vessels. Provide appropriate lighting to all floating pipelines and buoys. Check all navigational lights routinely to ensure that they are working properly. Limit the motor boat speed to 15 km/h to avoid any collision with dolphins. Pingers will be used to chase away dolphins.	Contractor	DSC, PIU	Included in contractors' costs
Noise from dredging activities	Noise and vibration under water: Disruption to fish migration and disturbance to dolphins. Noise and vibration above water: Nuisance to local community, disturbance to birds.	Reduce the dredger noise at source by isolation of exhaust systems, by keeping engine room doors shut and by additional measures such as shielding. Limit the noisy dredging to daylight hours, where possible, rather than at dawn or dusk (significant for wildlife) or during night time hours. Where unavoidable, the contractor should ramp up the levels of engines or other noise producing sources, so that the noise slowly increases. Inspect and maintain equipment in good working condition.	Contractor	DSC, PIU	Included in contractors' costs
Exhaust emissions	Air pollution and release of	Inspect and maintain equipment in good working	Contractor	DSC, PIU	Included in

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	greenhouse gases from construction equipment	condition. Proper maintenance of engines ensures full combustion with low soot emissions. Use low-sulphur heavy fuels to reduce noxious emissions. Provide Exhaust filtering.			contractors' costs
Oil spills	Oil spill will cover large area from a specific point location through tidal and wave action.	Refuel of barges and boats with a proper care to avoid any spills. Make available spill kits and other absorbent material at refueling points on the barges Report immediately in case of any accident related to oil spill and measures taken.	Contractor	DSC, PIU	Included in contractors' costs
River Water Quality	Increased suspended sediment concentrations	Select dredging equipment and methodology, which are known to have a low risk of sediment dispersal. Monitor local suspended sediment concentration and prepare a monitoring response plan to modify dredging and placement operations should threshold levels be exceeded under the prevailing hydrodynamic and wave conditions. Regularly inspect and maintain equipment in order to prevent leaks. Develop and implement a Spill Prevention Plan. With Cutter Suction Dredgers, the level of resuspended material released into the water column can be reduced by adjusting the ratio of	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		cutter revolutions to pump velocity Prior to dredging, sample and analyse sediment to ensure that only 'clean' material (i.e., material with low fine sediment content) should be used.			
	Increased turbidity and reduced transparency	Dredge cuts and lifts should be designed so as to prevent undercutting of material and hence a collapse of material locally at the cutter head, leading to an increase in the sediment being disturbed by dredging. If water quality as per DOE standards is not met, modify operations. Quality Control system shall be developed by the dredging contractor before commencement of work and get approved by DSC/CSC.	Contractor	DSC, PIU	Included in contractors' costs
	Spillage of oils and fuels	Develop and implement spill contingency plans for pipeline and hull leakages. Ensure that emergency response equipment, e.g. floating booms, are serviceable and available to deal with any oil spills or leakages.	Contractor	DSC, PIU	Included in contractors' costs
	Site runoff	Control the discharge of site runoff, including excess dredge water, by the installation and correct use of containment walls, bunds and weirs. Monitor the quality of water and take appropriate remedial action.	Contractor	DSC, PIU	
Drainage Congestion	Drainage will be blocked if vessel shelter is constructed using dredged material	Provision of proper drainage at the vessel shelter construction sites. Apply measures to minimize sediment dispersion.	Contractor	DSC, PIU	Included in contractors' costs
Noise from dredging and construction	Noise and vibration under water: Disruption to fish migration and disturbance to dolphins.	Reduce the dredger noise at source by isolation of exhaust systems, by keeping engine room doors shut and by additional measures such as	Contractor	DSC, PIU	Included in contractors' costs

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
activities	Noise and vibration above water: Nuisance to local community, disturbance to birds.	shielding. Limit the noisy dredging to daylight hours, where possible, rather than at dawn or dusk (significant for wildlife) or during night time hours. Where unavoidable, the contractor should ramp up the levels of engines or other noise producing sources, so that the noise slowly increases. Inspect and maintain equipment in good working condition.			
Exhaust emissions	Air pollution and release of greenhouse gases from construction equipment	Inspect and maintain equipment in good working condition. Proper maintenance of engines ensures full combustion with low soot emissions. Use low-sulphur heavy fuels to reduce noxious emissions. Provide Exhaust filtering.	Contractor	DSC, PIU	Included in contractors' costs
Worker's Health and Safety	Health impact from the exposure to hazardous and chemical materials, dust, gaseous emissions and accidental cause during operation of equipment, construction of anchorage facilities (pontoons, break walls).	OHS plan will be prepared and implemented. Implement fuels and hazardous substances management plan, Drinking water management plan, Spill control arrangements and Firefighting equipment	Contractor	DSC, PIU	Included in contractors' costs
Public Health	Workers mobilization, heavy equipment mobilization, dredging, transporting dredged materials and placement of dredged materials, construction of pontoons with anchorage facilities will cause deterioration of local people's health.	Observance of ECoPs, OHS Plan and relevant dredged materials management plan by the Contractor. Continue liaison and provide information to relevant community leaders, stakeholders and potentially affected communities throughout the	Contractor	DSC, PIU	Included in contractors' costs.

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		dredging period in order to maintain community support. Provide adequate training for staff to operate equipment, to carry out dredging, and to transport dredged material.			
Aquatic Flora including Benthos	Disturbance to riverbed and benthos. Loss of aquatic communities especially benthic biota	Restrict dredging only to the area where required. Dredging to be done in blocks with intervals for recovery of benthos Minimize habitat loss by applying careful control of cutter head, restrict digging to specified boundaries.	Contractor	DSC, PIU	Included in contractors' costs
Aquatic Fauna, including benthos	Disturbance to aquatic mammals and permanent impairment	Dredging area should be checked every day prior to commencement of dredging work. If any aquatic mammals sighted use pingers to drive them away prior to dredging Dredging to be done in blocks with intervals for recovery of benthos It is also recommended that adoption of a 'soft start'; using a low energy start to the operations would give dolphins and other fauna an opportunity to leave the area.	Contractor	DSC, PIU	Included in contractors' costs
Fisheries	Disturbance of fish and damage of aquatic vegetation.	No mitigation is required as operation will not be long lasting and due to dynamic nature of riverbed the system will regain soon. Restrict dredging during known breeding period and migration routes of hilsa fish (see Fig. 10.1 & Table 10.2).	Contractor	DSC, PIU	Included in contractors' costs
Geo-morphology and Bathymetry	Erosion and accretion of the river bank.	Ensure adequate measures through proper design and construction of training works. Before project implementation a pre-dredging survey will be carried out along the specified dredging location. From pre-dredging survey, dredging alignment will be delineated. Dredging	Contractor	DSC, PIU	

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		alignment will be fixed again, considering the safe distance from river bank level. The safe distance from the river bank will determined from hydrographic (distance of thalweg from river bank, alignment of river thalweg) and soil characteristics of river bank. Hence, there is no risk of bank erosion.			
Post Dredging Phase: Navigation Routes and Ferry Crossings					
IWT	Massive improvement on inland water transport in the selected routes and ferry crossings	Employment and livelihood generation with socio-economic development through transportation of cargo and passengers in the project influence area as well as with India and Nepal.	BIWTA	BIWTA	-
Air pollution	Increased gaseous emission due to operation of more riverine traffics (passenger and Cargo vessels). Fuel storage facilities and transfer may also release volatile organic compounds.	To limit gaseous emission vessel engines shall be maintained in good working condition by following manufacturer's standards. Good quality fuel (i.e. no/less sulfur content, lead free) to be used to ensure complete burning. Strict observance of relevant national and international rules. Valid fitness certificate mandatory for plying in the route,	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the ADB/O&M budget of BIWTA
Water pollution	River water will be subject to increased pollution from disposal of raw sewage from ships as well as dumping of solid wastes from passenger vessels. Spillage, leakage and accidents are significant potential sources of contamination, arising either directly from vessels, e.g. fuel oil and lubricants, or from their cargoes.	Observance of EMP and relevant ECoP. Strict compliance with relevant national and international rules to manage wastes from ships. Ensure facilities (trash cans, etc.) at designated locations to put solid wastes and subsequent on land disposal in sanitary manner. Treatment of raw sewage water must be ensured. To develop strategy and implement pilot	Vessel owners, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budgets of BIWTA

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
		program on greening the vessel fleet (including research, outreach, and incentive programs on developing and adopting cleaner technologies such as improvements in vessel engine and propeller design, fuel quality, port operational practices, cargo handling equipment, etc.). To address the potential issues associated with waste effluents generated by O&M activities, the HSE Plan to be prepared and implemented by the BIWTA will include disposal mechanism for waste effluents as well.			
Water from ships	The wastes generated from ships mainly include inert materials such as food packaging, and food waste. Solid wastes to be collected by the ships and dumped in to the municipal dust bins located near the terminals. Liquid effluents associated with ships are sewage, bilge water (e.g. from oil tankers), and vessel cleaning wastewater from ships. Ship sewage and wastewater contains high levels of BOD and coliform bacteria, with trace concentrations of constituents such as pharmaceuticals, and typically low pH levels. Wash water may contain residues such as oil.	Presently there are no facilities at the vessel shelter/terminals for collection of liquid waste from the ships. The ships usually dispose these wastes in the river. During detailed design of terminals, adequate reception facilities will be provided at the terminals for receiving ship generated waste. The reception facilities can be fixed, floating or mobile and should be adapted to collect the different types of ship generated waste and cargo residues. The wastes should be adequately disposed or treated, based on the type of waste, in cooperation with the local municipal authorities. No wastes (solid or liquid) to be dumped at or near the ecologically sensitive and biologically rich areas like fish sanctuaries, important bird	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budget of BIWTA

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	Pollutants in bilge water contain elevated levels of BOD, COD, dissolved solids, oil, and other chemicals that accumulate as the result of routine operations.	areas, etc. (see Fig 10.1)			
Occupational Health and Safety	Potential issues associated with OHS are physical hazards, chemical hazards, dust and noise. The main sources of physical hazards at cargo and passenger vessels as well as vessel shelters and landing stations are associated with cargo handling and use of associated machinery and vehicles. Workers may be exposed to chemical hazards especially if their work entails direct contact with fuels or chemicals, or depending on the nature of bulk and packaged products. Work with fuels may present a risk of exposure to volatile organic compounds via inhalation or skin contact during normal use or in the case of spills. Fuels, flammable liquid cargo, and flammable dust may also present a risk of fire and explosions. Noise sources may include generators, engines of vessels, and vehicular traffic.	During the O&M phase, the BIWTA will implement HSE procedures and its own Emergency Response Plan.	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budget of BIWTA

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Community Health and Safety	Community Health and Safety: During operation of navigation routes, the vessel shelter cargo terminals, the potential community health and safety issues are risk of accidents with activities associated with cargo handling visual impacts from the illumination of the vessels, and traffic activities. Other visual concerns from cargo operations are uncontrolled dumping, floating debris, derelict warehouses and broken machinery.	During the O&M phase, the BIWTA will be required to implement HSE procedures and prepare its own Emergency Response Plan.	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budget of BIWTA
Navigational Safety and Risk	Rules dealing with ship safety are generally preventive, designed to improve ship safety standards by reducing the risk of probability of accidents throughout the life cycle of a ship. Though there may be some casualties caused by weather, structural, mechanical or equipment failure, most shipping casualties in Bangladesh, are caused by substandard operation. This is more often poor stowage and overloading (especially in the peak holiday periods) - the main causes of capsizes and loss. This situation can also be compounded in a price-regulated market where tariffs set by the	Regular information and guidance is to be provided by mariners to improve the shipping safety. Use of radiotelephony, especially VHF, should be introduced to maintain a listening watch on general or distress frequencies. All vessels should be equipped with fog horns and powerful searchlights. A series of measures will be taken up under Component 3 of the Project, which include (i) the development of River Information Systems to improve navigational safety, and provision of a Traffic Monitoring System for passengers and cargo; and (ii) commissioning of a study to propose an institutional structure and reforms needed to develop an effective Search and Rescue organization.	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the ADB/O&M budget of BIWTA, and under Component 3.

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	Government are insufficient to generate reasonable profits. Lack of information and guidance to mariners also impacts negatively on shipping safety				
Change in river geometry due to erosion and accretion.	Due to high variation of seasonal flow and peculiar nature of the river system carrying huge quantity of silt annually, the navigability may be hampered due to erosion and siltation.	For smooth navigability routine maintenance dredging shall be in place through bathymetric survey during post monsoon and carrying out river training works as pilot programme to reduce dredging along the navigation route.	BIWTA,	BIWTA,	To be included in the O&M budget of BIWTA and under Component 3
Operation and Maintenance Phase: Vessel Shelters					
Air pollution	Increased gaseous emission due to operation of more riverine traffics (passenger and Cargo vessels). Fuel storage facilities and transfer may also release volatile organic compounds.	To limit gaseous emission vessel engines shall be maintained in good working condition by following manufacturer's standards. Good quality fuel (i.e. no/less sulfur content, lead free) to be used and ensure complete burning. Strict observance of relevant national and international rules. Valid fitness certificate mandatory for plying in the route,	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the ADB/O&M budget of BIWTA
Water pollution	River water will be subject to increased pollution from disposal of raw sewage from ships as well as dumping of solid wastes from passenger vessels.	Observance of EMP and relevant ECoP. Strict compliance with relevant national and international rules to manage wastes from ships. Ensure disposal facilities at designated locations to put solid wastes and subsequent on land	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the ADB/O&M budget of BIWTA

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	Spillage, leakage and accidents are significant potential sources of contamination, arising either directly from vessels, e.g. fuel oil and lubricants,	disposal in sanitary manner. Treatment of raw sewage water must be ensured. To develop strategy and implement pilot programson greening the vessel fleet (including research, outreach, and incentive programs on developing and adopting cleaner technologies such as improvements in vessel engine and propeller design, fuel quality, port operational practices, cargo handling equipment, etc.). To address the potential issues associated with waste effluents generated by O&M activities, The HSE Plan to be prepared and implemented by the BIWTA will include disposal mechanism for waste effluents as well.			
Water from ships	The wastes generated from ships mainly include inert materials such as food packaging, and food waste. Solid wastes are being collected by the ships and are being dumped in to the municipal dust bins located near the terminals. Liquid effluents associated with ships are sewage, bilge water (e.g. from oil tankers), and vessel cleaning wastewater from ships. Wash water may contain residues such as oil. Pollutants in bilge water contain elevated levels of BOD, COD, dissolved solids, oil, and other chemicals that accumulate as the result of routine operations.	Presently there are no facilities at the vesselshelter/terminals for collection of liquid waste from the ships. The ships usually dispose these wastes in the river. During detailed design of terminals, adequate reception facilities will be provided at the terminals for receiving ship generated waste. The reception facilities can be fixed, floating or mobile and should be adapted to collect the different types of ship generated waste and cargo residues. The wastes should be adequately disposed or treated, based on the type of waste, in cooperation with the local municipal authorities.	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budget of BIWTA

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
Occupational Health and Safety	Community Health and Safety: During operation of navigation routes, the vessel shelter cargo terminals, the potential community health and safety issues are risk of accidents with activities associated with cargo handling visual impacts from the illumination of the vessels, and traffic activities. Other visual concerns from cargo operations are uncontrolled dumping, floating debris, derelict warehouses and broken machinery.	During the O&M phase, the BIWTA will be required to implement HSE procedures and prepare its own Emergency Response Plan.	Vessel owner, BIWTA,	BIWTA, Independent M&E Consultant, DoE	To be included in the O&M budget of BIWTA
Induced and Cumulative Effects					
Aquatic Biodiversity	Dredging and land reclamation will impact negatively on water quality as well as the aquatic lives.	Detailed ecological baseline studies are recommended for the entire study area to be carried out prior to commencement of the dredging and to identify suitable areas of enhancement measures sanctuaries and spawning areas. (see Biodiversity Management Plan as Annex E)	BIWTA through Consultants	DSC, M & E Consultant	Included in Table 10.13
Industrialization	The potential negative impacts are loss of seasonal floodplain, deterioration in water quality, soil quality, waste generation, Land acquisition and resettlement, loss of agricultural lands and change in landuse.	The negative impacts may be reduced or eliminated through proper planning at the beginning of the Project by conducting relevant baseline studies including irrigation, water resources, institutional, social, environment and floodplain ecology. The studies will also identify potential ecosystem areas of conservation significance and	BIWTA through Consultants	DSC, M & E Consultant	Included in Table 10.13

Activity/Issues	Potential Impacts	Proposed Mitigation and Enhancement Measures	Responsible Parties		Budget (USD)*
			Implementation	Supervision/ Approval Authority	
	Major positive impacts are employment generation and gender.	ensure that any development activities will not impact the quality of these ecosystems. The positive impacts should be accelerated through recruiting local people in the new industries and factories with equal gender opportunities.			

10.3.3 Criteria for Placement of Dredged Material in River or on Land

Various options have been considered for dredged material management (see **Figure 10-3**). These options can be primarily grouped in to two categories: (i) placement in the river in the deep scour holes and along eroding river banks; and (ii) placement on the land for beneficial use where there is a demand and material is suitable or in river disposal is not feasible. The options for land required for on land disposal include existing stack yards of the sand traders, encumbrance free government owned land, or leasing land from private people or community. Placement of the material in the deep scour holes (<5 meter) in the river or in the erosion vulnerable location is a preferred option. Since removal of sediment, by dredging, from its natural path or cycle, may have damaging environmental consequences (in the estuaries, the balance between erosion and accretion will be disturbed by dredging). Therefore, it can be beneficial to return the material into the originating system, rather than removing it to a separated site. However, the placement of dredged material on the land is also considered as a preferred option if it fulfills all the mentioned criteria (**Figure 10-3**).

10.3.4 Dredge Material Placement on Land

From the analysis of dredging requirements and river morphology, it is expected that the dredged material will need to be placed on the land, given the lack of sufficient suitable in-river disposal locations.

Several potential dredged material placement sites on land have been identified. The dredged material can be placed on Existing sand stackyard, Government owned land such as School, college and University playground, Park, Grave yard etc. Moreover, privately owned land can be leased for the placement of dredged material. Their locations, along with the respective dredging locations are elaborated in **Figure 10-3**. Details of these potential placement locations and their approximate distances from the dredging locations and amount of dredged material that would potentially be accommodated at these locations are given in Table 10.2. It is important to note that these locations are not finalized, and detailed land acquisition or lease negotiations and resettlement planning (if required) has not yet been undertaken. This is in light of the ever-changing nature of the river system and the likelihood that there will be some updates to volumes and specific locations of required dredging on these routes by the time activities get underway under the PBC contract. Prior to finalize the location of dredged earth placement site, some criteria must be fulfilled such as it can not be placed on a existing waterbody (beel, drainage canal etc.), agricultural land, floodplain, mashland or any ecologically sensitive area. Again, site of dredge material can not hamper the livelihood of a community. From stakeholder consultations it is perceived that there is general interest/willingness and community demand for dredged material in these locations. During mobilization and as part of the ongoing monthly dredging planning process, the contractor will confirm the need and dredge material volumes for on-land disposal, and specific locations will be identified, acquired or leased as necessary, and provided by the BIWTA to the contractor.

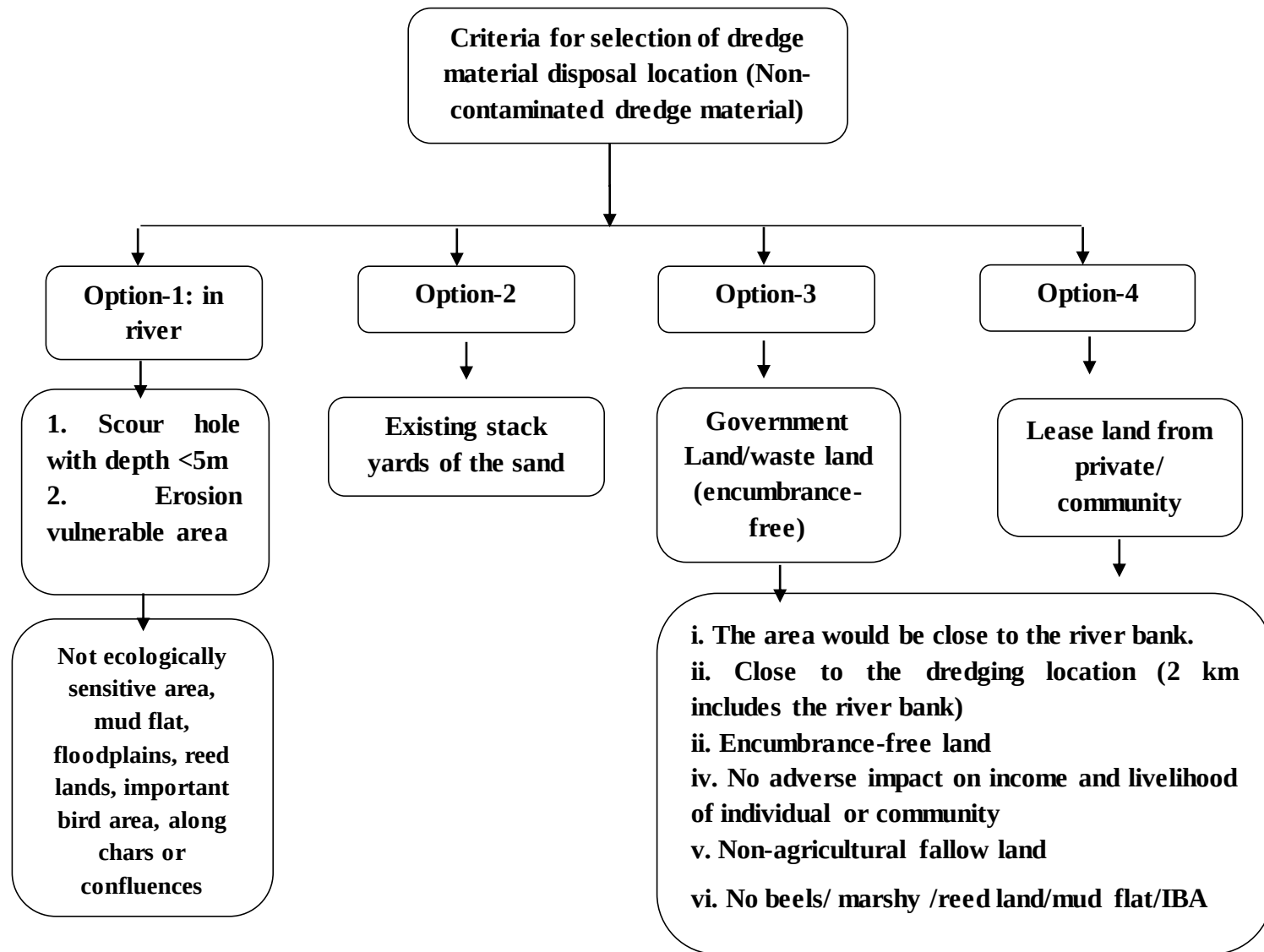


Figure 10-3: Criteria for selection of dredge material disposal location

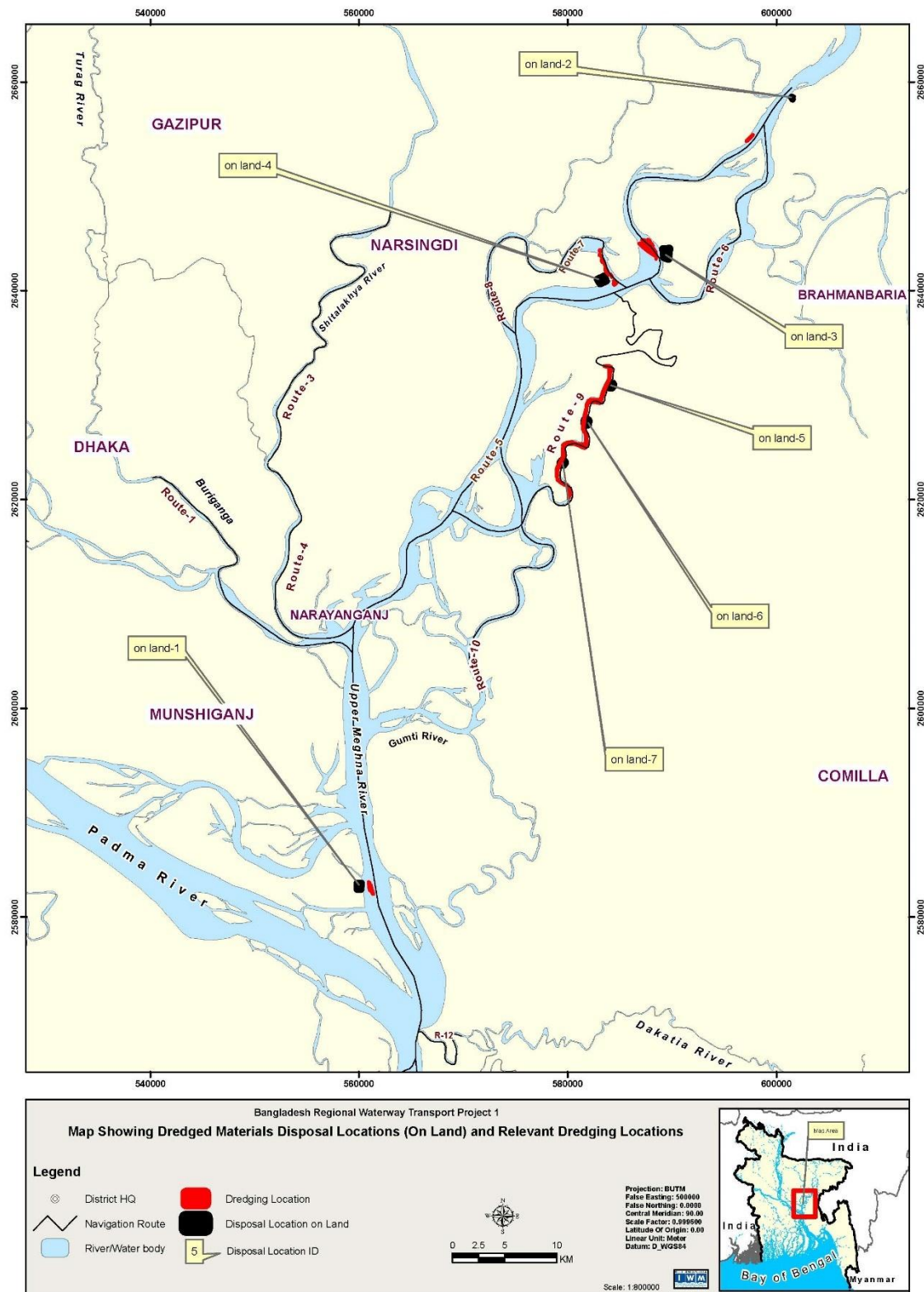


Figure 10-4: Locations of Land Based Dredged Material Placement

Table 10-2 : Details of Dredging in the Loop Rivers and Dredged Material Placement Locations on the Land

Route No.	Name of the River	Part of Upper Meghna or Lower Meghna	Priority	Route Class	Channel Width, m (no slope)	Dredging Depth, m	Base Line Dredge Volume, m ³	Potential Annual Volume with 50% Re-Sedimentation Rate, m ³	Minimum Dredging Distance to be Maintained from Banks/Chars, m	Position of the Disposal location		Distance from Dredging to Placement Site, km	Area, m ²	Maximum Volume that can be Disposed at the Placement Location, m ³
										Easting (BUTM_X)	Northing (BUTM_Y)			
1 & 2	Upper Meghna	Upper	A	1	76	-4.3	37,500	56,250	100 m	560116	2582960	1	190,000	570,000
5	Upper Meghna	Upper	A	1	76	-4.3	236,000	354,000	100 m	601533	2658403	5	146,330	438,990
										589324	2643917	1.3	500,000	1,500,000
7&8	Upper Meghna	Upper	B	2	76	-2.8	370,000	555,000	100 m	583069	2641001	1.2	290,000	870,000
9	Upper Meghna (Branch)	Upper	C	3	30	-2.1	126,800	190,200	100 m	584135	2630914	1	34,500	103,500
										581828	2627380	1	33,500	100,500
										579518	2623529	1	34,000	102,000
Total								1,155,450						3,684,990

Table 10-3: Details of Dredging and Dredged Material Placement Locations in the River

Route No.	Name of the River	Part of Upper Meghna or Lower Meghna	Priority	Route Class	Channel Width, m (no slope)	Dredging Depth, m	Base Line Dredge Volume, m ³	Potential Annual Volume with 50% Re-Sedimentation Rate, m ³	Potential Contractor Split (By Geographical Area)	Type of Sensitivity (Reed Lands, IBA, Hilsa Sanctuaries, Hilsa Spawning Grounds)	Minimum Dredging Distance to be Maintained from Banks/Chars, m	Location of Dredged Material Placement, See Figure 1	Position of the Material Placement location (central location)		Distance from Dredging to Placement Site, km	Available Depth at the Placement location during Dry Season, m	Area of the placement location, m ²	Maximum Volume that can be Disposed at the Placement Location, m ³
													Easting (BUTM_X)	Northing (BUTM_Y)				
1 & 2	Buriganga, Dhaleshwari and Upper Mehna	Upper	A	1	76	-4.3	37,500	56,250	PBC-1	None	100 m	1	560769	2580981	1.8	6	340,030	2,040,180
												2	562796	2576859	1	7	231,220	1,618,540
												39	568018	2571594	5	12	2,875,000	34,500,000
												40	565135	2567969	2	28	1,232,143	34,500,000
2 (South of Chandpur)	Lower Meghna	Lower	A	1	76	-4.3	597,400	896,100	PBC-2	Sanctuary	100 m	41	584304	2517511	3.5	15	1,500,000	22,500,000
										Sanctuary, Spawning		42	594951	2492108	3.5	9	1,002,778	9,025,000
										Spawning		43	612123	2487402	6.5	12	1,375,000	16,500,000
										Spawning		44	618031	2473586	2.3	14	2,500,000	35,000,000
										Spawning		in stream-1	631,845	2,463,566	-	-	-	-
										Spawning		in stream-2	643,806	2,465,101	-	-	-	-
										Spawning		in stream-3	656,297	2,459,491	-	-	-	-
										Spawning								
3 & 4	Shitalakshya	Upper	A	1	76	-4.3	22,600	33,900	PBC-1	None	100 m	3	550968	2623171	0.5	6	31,543	189,258
												4	553099	2616694	0.5	9	20,100	180,900
5	Upper Meghna	Upper	A	1	76	-4.3	236,000	354,000	PBC-1	None	100 m	6	597438	2653674	0.8	8	50,000	400,000
												7	594,389	2,652,1	0.8	9	56,889	512,000
												8	587397	2651114	0.5	6	147,333	884,000
												10	588573	2643457	2	13	98,000	1,274,000
6	Upper Meghna	Upper	A	1	76	-4.3	-	-	PBC-1	None	100 m	-	-	-	-	-	-	-
14	Lower Meghna, Nayabhangha and Bishkhali	Lower	A	1	76	-4.3	432,900	649,350	PBC-2	None	100 m	46	543066	2514951	1	15	115,000	1,725,000
18	Bishkhali	Lower	A	2	76	-2.8	1,000	1,500	PBC-2	None	100 m	49	538750	2510244	0.5	18	88,000	1,584,000
19	Lower Meghna	Lower	A	2	76	-2.8	25,100	37,650	PBC-1	Spawning	100 m	51	560012	2563276	1.2	9	9,000	81,000
20	Lower Meghna	Lower	A	2	76	-2.8	387,000	580,500	PBC-2	Spawning	100 m	52	580589	2524731	4	8	125,000	1,000,000
21	Tentulia	Lower	A	2	76	-2.8	392,300	588,450	PBC-2	Spawning	100 m	53	552667	2509530	2.5	11	84,000	924,000
										Reed lands		61	554598	2511478	1.5	15	16,500	247,500

Route No.	Name of the River	Part of Upper Meghna or Lower Meghna	Priority	Route Class	Channel Width, m (no slope)	Dredging Depth, m	Base Line Dredge Volume, m ³	Potential Annual Volume with 50% Re-Sedimentation Rate, m ³	Potential Contractor Split (By Geographical Area)	Type of Sensitivity (Reed Lands, IBA, Hilsa Sanctuaries, Hilsa Spawning Grounds)	Minimum Dredging Distance to be Maintained from Banks/Chas, m	Location of Dredged Material Placement, See Figure 1	Position of the Material Placement location (central location)		Distance from Dredging to Placement Site, km	Available Depth at the Placement location during Dry Season, m	Area of the placement location, m ²	Maximum Volume that can be Disposed at the Placement Location, m ³
													Easting (BUTM_X)	Northing (BUTM_Y)				
22	Lower Meghna	Lower	A	2	76	-2.8	396,500	594,750	PBC-2	Spawning	100 m	54	585316	2508183	1.5	17	170,000	2,890,000
7&8	Upper Meghna	Upper	B	2	76	-2.8	370,000	555,000	PBC-1	None	100 m	18	586607	2640862	2	25	200,000	5,000,000
												19	577918	2641797	1	9	24,000	216,000
												20	575660	2644883	0.9	14	21,000	294,000
												55	568851	2565929	1.5	12	19,000	228,000
12	Chandpur	Lower	B	2	76	-2.8	152,800	229,200	PBC-1	Reed lands	100 m	56	567998	2566413	2.5	8	15,000	120,000
										Reed lands		58	537042	2538395	3	14	62,000	868,000
13	Lower Meghna and Arial Khan	Lower	B	2	76	-2.8	76,400	114,600	PBC-2	None	100 m	59	552641	2537734	2	9	16,000	144,000
9	Upper Meghna	Upper	C	3	30	-2.1	126,800	190,200	PBC-1	None	100 m	34	578,206	2,621,320	0.5	5	32,500	162,500
												35	575,282	2,617,447	1	15	100,000	1,500,000
10	Upper Meghna	Upper	C	3	30	-2.1	33,274	49,911	PBC-1	None	100 m	37	576430	2615653	4	6	40,000	240,000
15 & 16	Lower Meghna and Tentulia	Lower	C	3	30	-2.1	607,500	911,250	PBC-2	None	100 m	60	558967	2523114	5	13	136,000	1,768,000
17	Tentulia	Lower	C	3	30	-2.1	500	750	PBC-2	None	100 m	62	550858	2511917	3	19	53,500	1,016,500
Total								5,844,861										179,132,378

For on-land disposal sites, the contractor will construct and maintain disposal facilities. The facilities shall meet the following minimum criteria for design and operation:

Sites shall be bunded/ closed, with a water outlet weir box at its downstream end. Bunding is undertaken with hydraulic excavators using nearby surface material, or may be constructed from previously dredged material. Bund heights can be raised as necessary using dredged material.

The weir box can be used to control the water level in the disposal area. Adjusting the weir allows control of the setting process in the disposal area. The outflow from the disposal area can either be directed to the surrounding waters by a ditch, or be pumped back from a small collecting basin at the weir box.

Depending on the physical makeup of the dredged material, the disposal area can be split into two or more bunded areas: sand (disposal) area and the silt (disposal) area/pond, placed in tandem in the downstream direction. The dredged material would be pumped first to the sand area where segregation would ensure only fine sand to pass into the silt pond, from which virtually clean water would flow. An example is given below of a sand (disposal) area with silt (disposal) area/pond below.



Figure 10-5: Disposal Area with Silt Pond

The contractor shall directly place the sediments for filling the proposed disposal areas. Filling will be achieved by progressively pumping slurry of sand and water into the bunded areas, allowing the surplus water to drain away to artificial and natural waterways in a controlled manner through the pipeline, without affecting floodplains.

Considering the volume of dredge material 2 to 3 compartments shall be prepared for management of sediment laden water from dredged material disposal site. The dredged material first shall be pumped in to first compartment to settle the coarse sediment. The second compartment will be linked to the first compartment through the pipe at the top. Water at the top of first compartment transferred to the second through the linked pipe.

Second compartment receives less sediment concentrated water from the first compartment, however comparatively fine sediment is settled in this compartment. Relatively less sediment concentrated water is remained at the top after suspension of fine sediment, which will be drained to nearby river/canal.

A Schematic diagram of the above mentioned process is shown **Figure 10-6**. Typical design is shown disposal pond is shown in **Annex-V**.

Leaching from the sediments as well as other site runoff shall be contained, either to seep into the subsoil, or to be discharged in a controlled manner so as to minimize release of sediment laden water in excess of 200mg/l of suspended materials into adjacent lands or waterways. The contractor shall regularly monitor water quality of site runoff. If necessary, additional siltation ponds shall be constructed and utilized by the contractor to settle out excess suspended materials prior to discharge.

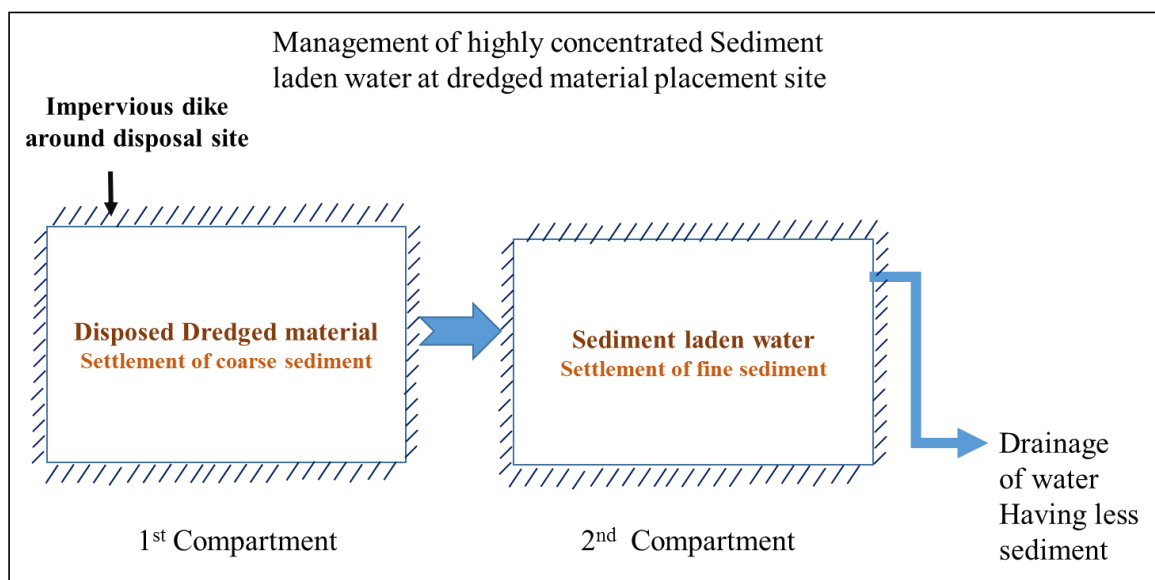


Figure 10-6: Flow chart of high concentrated sediment laden water management.

In most cases, it is expected that dewatered sands and sediments will be removed from the site over time by local communities for land-filling or other projects. All dredged materials are the property of BIWTA (not the contractor), and authorizations for local communities or others to avail of the material will be given by BIWTA. BIWTA will inform the contractor when such permissions have been granted.

In cases where there is no local demand for the dredged materials, the contractor shall properly compact them and, when the site has reached capacity, shall restore the area. Top layer shall be the 0.5 m thick clay on the surface and boundary slopes along with grass. Side Slope of Filled Land of 1:3 for river side and other sites 1:2 shall be constructed by suitable soils with proper compaction as per design. Slope surface shall be covered by top soils/cladding materials (0.5m thick) and grass turfing with suitable grass.

After settlement of sediment, less sediment laden water will be released into the artificial or natural waterways like rivers or canals in a controlled manner without affecting the floodplains or agricultural land using GI pipe.

10.3.5 Criteria for Selection of Additional Sites for Dredged Material Placement on Land

Locations of dredging may change in future due to dynamic nature of the rivers. Additional placement sites may be required if there are more dredging volumes or the proposed placement sites are more than 5 km from the dredging sites. BIWTA will identify the additional land based placement sites using the following criteria and handed over them to the contractor.

- (i) The dredged material placement sites on the land are not located in any sensitive environmental areas (as shown in Figure 10.1) or in any wet lands
- (ii) The government owned waste lands will be given priority if available
- (iii) Use of agriculture lands will be minimized to the extent possible

Table 10-4 provides an overview of the overall criteria for selection of dredged material disposal location, and order of preference. :

Table 10-4: Options of Dredge dredge material disposal location according to criteria

Options for disposal of dredged material (in order of preference)	Description/ Intervention	Additional applicable criteria
Option-1: in-river disposal	- In the river bed - Scour hole of depth <5m - Erosion vulnerable area	<i>Exceptions:</i> ecologically sensitive areas, mud flat, reed lands, important bird areas, or along chars or confluences
Option-2: on-land disposal	Existing stake yard of the sand traders (if identified near the dredging site)	i. Close to the river bank. ii. Close to the dredging location (within 2 km, includes the river bank) iii. Encumbrance-free land iv. No adverse impact on income and livelihood of individual or community v. Non-agricultural fallow land vi. No impacts to cultural heritage vi. Not within 100m of beels/ marshy areas /reed land/mud flat/IBA
Option-3 - on-land disposal	Government Land/waste land	
Option-4 - on-land disposal	- Lease land from the private - Lease Land from the Community	

10.3.6 Dredge Material Placement in River

Dredged material from all the dredging locations except for some sections of the routes 1, 2, 5, 7, 8 and 9 will be placed in the deep scour holes in the river. Details of the dredged material placement locations, their distances from the dredging locations, and approximate quantities of material can be placed at these locations are given in Table 10.3.

The Contractor shall place all the dredged material in these designated disposal locations. The contractor shall use submerged discharges for hydraulic disposal of dredged material. To minimize the extent of impact from the disposal activities, the contractor is recommended to use diffusers at the outlets of the hydraulic pipes (to reduce exist velocity of the sediments to minimize sediment dispersion).

Numerous scour holes were identified in the rivers using the bathymetry data (numbered in Fig. 10.1). Scour holes are important for the aquatic biodiversity and used as a refuge by some large fishes, turtles, dolphins and other aquatic animals during dry season/winter. During dry season no dumping of dredged materials in the scour holes in the Upper Meghna (refer to Fig. 10.1 for location of scour holes) has been suggested. However, for practical reasons the selection of scour holes where in-river disposal of non-contaminated/non-toxic dredged materials is to be carried out, the following criteria in Table 10.5 may be used.

Table 10-5 . Criteria for selectionof scour holes for in-river dredged spoil disposal.

Scour hole exclusion Criteria	Scour hole inclusion Criteria
Located along the chars Located at the river confluences and river bends Low current (velocity) areas Shallow areas Deeper sections of the river during dry season and with low velocity	• Vicinity of eroding river banks • River sections with high velocity/current • Areas with continuous river bank erosion • Areas with minimum river depths of 10m

Similarly, the following criteria may be used for exclusion of inland disposal sites.

- Freshwater wetlands, including ponds, ditches, beels, haors.
- Agricultural land.
- Public places like school fields, eidgahs, etc., (unless demanded by the local people).

10.3.7 Mangement of Contaminated Materials

The Contractor shall carry out the sampling and testing of the river bed material at the starting of the dry season every year. The locations of sampling, frequency of sampling and parameters to be tested are given in Table 10.1. The river bed sediments in the Buriganga (Route 1) and Shitalakhya (Route 3 and 4) are contaminated. Based on the historic and bathymetric charts of 2015, no dredging is expected in Buriganga; while dredging may be required in some sections of Shitalakhya.

The Contractor shall minimize the dredging in Shitalakhya River by properly selecting the

navigation alignment (this seems possible as per bathymetric chart of 2015). The same practice will apply to any other river section where contamination is identified during the course of project implementation. If the dredged material is found to be contaminated, the dredged material is placed back in to the same rivers and shall not be brought on to the land. The Department of Environment of Government of Bangladesh has a long term plan to clean up the rivers around Dhaka, including Buriganga and Shitalakhya, and hence requested to BIWTA to dispose the contaminated sediments back into the same rivers.

In the unlikely case that (a) the presence of contaminated or hazardous substances is encountered within riverbed materials in an area where dredging cannot be avoided by adjusting the navigation channel, AND (b) in-river disposal locations are not available, the contractor will be required to carry out one of the following:

Utilize an existing hazardous substance disposal facility that is designed, legally permitted, and operated in a manner which is in compliance with applicable laws and regulations, and which appropriately minimizes risks to the public and the natural environment associated with the hazardous or contaminated material; or

Construct and maintain, through the life of the contract, a special disposal facility at an approved location near the dredging site, which appropriately minimizes risks to the public and the natural environment associated with the hazardous or contaminated material.

If either option needs to be utilized, the Contractor shall propose a detailed site-specific hazardous materials management plan to the Engineer, as part of the CEAP (or as part of the monthly update to the CEAP, if such need arises during the course of project implementation), to be approved by the Engineer prior to initiating dredging at the location where contamination is present.

In case of option #1, the detailed plan shall include all necessary control and management measures associated with removal and transportation of the contaminated materials to the approved existing facility, as well as evidence satisfactory to the Engineer of the legal and safe operation of the existing facility.

In case of option #2, the detailed plan shall include a detailed site plan, construction and management specifications, for the facility to be constructed and operated by the contractor. The design shall conform to the general specifications and requirements for all on-land disposal facilities, as well as the following additional minimum specifications:

Scope of Additional Routes:

There is a possibility that additional routes may be included to the scope of the contractor's work during project implementation. In such cases, following steps have to be followed:

- i. BIWTA may be required to undertake a separate, stand-alone EIA of the additional routes / geographic scope, including an EMP (either validating that the current EMP is appropriate, or proposing additional specific measures as required), in accordance with both national and World Bank standards. This will be determined in consultation with DOE and the World Bank.
- ii. This additional EIA/EMP needs to be submitted to the World Bank and to DOE for approval and issuance of environmental clearance prior to initiation of any dredging or other activities on the added routes/geographic area.

- iii. The DSC and Independent Third Party Monitor's contracts would then also need to be revised as required to ensure full coverage of monitoring arrangements for the additional geographic area.

10.3.8 The Environmental Codes of Practice (ECoPs)

The environmental codes of practice (ECoPs) are generic, non-site-specific guidelines. The ECoPs consist of environmental management guidelines and practices to be followed by the contractors for sustainable management of all environmental issues. The contractor will be required to follow them and also use them to prepare site-specific management plans. The ECoPs are listed below and attached in Annex K of EMF. These ECoPs will be annexed to the bid documents to all construction works to be carried out under the Project. The contractor is expected to interpret these requirements in a site-specific manner as part of the detailed, site specific Environmental Management Action Plan which shall be presented as part of the detailed dredging plan on an annual basis for DSC and BIWTA approval prior to initiation of dredging. Contractor has to make monthly work plan as an essential part of ECAP.

- ECoP 1: Dredging Management
- ECoP 2: Waste Management
- ECoP3: Fuels and Hazardous Goods Management
- ECoP4: Water Resources Management
- ECoP 5: Drainage Management
- ECoP 6: Soil Quality Management
- ECoP7: Erosion and Sediment Control
- ECoP 8: Top Soil Management
- ECoP 9: Topography and Landscaping
- ECoP10: Borrow Areas Management
- ECoP11: Air Quality Management
- ECoP 12: Noise and Vibration Management
- ECoP 13: Protection of Flora
- ECoP 14: Protection of Fauna
- ECoP 15: Protection of Fisheries
- ECoP 16: Road Transport and Road Traffic Management
- ECop 17: River Transport Management
- ECoP 18: Construction Camp Management
- ECoP 19: Cultural and Religious Issues
- ECoP20: Workers Health and Safety

10.3.9 Biodiversity Management Plan (BMP)

A biodiversity management plan is prepared as part of EIA to manage impacts on biodiversity from project related interventions. Additional studies will be carried out during early stages of project implementation (a) to collect baseline data on biodiversity at sensitive locations; and (b) to develop and implement biodiversity management programs including habitat enhancement and protection for key species. BMP has been prepared and details are presented in Annex E.

10.3.10 Site-specific management plans

The following site-specific plans will be prepared by the contractors as part of their bid package, and implemented throughout the life of the contract, to manage and mitigate/reverse potential adverse environmental impacts. All these plans will be prepared on the basis of this EMP document (including the mitigation measures items presented below in Table 10.1, ECoPs presented in Annex K and all applicable national and World Bank requirements including WBG EHS Guidelines (2007). They will be submitted to BIWTA as part of the bid package, and then during the mobilization period and prior to starting any physical works, will be validated, updated as needed, and re-submitted the DSC for review and approval. Each plan shall provide site-specific details for each route, and shall indicate requirements, milestones for implementation, indicators for verification and monitoring, skills and equipment required to implement, and training requirements / training plan, among any other relevant aspects:

Contractor's dredge management and disposal plan for each dredging location: The plan shall specify:

(a) the control measures to be put in place at each location in order to comply with EMP thresholds and requirements to minimize benthic and aquatic disturbances, as well as noise, air pollution, and other impacts during the dredging process – based on ecological sensitivity and presence of contamination;

(b) all exact locations and management provisions for dredged material placement and disposal, in accordance with this EMP, based on the actual anticipated dredge volumes and locations as per updated the most recent survey data. The locations shall include the pre-specified locations from Figure 10.1 and Table 10.2 and Table 10.3 above, where applicable. For any additional/new areas requiring dredging for which the pre-identified locations are not feasible, additional sites shall be proposed following the criteria specified in this EMP.

(c) Contaminated/ Toxic Dredged Material Management Plan: This has been discussed under section 10.3.6.

Documentation to be maintained and provided to the DSC on environmental management for the dredging activity.

- **Pollution Prevention and control Plan** will be prepared and implemented by the contractors on the basis of the ECoPs and WBG EHS Guidelines (2007) that will be part of the bidding documents.
- **Waste Disposal and Effluent Management Plan** will be prepared and implemented by the Contractor on the basis of the EMP, ECoP, and WBG EHS Guidelines (2007), which will be part of the bidding documents.
- **Drinking Water Supply and Sanitation Plan:** Separate water supply and sanitation provisions will be needed for the temporary facilities including offices, labor camps and workshops in order not to cause shortages and/or contamination of existing drinking water sources. A Plan will be prepared by the contractors on basis of the EMP and ECoPs, which are part of the bidding documents.
- **Occupational Health and Safety (OHS) Plan** will be prepared and implemented by the contractor on the basis of the WBG EHS Guidelines (2007), ECoPs, and other relevant standards.

- **Traffic Management Plan** will be prepared by the dredging contractor after discussion with BIWTA and authorities responsible for roads and traffic. The Plan will be submitted to the DSC for their review and approval before contractor mobilization. The Plan will identify the routes to be used by the contractors for all on-shore activities (including for example, movement of equipment, laying of sluice pipes for deposition of on-shore dredge material as applicable, worker camps and facilities, construction and maintenance of vessel shelters, etc.), procedures for the safety of the local community particularly pedestrians, and monitoring mechanism to avoid traffic congestion. Also plan for river traffic is to be prepared by the contractor in consultation with the vessel owner and taking adequate safety measure at disposal site. This also includes engaging watch man to warn the navigation traffic.
- **Construction Camp Management Plan** will be prepared by the contractor. The Plan will include the camp layout, details of various facilities including supplies, storage, and disposal. The Plan will be submitted to the DSC for their review and approval before camp establishment.
- **Fuel and Hazardous Substances Management Plan** will be prepared by the contractor in accordance with the standard operating procedures, relevant guidelines, and where applicable, material safety data sheets (MSDS). The Plan will include the procedures for handling and storage of oils, fuels, and hazardous substances. The plan will also outline requirements and procedures to safeguard worker and community health and safety as well as the environment in case of any accidental spills. Suitable equipment and materials for the clean up of small oil spill should be available for use at all time. Close attention should be paid to the location and design of fuel storage, and dispensing facilities..
- **An Emergency Preparedness and Response Plan** will be prepared by the contractor after assessing potential risks and hazards that could be encountered during construction.

During implementation of the project, the contractor will carry out continuous surveying and will prepare a monthly work plan projecting the specific activities, dredge locations and volumes to be carried out in the coming month, based on the updated survey data. As part of this monthly plan, the contractor will include a Detailed Updated Contractor's EMP, which shall specify any relevant updates or modifications to the above-mentioned site-specific plans, to account for changes in location, scope or methodology of river channel / ferry crossing / vessel shelter maintenance activities. For example, if new geographic areas need to be dredged or if dredging volumes exceed available capacity for disposal in the pre-specified disposal areas as shown in Figure 10.1, the monthly plan shall propose new locations and all relevant mitigation and management requirements, in accordance with the criteria specified in this EMP and the detailed plans outlined above. The monthly work plan will be submitted to the DSC for approval prior to the contractor initiating activities that month. As part of this review, the DSC's Environmental Expert shall review and approve the Detailed Updated Contractor's EMP component of the monthly work plan.

10.4 Environmental Monitoring Plan

10.4.1 General

The Contractor shall perform environmental monitoring for the duration of this contract and submit results to the Engineer. Monitoring activities shall include

- Surface water quality (including spot measurements for suspended solids, turbidity, dissolved oxygen, and pH)
- River bed sediments quality
- Noise; spot measurements for noise and under water noise levels

The monitoring shall be conducted only by qualified persons or accredited laboratories approved by the Engineer in compliance with the relevant laws, regulations and/or international standards.

If any of the monitored results including laboratory test results showed excessive or long-term deterioration of water and sediment in qualities in comparison with the environmental baseline, the Contractor shall take immediate counter-measures necessary to recover the acceptable environmental conditions.

If the Contractor's countermeasures are not satisfactory in the opinion of the Engineer, the Engineer may order suspension of the work until the newly monitored results become satisfactory. No additional payment or time extension will be granted for the work delay caused by this work suspension.

Should the Contractor fail to comply with the requirements of the listed statutes as well as effect and maintain monitoring operations, the Employer may directly undertake required countermeasures and/or monitoring activities. The costs which the Employer incurs shall be deducted from the payment to the Contractor. Any deduction shall be subject to the Engineer's determination.

A monitoring plan has been prepared to be carried during implementation of the project to ensure contractors' compliance with the mitigation measures is given in Table 10.6 along with the monitoring indicators and frequency to record the response of the project on the natural system. DSC will be responsible for supervision of implementation of the plan.

Table 10-6 : Environmental Monitoring Plan

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
During Dredging andConstruction Phase (Navigation routes and Ferry crossings:							
1	Aquatic Flora and Fauna including Plankton	Sensitive habitats at the potential dredging	Study of bathymetric Charts. Inspection, sampling,	1 week before dredging, Quarterly after	BIWTA through biodiversit y consultant,	DSC, M&E Consult ant, BIWTA	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
	and Benthos	location	analyses and comparison with baseline condition.	dredging for 7 year	Contractor , outsourcing to NGO having relevant survey experience		
2	Aquatic Fauna (fish, dolphin)	Sensitive habitats in the area where dredging will be required	Study of bathymetric charts to identify potential dredging locations. Inspection of aquatic habitats, and monitoring of faunal species (fish, dolphin)	3 months before dredging, monthly after dredging	BIWTA through biodiversity consultant, Contractor , outsourcing to NGO having relevant wildlife survey experience	DSC, M&E Consultant, BIWTA , ES	Included in Table 10.13
3	Sediment Dispersion	At the dredging locations	Inspection of dredging activities, check sediment concentration and extent.	Weekly	Contractor	DSC	Included in Table 10.13
4	River bank erosion	Locations near dredging and placement locations	Visual inspection of the river banks for erosion, and formation of sand bars	Monthly	Contractor	DSC	Included in Table 10.13
5	Hydro-logical condition	At the dredging site.	Inspection of river flow, water level and current speed	Weekly	Contractor ,	DSC	Included in Table 10.13
6	Drainage	At the on	Inspection of	Daily	Contractor	DSC	Included

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
	Congestion	land disposal site in the Upper Meghna River.	the drainage outlets in the disposal area are functional, and adequate to discharge water		,		in Table 10.13
7	River transport	At the dredging location of the project influence area	Watch boat, watchman, sign boards, etc.	Daily	Contractor	DSC	Included in Table 10.13
8	Spills from Hydrocarbon and chemical storage	Material storage sites and dredging sites	Visual Inspection for leaks and spills	Monthly	Contractor	DSC	Included in Table 10.13
9	Sediment leakages from pipes	Along the dredged material carrying pipes to the placement locations	Visual inspection	Monthly	Contractor	DSC	Included in Table 10.13
10	Sediment disposal	At the dredging and disposal sites of the project influence area	Inspection of the sediment disposal sites	Daily	Contractor	DSC	Included in Table 10.13
11	Surface Water Quality (spot measurements)	At 100 m downstream of all the dredging locations	Spot measurements using portable equipment (in presence of Engineer) for suspended	Monthly	Contractor	DSC	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
			solids, turbidity, dissolved oxygen, and pH. Visual inspection on presence of petroleum products.				
12	Surface water quality (detailed analysis)	At 25 locations covering all proposed 22 river routes. The locations will be determine d by the Engineerat the beginning of each sampling.	Sampling and analysis of river water quality and waste water discharges for pH, Temperature, Turbidity, TSS, TDS, EC, DO, BOD, TOC, Ca, Mg, Na, K, F,Cl, Br, SO4, NO3, PO4	Quarterly (October, January, April)	Contractor through a nationally recognized laboratory	DSC	Included in Table 10.13
13	Waste Water	Waste water releases from the land based dredged material placement sites	Sampling and analysis as per the requirements of ECR 1997 for waste water discharges	Quarterly	Contractor through a nationally recognized laboratory	DSC	Included in Table 10.13
14	Soil pollution	At vessel shelter constructi on sites	Visual inspection that filling is through several compartments	Beginning of earth filling works	Contractor	DSC	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
		Constructi on and material storage sites	Ensure no contaminated effluent is leaving from the filling area to the nearby agricultural lands	Weekly	Contractor	DSC	
15	Waste Managemen t	At the dredging work sites and constructi on camps	Visual inspection that proper collection and disposal of solid and liquid wastes approved by the Engineer	Monthly	Contractor	DSC	Included in Table 10.13
16	Drinking water and sanitation	Camps, offices	Ensure the construction workers are provided with safe water and sanitation facilities at the site and that the camp site is kept clean and hygienic	Weekly	Contractor	DSC,	Include in Table 10.13
17	Air Quality (dust, smoke)	Vessel Shelter Constructi on sites	Visual inspection to ensure good standard equipment is in use and dust suppression measures (e.g., spraying of waters) are in place.	Daily	Contractor	DSC	Included in Table 10.13
18		Dredged Materialdu	Visual inspection to	Daily	Contractor	DSC	Included in Table

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
		mping /storage sites	ensure dust suppression work plan is being implemented				10.13
18	Emissions from vehicles and vessels	Motor vehicles and mechanica l vessels used by the contractor	Emissions as specified in ECR 1997	Annually	Contractor	DSC	Included in Table 10.13
19	Air Quality (dust, smoke)	Constructi on sites and camps	Spot measurements of particulate Matter in presence of Engineer Visual inspection to ensure good standard equipment is in use and dust suppression measures (spraying of waters) are in place.	Monthly	Contractor	DSC	Included in Table 10.13
		Land based dredged material placement sites	Spot measurements of particulate matter in presence of Engineer Visual inspection to ensure dust suppression measures are	Monthly	Contractor	DSC	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
			in place				
20	Noise and vibration	At 10 locations; near the sensitive sites and settlements at the close to the dredging works and placement sites. The locations of sampling will be recommended by the Engineer	24 hour noise monitoring	Quarterly	Contractor	DSC	Included in Table 10.13
21	Under water noise levels	At the dredging locations	Spot measurements at 100 m away from dredging locations	Monthly	Contractor	DSC, ES	Included in Table 10.13
22	River bed sediments	At 25 locations covering all proposed 22 river routes. The locations will be determined by the Engineer	Sampling and analysis of river bed sediments for Pb, Cd, Cr, Cu, Zn, Mn, As, Se, Hg, PCBs, POPs, and hydrocarbons	Quarterly (October, January, April)	Contractor through a nationally recognized laboratory	DSC	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
		the beginning of each sampling.					
23	Drinking Water Quality	At the drinking water wells established for construction workers	Sampling and analysis for parameters specified in ECR 1997: Drinking Water Standards	Annually	Contractor through a nationally recognized laboratory	External Monitor	Included in Table 10.13
		Water wells to be used by contractors for drinking	Laboratory analysis of all drinking water parameters specified in national standards	After development of wells	Contractor through a nationally recognized laboratory	DSC	
24	Safety of workers	At work sites	Usage of Personal Protective equipment	Monthly	Contractor	DSC M&E Consultant, BIWTA	Included in Table 10.13
25	Cultural and archeological Sites	At all work sites	Visual observation for chance finds	Daily	Contractor	DSC M&E Consultant, BIWTA	Included in Table 10.13
26	Reinstatement of Work Sites	All Work Sites	Visual Inspection to ensure removal of all buildings and equipment from the site. The site is clean and was restored to original condition	After completion of all works	Contractor	/DSC M&E Consultant, BIWTA	Included in Table 10.13

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
27	Grievances	In the project area	Number of grievances registered and addressed	Monthly	PIU	DSC/ M&E Consult ant, BIWTA	Included in Table 10.13
28	Sound from the vehicles and vessels	Motor vehicles and mechanica l vessels used by the contractor	Sound emissions as specified in ECR 1997	Annually			
During Post Dredging (O&M) Phase:							
1	River erosion and accretion	At the project influence area	Inspection of reo- morphology of the rivers	Monthlydur ing Monsoon and postmonsoo n	BIWTA	BIWTA	O & M Budget
2	Aquatic Flora and Fauna	At the sensitive locaton of project influence area	Inspection of aquatic habitats, river morphology and monitoring of faunal species (fish, dolphin)	Six Monthly	NGO with relevant backgrou nd experien ce (out- sourcing)	BIWTA	O & M Budget
3	Surface water quality Temperature , Turbidity, TSS, TDS,TSS, EC,DO, BOD, TOC, Ca, Mg, Na, K, F, Cl, Br, SO4, NO3,	At the potential dredging sites.	Collection of water sample at dredging sites	Dry season	BIWTAat recognize d laboratory or relevant NGO	BIWTA	O & M Budget

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitorin g Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
	PO4						
4	Ground- water quality	Monitorin g in accordanc e with groundwat er monitorin g program Number of related complaints	pH, Temperature, TDS, EC, Ca, Mg, Na, K, F, Cl, Fe, Br, SO ₄ , As, Mn	Once a year	BIWTA or relevant NGO	BIWTA	O & M Budget
5	Air Quality	Number of air quality related complaints , Air quality monitorin g data, Ambient air quality found beyond the national standards (EQS)	PM ₁₀ , PM _{2.5} , CO, SO ₂ , O ₃ , NO _x	Dry season	BIWTA / External Monitor	BIWTA	O & M Budget
6	Noise Level Measureme nt	Number of non- complianc es, Noise monitorin g data Number of communit y complaints	Leq in dBA	Once a year	BIWTA (External)	BIWTA	O & M Budget
7	Agriculture	Number of non-	Compare the production	Yearly	BIWTA	BIWTA	O & M

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
		compliances, Number of community complaints	with the baseline		(External)		Budget
8	Cleanliness	At all Vessel Shelters and Ferry crossings' landing sites	Visual Inspection	Monthly	Terminal Administration Offices	BIWTA	O & M Budget
9	Waste effluents	Vessel Shelters and Ferry crossings' landing sites	Visual inspection that solid and liquid waste effluents are properly managed during maintenance works	Six-monthly	BIWTA	BIWTA	O & M Budget
10	Waste reception facilities	Vessel Shelters and Ferry crossings' landing sites	Visual inspection that waste collection facilities are in use	Six-monthly	Terminal Administration Offices	BIWTA	O & M Budget
11	Workers and community health and safety	Vessel Shelters and Ferry crossings' landing sites	Visual inspection on health and safety issues	Six-monthly	Terminal Administration Offices	BIWTA	O & M Budget
12	Water Quality	Vessel Shelters and Ferry crossings' landing sites	Sampling and analysis	Six-monthly	BIWTA through a nationally recognised laboratory	BIWTA	O & M Budget

Sl.	Activity/ Parameter	Location	Means of Monitoring	Monitoring Frequency	Responsible Organization		Budget (USD)
					Implemen ted by	Superv ised by	
					(External)		
13	Accidents	Vessel Shelters and Ferry crossings, landing sites	Visual assessment and Interviews with involved people	As and when happened	BIWTA Administra tion Offices	BIWTA	Special Emergency Budget

Note: There is no contaminated dredged material within the study area of the project (Bangladesh Regional Waterway Transport Project 1)

10.4.2 Standards and Thresholds

Standards for DOE's Environmental Conservation Rule 1997 are presented as Annex-L. Relevant standards for water, air, noise, etc. are also presented in this section for easy reference. The relevant standards to be followed during the implementation of the Project include Government of Bangladesh Environmental Conservation Rules and international standards provided in the EIA for assessing the contamination of dredged material.

Wherever the standards are not available for some parameters, for example suspended solids and underwater noise levels during, the threshold limits for those parameters are 20 percent of the baseline concentrations. The threshold limits will be applied from a minimum distance of 100 m from the downstream of the dredging locations. The baseline concentrations and threshold limits will be established by the Engineer based on the water quality data during the beginning of each dry season (dredging season).

Standards and Thresholds for water quality

The physical and chemical parameters recommended for analysis of surface water quality relevant to the proposed project are pH, temperature, turbidity, DO, BOD5, EC, TOC, TDS, TSS, Ca, Mg, Na, K, Cl, F, Br, SO4, NO3, PO4. The monitoring should be carried out in accordance to the DOE surface water standard for irrigation and fisheries, given below in 10.7.

Table 10-7 : Bangladesh Surface Water Quality Standards

Sl No.	Best Practices Based Classification	Parameters			
		Temperature (°C)	pH	DO (mg/l)	BOD5 (mg/l)
1	Water usable for fisheries	25 - 30	6.5- 8.5	5 or more	6 or less
2	Water usable for irrigation	25 - 30	6.5- 8.5	5 or more	10 or less

Source: Environmental Conservation Rule (ECR)'97

Notes:

- In water used for pisciculture, maximum limit of presence of ammonia as Nitrogen is 1.2 mg/l
- Electrical conductivity for irrigation water– 2250 mhos/cm (at a temperature of 25°C); Sodium less than 26 percent; boron less than 0.2 percent

The parameters recommended for analysis of groundwater quality relevant to the proposed project are pH, temperature, EC, TDS, Ca, Mg, Na, K, Cl, F, Br, SO₄, As, Fe, Mn. The monitoring should be carried out in accordance to the DOE standard for drinking water, given below in 10.8

Table 10-8 : Bangladesh Drinking Water Quality Standards

Parameter	Unit	DOE Standard for Drinking Water
pH	-	6.5 – 8.5
Temperature	°C	20 - 30
Electric Conductivity (EC)	µS/cm	-
Total Dissolved Solids (TDS)	mg/L	1000
Calcium (Ca)	mg/L	75
Magnesium (Mg)	mg/L	30 – 35
Sodium (Na)	mg/L	200
Potassium (K)	mg/L	12
Chloride (Cl)	mg/L	150 – 600
Fluoride (F)	mg/L	1
Bromine (Br)	mg/L	-
Sulphate (SO ₄ ,)	mg/L	400
Arsenic (As)	mg/L	0.05
Iron (Fe)	mg/L	0.3 – 1.0
Manganese (Mn)	mg/L	0.1

10.5 Institutional Arrangements

An appropriate institutional arrangement is vital for the successful implementation of the EMP for the project. BIWTA is responsible for ensuring that dredging and construction and maintenance period mitigative and monitoring tasks defined the EIA's EMP are completed on time and in a technically sound manner. Monitoring of EMP by BIWTA will require field surveys, analyses and technical reporting to DoE in addition to receiving environmental reports from the contractor as well as the Supervision and Monitoring Consultants. At present, BIWTA lacks such capability, and therefore, will require a project implementation Unit (PIU) to address EMP and RPF implementation as shown in Figure 10.6. **The Director Generals of the Department of Fisheries (DOF) and Bangladesh Fisheries Research Institute (BFRI) or their representatives would be members of the PIC while a representative from the Ministry of Fisheries and Livestock will be a member of the Project Steering Committee (PSC).**

PIU would be responsible for all aspects of project implementation including technical, operational and financial management, and overseeing the implementation of EMP. The PIU will be headed by the Project Director (PD). The PIU will include an Environment and Social (E&S) Cell with qualified staff (Table 10.9). This E&S Cell will assist the PD on issues related to environmental and social management and oversee the Dredging Supervision Consultant (DSC) for IWT route maintenance and Construction Supervision Consultants (CSC) for terminals and landing stations for environmental and social management, EIA consultants (for terminals and landings), and the environmental and social aspects of various activities, studies and future project preparation to be carried out under the project. E & S Cell will oversee contractors and will compile quarterly monitoring reports and annual monitoring reports on EMP compliance, to be sent to the Project Director and also shared with the World Bank, throughout the construction period. The E&S Cell will also provide trainings to the BIWTA field personnel responsible for monitoring of environmental compliance during both construction and O&M phases of the project. In addition, BIWTA will establish a permanent Environmental, Social and Climate Change Unit in its institutional structure, which will ensure the long term sustainability, climate resilience and climate sensitivity of project investments as well as other activities across the organization.

Table 10-9: Description of PIU Staff and Consultants for E & S Cell

Sl. No.	Position	Number	Periods/Duration (Person months)
1	Project Director (PD), BIWTA Staff	1	84 (7 years)
2	Deputy Project Director Environment, BIWTA Staff	1	84
3	Deputy Project Director Environment, BIWTA Staff	1	84
4	Senior Environmental Consultant	1	84
5	Senior Social Consultant	1	84
6	GRM officer	1	84

The PD shall be of the rank of Deputy Director and have a minimum degree related to environmental science/engineering and have experiences of more than 15 years in dredging. The DPDs have a minimum degree related to environmental science/engineering and Social Science. Each of the DPDs shall have experiences of more than 10 years in dredging Operation and Dredge material management work. The environmental and Social Consultants shall have relevant masters' degrees with minimum 10 years of experience in their relevant fields. The GRM officer shall have relevant masters' degree with minimum 10 years of experience in the relevant field.

Dredging Supervision Consultants will be responsible for supervising the contractors for the implementation of EMP. For this purpose, the DSC will appoint international and national environmental and social specialists, to ensure the EMP implementation during the project period. They will supervise the contractor for the EMP implementation, particularly the mitigation measures. They will also be responsible for implementing the monitoring of effects of these measures. Proposed staff with number and duration is presented in Table 10.10.

The DSC shall have a minimum Master degree related to environmental science/engineering and have experiences of more than 10 years in dredging Operation and Dredge material management work. The environmental and Social Specialists shall have relevant masters' degrees with minimum 10 years of experience in their relevant fields.

Table 10-10 : Description of Dredging Supervision Consultants

Sl. No.	Position	Number	Periods/Duration (Person months)
1	Environmental Specialist (International)	1	42
2	River Ecologist (National)	1	84
3	Environmental Specialist (National)	1	84
4	Social and Community Specialist	1	84

Contractors are also required to appoint one environmental health and safety officer (EHS), one Aquatic Ecologist and one Social and Community Liaison Officer for the implementation of EMP in the field (Table 10.11). The contractor will also be responsible for communicating with and training of its staff in the environmental/social aspects.

The EHS shall have a minimum bachelor degree related to environmental science/engineering and have experience of more than 10 years in environmental and OHS management work in construction. The Aquatic Ecologist and Social Officers shall have relevant masters' degrees with minimum 5 years of experience in their relevant fields.

In addition to the above personnel, the contractor shall designate one his crew members as Environmental Site Manager for each dredging site.

During implementation of the project, the contractor will carry out continuous surveying and will prepare a monthly work plan projecting the specific activities, dredge locations and volumes to be carried out in the coming month, based on the updated survey data. As part of this monthly plan, the contractor will include a Detailed Updated Contractor's EMP, which shall specify any relevant updates or modifications to the above-mentioned site-specific plans, to account for changes in location, scope or methodology of river channel / ferry crossing / vessel shelter maintenance activities. For example, if new geographic areas need to be dredged or if dredging volumes exceed available capacity for disposal in the pre-specified disposal areas as shown in Figure 10.3, the monthly plan shall propose new locations and all relevant mitigation and management requirements, in accordance with the criteria specified in this EMP and the detailed plans outlined above. The monthly work plan will be submitted to the DSC for approval prior to the contractor initiating activities that month. As part of this review, the DSC's Environmental Expert shall review and approve the Detailed Updated Contractor's EMP component of the monthly work plan. If in the future the geographic area of the contract is modified by BIWTA through a contract variance, the contractor will be responsible for preparing a site-specific Contractor's Environmental Management Plan (CEAP) and following all applicable ECoPs and any other measures as specified in the additional EMP to be carried out for this added geographic scope.

Table 10-11: Description of Contractor's Staff

Sl. No.	Position	Number	Periods/Duration (Person months)
1	Environmental Health and Safety Specialist	1	84
2	Aquatic Ecologist	1	84
3	Social and Community Liaison Officer	1	84

External Monitoring and Evaluation Consultants will be engaged by the PIU to conduct external and independent monitoring and evaluation of the EMP and RAP implementation. The main purpose of the external monitoring will be to ensure that all the key entities including contractors are effectively and adequately fulfilling their designated role for EMP and RAP implementation and that all the EMP and RAP requirements are being implemented in a timely and effective manner (Table 10.12).

The Monitoring and Evaluation Consultants shall have a minimum Master degree related to environmental / Social sciences and have experiences of more than 10 years in relevant fields.

Table 10-12 : Description of M & E Consultants

Sl. No.	Position	Number	Period/Duration (Person months)
1	EMP Implementation Specialist	1	30
2.	Environmental Specialist	1	24
2	Monitoring and Evaluation Consultants (Social)	1	24
3	Ecological Monitoring Specialist	1	24

Other study consultants: The Project will also hire several other consultants to carry out studies such as EIA studies for future proposed investment activities; collection of baseline data on biodiversity at sensitive locations and implementation of a biodiversity conservation program; sustainable long-term maintenance of river terminals, landings and other BIWTA assets; techniques to minimize dredging and other maintenance needs through application of river training schemes.

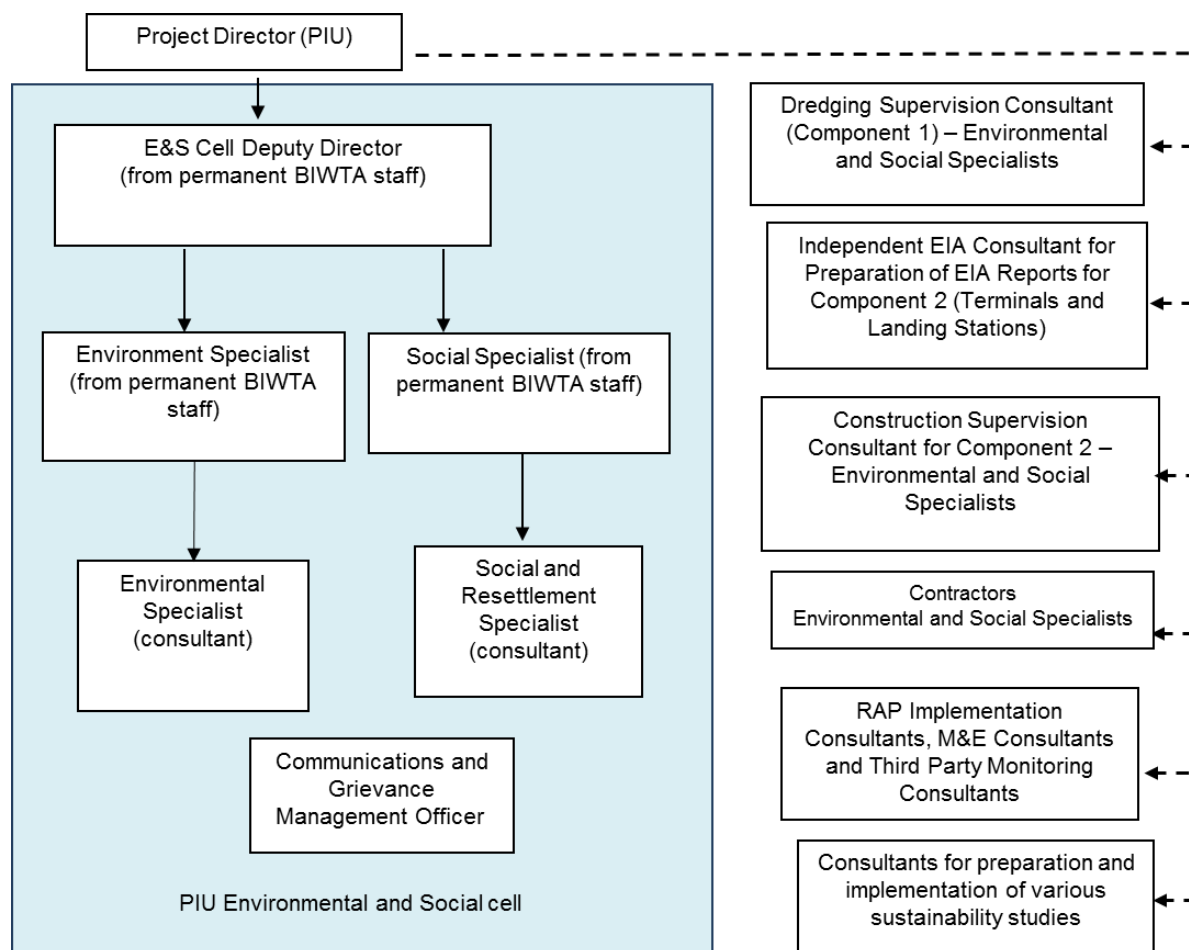


Figure 10-7: Institutional Structure for Environmental and Social Management of the Project

Grievance Redress Mechanism (GRM): The Project will establish a Grievance Redress Mechanism (GRM). GRM will receive and act upon complaints from citizens or organizations in relation to any occurrences for which the Project is directly responsible. The GRM will be managed by PIU at Bangladesh Inland Water Transport Authority.

A three-tier bottom up GRC will be established in this Project. First, there will be GRCs at the local level, hereafter called Local GRC (union/municipality level); and second, GRC at the District level and thirdly at project unit level to ensure transparent and accountable process of reviewing, resolving, and responding to grievances. These GRCs will be established through gazette notifications from the Ministry of Inland Water transport Authority. The APs will be informed through public consultation that they have a right to have their grievances redressed by the local committees as well as by the project management. The local GRCs (at the union/municipal level) will hear the grievances first. Only unresolved cases will be forwarded to the next tier – District Level GRC. Cases with all proceedings are placed with the District level GRC. BIWTA District level senior official (selected by the PD), with assistance from other officials review them. If found necessary, field investigation is carried out and the resolutions are given within 4 weeks of receiving the complaints. Unsolved cases will be forwarded to the project level GRC for further review and resolution.

10.6 Reports

10.6.1 Reports by Contractor

The Contractor shall prepare the following site specific reports

- Site Specific Environmental Management Plans;
- Construction Environmental Action Plans (CEAPs);
- Advance monthly plan for dredging and disposal , and
- Monthly progress report with location of dredging and disposal sites;

10.7 Site Specific Environmental Management Plans

The Contractor as per EMP guide lines will prepare site specific EMP and get it approved by the Environmental Consultant of E&S Cell within forty-five (45) calendar days after the date of the Letter of Acceptance. Any dredging operation shall not begin until the site specific EMP has been approved.

10.8 Construction Environmental Action Plan (CEAP)

The Contractor shall prepare a 'Construction Environmental Action Plan' (CEAP) demonstrating the manner in which he will comply with the requirements. The Contractor shall submit the CEAP to the Engineer for his approval within forty-five (45) calendar days after the date of the Letter of Acceptance. Any construction operation shall not begin until the CEAP has been approved by the Engineer.

The plan will include a series of management plans:

- Site specific dredging management plan. The plan shall include (i) the control measures to be put in place at each location in order to comply with EMP thresholds and requirements to minimize benthic and aquatic disturbances, as well as noise, air pollution, and other impacts during the dredging process – based on ecological sensitivity and presence of contamination; (b) all exact locations and management provisions for dredged material placement, for both on land and in river placement, based on the actual anticipated dredge volumes and locations as per updated the most recent survey data. The locations shall include the pre-specified locations from Figure 10.1 and Table 10.2 and Table 10.3, where applicable. For any additional/new areas requiring dredging for which the pre-identified locations are not feasible, additional sites shall be proposed following the criteria specified in this EMP; and (c) Documentation to be maintained and provided to the Engineer on environmental management for the dredging activity
- Site specific pollution prevention and control (water, air, noise) plan for each construction and disposal area;
- Site specific waste disposal and effluent management plan for each work site and workers camp;
- Site specific drinking water supply and sanitation plan for each work site and workers camp;
- Occupational health and safety plan and training programs;
- Site specific traffic management plan, for both river and on land, for each work site;
- Emergency Response Plan and Early Warning System;
- HIV-AIDS Preventive Management Plan and training programs;
- Complaints logging system and response plan, and
- Standard Operating Procedures for pollution spills, and management of fuels and hazardous goods.

The payment towards the preparation and implementation of CEAP will be made in instalments in a proportion equal to the percentage of the overall work completed by the contractor during that particular period.

In case that the Contractor fails to comply with the requirements of the EMP and approved CEAP, and the monitoring results suggest contamination beyond standards and thresholds, the Employer may take any of the following actions.

- Stop the Contractor's work until the contractors rectify or remediate any environmental damages caused by noncompliance in a time frame agreed by the Engineer; and/or newly monitored results became satisfactory. No additional payment or time extension will be granted for the work delay caused by this work suspension.
- Stop the Contractor's overall payment (not limited to amount towards CEAP) until the remediation works are completed, and/or newly monitored results became satisfactory.
- Directly undertake required counter measures and/or monitoring activities. The costs which the Employer incurs shall be deducted from the payment to the Contractor. Any deduction shall be subject to the Engineer's determination.

10.9 Advance Monthly Work Plan for Dredging and Dipsoal

During implementation of the project, the contractor will carry out continuous surveying and will prepare a monthly work plan projecting the specific activities, dredge locations and volumes to be carried out in the coming month, based on the updated survey data. As part of this monthly plan, the contractor shall specify any relevant updates or modifications to the site-specific plans given in CEAP, to account for changes in the locations of dredging and dredged material placement. The monthly work plan will be submitted to the Engineer for approval prior to the contractor initiating activities that month. As part of this review, the Engineer's Environmental Expert shall review and approve the Detailed Updated Contractor's EMP component of the monthly work plan.

Monthly progress reports with location of dredging and disposal sites

The Contractor will submit monthly report including progress achieved in respect dredging and disposal of dredge spoil. The Contractor shall submit sample copy of the monthly progress report 30 days in advance to the Engineer's Environmental Expert for review and approval.

The Contractor shall submit the monthly progress report in 10 copies within the first week of every month starting from the month of commencement date until issuance of Hand-Over Certificate of the assignment. The report after the DSC's comments and Contractor's correction shall be submitted to the Environmental Consultant in both hard and soft copy.

Quarterly monitoring report

The M&E Consultant will prepare quarterly monitoring reports and submit to the Environmental Consultant of E&S Cell.

Annual Audit Report

To ensure transparency and EMP compliance, Annual audit report will be prepared by an independent third party consultant of the project.

Report by M & E Consultant

The M & E consultant will prepare Quarterly and Annual Report to ensure EMP compliance. For effective environmental compliance to EMP obligations M & E Consultants will also ensure the following obligations.

- Timely reporting of documents (as defined in EMP and monitoring plan)
- Number of non-compliances observed by supervision consultant
- Availability of environmental specialists with contractors, supervision consultant and BIWTA
- Number of inspections carried out by supervision consultant per month
- Number of trainings imparted to stakeholders/other capacity building initiatives
- Number of accidents related to Project
- Number of grievances received
- Number of grievances resolved.

10.10 Budgets

10.10.1 BOQ of Contractor

No separate payment shall be made for fulfilling the requirements of EMP except as specified Table 10.13. For items not specified here, all costs shall be deemed to be included in the unit rates and/or lump sum prices of the various other items in the Bill of Quantities.

Table 10-13 : Bills of Quantities for EMP

Item No.	Items of Work	Unit	Quantity
1	Preparation and implementation of Construction Environmental Action Plan	Lump sum	
2	Provision of EHS Officer, Aquatic Ecologist and Social Officer	Years	7
3	Providing and maintenance of survey equipment for spot measurements	Lump sum	
4	River bed sediments quality: sampling and analysis of river bed sediments quality(see Section 6.3 of EMP)	Nos.	500
6	Surface water quality: sampling and analysis of river water and waste water discharges quality (see Section 6.3 of EMP)	Nos.	500

10.10.2 Overall EMP Implementation Cost

The total cost for the environmental and social management and monitoring activities has been estimated to be USD 14.9 million (Table 10-14). Of this amount, USD 5.6 million has been included under Component 3 of the project; the remaining amount of USD 9.3 million is included in other project components, as shown in Table 10.14. The total administrative budget for RPF/RAP/ARAP implementation under this project has been worked out as US\$ 3.8 million.

Table 10-14: Budget Cost Estimates for Environmental Management and Monitoring of the Project

	Description	Amount, million USD	Project Component (Chapter 1 Sec 1.1.1)
	Contractor's Budget (for development and implementation of management plans, staff, training, etc.)	1.0	Component 1: IWT
	Sediment, water, soil, air and noise quality monitoring during construction (quarterly for 6 years), benthic fauna, other aquatic biodiversity, migratory birds	0.5	
	DSC Environmental and Social Staff	1.0	
	CSC Environmental and Social Staff	1.0	Component 2: Terminals
	Contractor's Budget (for development and implementation of management plans, staff, training, etc.)	1.5	
	Sediment, water, soil, air and noise quality monitoring during construction (quarterly for 6 years)	0.5	
	Administrative budget for RPF activities	3.8	
	Study, development of action plan, and capacity building of BIWTA to ensure effective and sustainable long-term maintenance of river terminals, landings, other BIWTA	0.5	Component 3: Institutional Capacity Development and Sustainability
	Origin destination survey of inland waterways along Dhaka-Chittagong corridor, including understanding which supply chains to promote, and logistics gaps for development	0.35	
	Social NGO to support BIWTA on implementation of Social Management Plans / RAPs for specific investments	0.2	
	Third party M&E consultant for social safeguards (including midterm and ex-post evaluations of RAP implementation)	0.25	
	Third party M&E consultant for environmental safeguards	0.25	
	Environmental NGO/firm to: (a) carry out additional baseline data collection on biodiversity at sensitive locations; and (b) develop and implement biodiversity management	0.5	
	Implementation of additional EMP programs (such as management of dredge spoils, biodiversity conservation, capacity building support to establish the permanent	2.0	
	PIU Environmental staff	1.5	
	TOTAL	14.9	

11 SOCIAL MANAGEMENT PLAN

11.1 General

This chapter reflects on Environmental and Social Management Issues including institutional capacity development of the executing agency and other line agencies institutional arrangement, grievance redress mechanism etc.

11.2 Resettlement Policy Framework (brief summary)

Most of the terminals are on GoB land, but proposed launch terminal facilities will require approximately **2.093** ha land acquisition. The proposed 06 vessel shelters are planned to be constructed on public land to avoid any negative impacts on the population near project sites. At most of the project locations, land belongs to BIWTA. This land is used for common purposes such as Ghats for boats, by the nearby communities. There are Persons without title to the land on the BIWTA land with shop and residences. Places of worship are built on BIWTA Land. BIWTA has built shops and leased them to shop keepers. This will lead to loss of livelihoods. At some locations access to common property resources such as Burial grounds will get restricted due to the present interventions. At some locations access granted to cultural practices such as immersion of ashes of the dead in rivers at certain ghats, will be impacted. Further access infrastructure such as roads will cause impacts as the present roads are narrow and they need to be widened for optimizing the capacity of the facilities built.

As per the EIA, there are no small ethnic communities; indigenous people, at the project locations.

The key social impacts due to project interventions are Land acquisition and subsequent resettlement, Loss of Livelihoods, Inconvenience and nuisance during construction, Loss of access to CPRs and Likely increase in transport costs

For each of these sub-projects an RAP will be prepared, where required during the planning and design stage. The following social management measures are proposed in the Resettlement Policy Framework (available under separate cover, and summarized briefly here) for:

- Development and adopting a Resettlement Policy Framework (RPF) to be used for all sub-projects under this project. This RPF should serve as a guide for further SIA studies and for preparation of RAPs under this project.
- Integrate the rehabilitation of livelihoods into design of terminals and other infrastructure facilities. Designs are to consider the following:
 - Livelihoods: such as integrating shops and vendors
 - Facilities for women such as: separate counters, waiting areas, sanitation, seating arrangements
 - Facilities for disabled
 - Arrangements to continue cultural practices
 - Design and general arrangement to be ready for impact identification and resettlement plan preparation
- Alternate temporary transit arrangements before resettlement
- Resettlement Policy Framework with clear entitlements
- Grievance Redressal Mechanism

- Community Engagement in planning and implementation
- Gender Mainstreaming Plan
- Disclosure: disclosure of resettlement plans

The primary objective of this RPF is to improve the standard of living of the affected population. The other objectives of this RPF are to; a) Ensure the principles of Social Justice is adhered to at all times, b) Avoid or minimize any negative impacts on the communities, c) If land is required for project facilities, then same may be purchased under Willing Buyer-Willing Seller norm, d) Assist affected population in improving their living standards, income earning capacity, and production levels, etc.). Encourage and enable community participation in planning and implementing project components and f) Provide assistance to affected communities in redressing their grievances.

This RPF addresses social issues such as Land Procurement, Community Engagement, Special Attention to Women and Other Vulnerable Groups and Grievance Redressal.

This RPF specifies procedures for a) Buying Land under Willing Buyer and Willing Seller concept and registration and mutation of records and b) for land Acquisition. When land needs to be acquired as per the Land Acquisition Act 1894, the RPF has set the procedures to be followed by project. Compensation norms are set ensuring that the properties (land, structure, and non-structured assets) to be affected by the project will be compensated at their full replacement cost determined by a legally constituted Resettlement Sub-committee (RSC) as per structure and mandated outlined in the RAP. The payment of compensation and other assistance, target replacement of productive assets and restoration of loss of income and workdays by the relocated households, especially the vulnerable households will be ensured by this committee. Compensation and other cash assistance will be paid through bank bills (cheques) payable to Bank accounts opened by the affected persons eligible for compensation and assistance under RAP. The Bank account will be in the joint name of husband and wife as the case may be. Compensation under law (CUL) will be paid through two different channels as per provision of RAP. CUL will be paid by Deputy Commissioner mandated for acquisition of land for the PMU while PMU will directly pay the remaining as per requirement of the RAPs directly to the project affected persons. PMU with the help of the project consultants will advise, assist, and monitor the affected persons receiving compensation and other cash assistance for better use of the money.

Regardless of their tenure status to the lands used for project component, the project affected persons/ households will be eligible for compensation and assistance. All PAPs irrespective of their title will be entitled to compensation and assistance based on loss and impact categories identified through census survey in respect of the policy guidelines adopted for the project. Nevertheless, eligibility to receive compensation and other assistance will be limited by the cut-off date. The absence of legal title will not bar PAPs from compensation and assistance, as specified in the entitlement matrices. An Entitlement Matrix has been prepared for the project on the basis of field study and consultation with government officials as a part of preparing the resettlement policy framework. A person could be eligible for compensation/entitlement in more than one category of losses and in more than one mouza. DCs will pay CCL for each mauza separately for one person whose lands/assets have been

acquired in more than one mauza. A resettlement policy framework has been prepared as a standalone document.

11.3 Dredge Material Disposal Plan

Composition of the dredged material is dominated by sand followed by silt and clay. The following table provides options for disposal of non-contaminated dredged material. On-land disposal of the dredged material will be last option provided there are no additional adverse impacts on the adjacent land and on the community's livelihood. According to the dredged material disposal plan there are four options to deposit dredged material preferably in the river particularly scour hole.

Table 11-1: Options of dredge Material disposal plan according to criteria.

Options for disposal of dredged material (in order of preference)	Description/ Intervention	Additional applicable criteria
Option-1: in-river disposal	- In the river bed - Scour hole of depth <5m - Erosion vulnerable area	<i>Exceptions:</i> ecologically sensitive areas, mud flat, reed lands, important bird areas, or along chars or confluences
Option-2: on-land disposal	Existing stake yard of the sand traders (if identified near the dredging site)	i. Close to the river bank. ii. Close to the dredging location (within 2 km, includes the river bank) iii. Encumbrance-free land iv. No adverse impact on income and livelihood of individual or community v. Non-agricultural fallow land vi. No impacts to cultural heritage vi. Not within 100m of beels/ marshy areas /reed land/mud flat/IBA
Option-3 - on-land disposal	Government Land/waste land	
Option-4 - on-land disposal	- Lease land from the private - Lease Land from the Community	

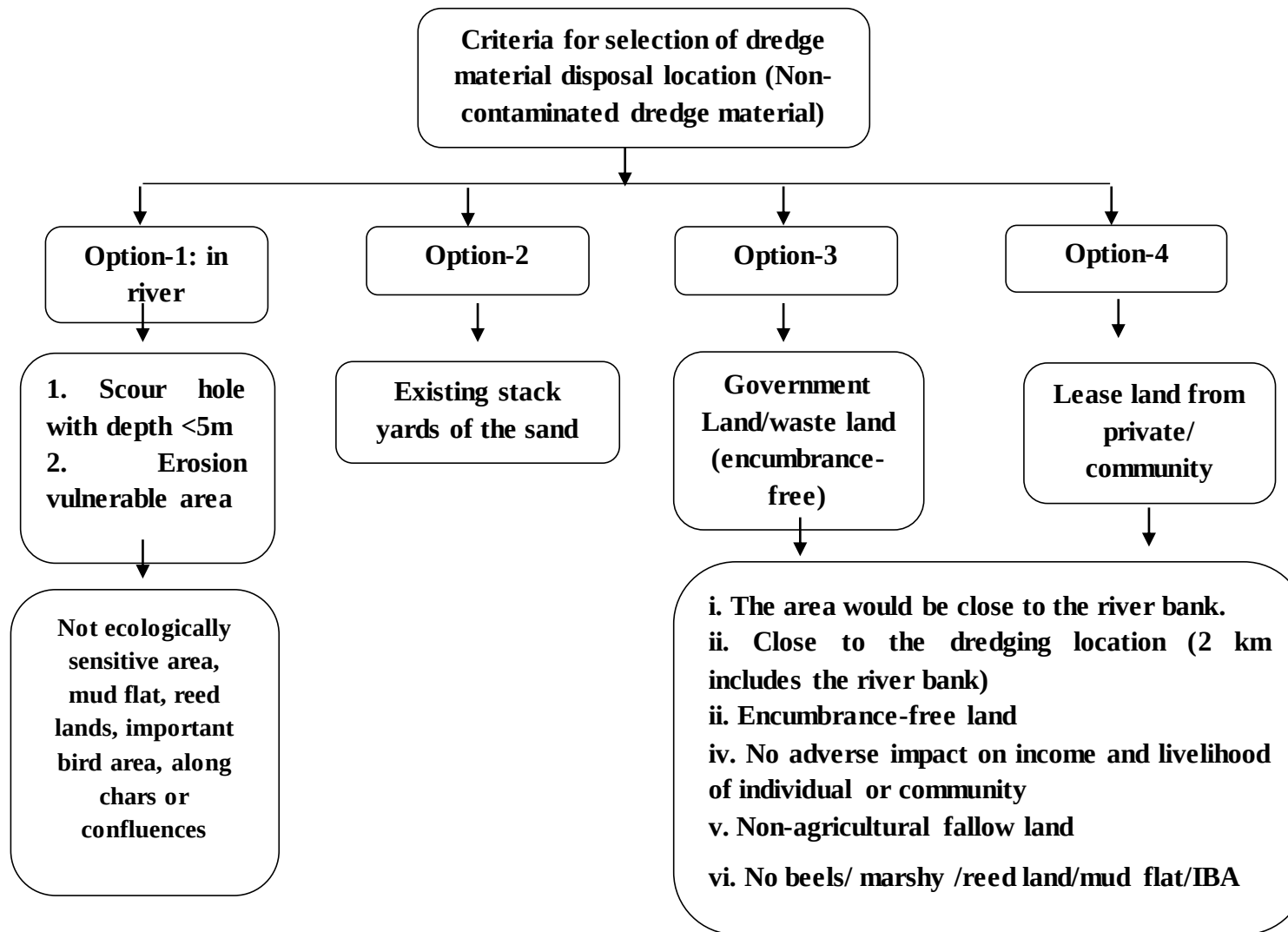


Figure 11-1 : Criteria for selection of dredge material disposal location

A comprehensive dredged material disposal plan is prepared and annexed with EIA (Annex-K)

11.4 BIWTA requirements to oversee dredging and dredge disposal activities

BIWTA will have the following core responsibilities with respect to environmental management of dredging and dredge disposal activities under the project. The contractor's responsibilities are detailed under the separate chapter which is chapter 12: Contractor's EMP.

- Overall accountability for implementation of all aspects of the EMP
- Ensuring all necessary legal and regulatory requirements are met, including renewal of environmental clearance certificate and any other applicable requirements
- Hiring and overseeing the work of the Dredging Supervision Consultant (DSC) on environmental and social management and monitoring, including: reviewing monthly monitoring reports, following up proactively with the DSC to clarify issues raised and to discuss and agree on penalties or remedial actions where required, etc.
- Monitoring and supervising the contractor's operations as required, to supplement and verify the work of the DSC
- Provide final approval to site-specific Contractor Environmental Action Plans (under advice of DSC)
- Hire and oversee the work of the third party independent environmental monitor
- Enforce penalties on the contractor and oversee remedial measures in cases of non-compliance
- Carry out ongoing stakeholder consultations and grievance management
- Quarterly reporting to the World Bank on environmental management
- Establish a permanent E,S and Climate Change Cell within the permanent organizational structure
- Implement the biodiversity conservation program, including finalizing TORs and hiring consultants, overseeing their work to develop a comprehensive program proposal, and facilitating the implementation of that program as required, including through liaison with other relevant line ministries and forming partnerships with external stakeholders. The TORs for the biodiversity conservation program are presented in Annex L
- Additional activities as required to ensure full compliance with all requirements of the EIA, EMP, and RPF

11.5 Capacity Assessment of BIWTA for Environmental and Social Management

Capacity building for effective implementation of the environmental and social safeguard requirements is a key element of the EMP **as well as RPF**. Capacity building for environmental and social safeguard management will need to be carried out at all tiers of the project, including BIWTA, PIU, supervision consultants, and contractors. At the dredging/construction site, supervision consultant will take the lead in implementing the capacity building plan, though the contractors will also be responsible to conduct trainings for their own staff and workers. The various aspects that are covered under the capacity building will include general environmental and social awareness, key environmental and social sensitivities of the area, key environmental and social impacts of the project, EMP requirements, OHS aspects, and waste disposal. PIU may revise the plan during the Project

implementation as required. During the maintenance phase of the Project, these trainings will continue to be conducted by BIWTA for all relevant maintenance personnel and community.

The existing organizational structure of BIWTA was approved by the Government in 1982. With few changes at different times, BIWTA has been performing responsibilities with this 33 years old structure. But significant and qualitative changes have taken place in the meantime: river morphology, transport demand, transport pattern, technology, challenges etc. Most important is that the existing structure does not include environment, climate change and information technology in its regular work flow.

Since approval of the existing organizational structure in 1982 following changes have taken place:

- Conditions of rivers deteriorated so the navigability.
- Annual volume of dredging was 350,000 cubic meters at that time as against 5 million now.
- Presently 21 inland ports and almost 400 landing stations as against 7 ports and about 100 landing stations.
- Presently 21 dredgers, only 8 during early 1980s.
- About 3,000 inland vessels used to operate at that time as against more than 10,000 vessels as in December 2013.
- Dimensions and capacity of vessels increased significantly.
- Private sector has become more participative than it was in that time.

A total number of 3,978 employees were approved for BIWTA in 1982. With few changes this number was increased to 4,288. With the increased participation of private sector in port operation toll collector, toll guard, pontoon lascar etc have become redundant. On the contrary Planning Department, Dredging Department, Civil Engineering Department and Traffic Department have not been organized according to required number of personnel.

Most important aspect is that at present there exist no unit or cell in BIWTA for EIA or SIA and BIWTA is yet to introduce e-tendering or e- governance. Poor conditions prevail in Planning Department and Dredging Department. Most recently BIWTA initiated an effort to reorganize. During consultation, it has been gathered that only additional requirement of departments was considered. Redundancy was not identified. Planning Department put forward proposal for strengthening department with additional employees with a section responsible for SIA / EIA. Similarly Dredging Department estimated capacity in accordance with future dredging program.

So far BIWTA paid no attention to develop professional efficiency and skill of its employees. There exist neither targets nor any defined area for undertaking training programs. In 2012 BIWTA appointed a Consultant with the objective of determining strategy for preparation of a Training Calendar as well as to assess actual training need and prepare / develop a training module for human resource development for the officials. The Final Report was submitted in May, 2012 with an annual training calendar of 40 weeks of different disciplines along with module. But this was not implemented.

Environmental Impact Assessment was included in the calendar but not focused according to actual requirement.

Proposed Institutional Arrangements For the purpose of managing the necessary Environmental and Social safeguards compliance issues associated with Project activities, the PIU shall have an Environmental and Social Cell headed by a Deputy Director, an Environment Specialist and a Social Specialist, and individual consultants employed under the Project for environmental, social and communications support. The Environmental and Social Cell shall be fully responsible to coordinate with Project activities and ensure the compliance of inclusion, safeguards and communications requirements in planning and implementation of Project interventions following the legal and policy framework of the GoB and the Bank. The Environmental and Social Cell shall also coordinate the launching of the grievance management system for the project, and will also oversee implementation of value-added sustainability activities under Component 3 of the Project which go beyond risk management. In addition, to ensure the long term sustainability of project investments and to mainstream climate resilience and climate sensitivity across the organization, the Project will support the establishment and initial capacity building of a permanent Environmental, Social, and Climate Change Unit (ESCCU) within BIWTA's permanent organigram. The Environmental and Social Cell within the PIU will provide training to the permanent unit, and will integrate permanent unit staff once appointed into the ongoing management of the Project. In particular, preparatory studies for a potential follow on investment project, as well as diagnostic, modeling and planning studies on climate change in the IWT sector, will be closely overseen by the new permanent Unit, with in coordination with the PIU's Environmental and Social Cell.

Institutional Structure for Environmental and Social Management of the Project:

Institutional Structure for Environmental and Social Management of the Project is represented in below the Figure 11.2

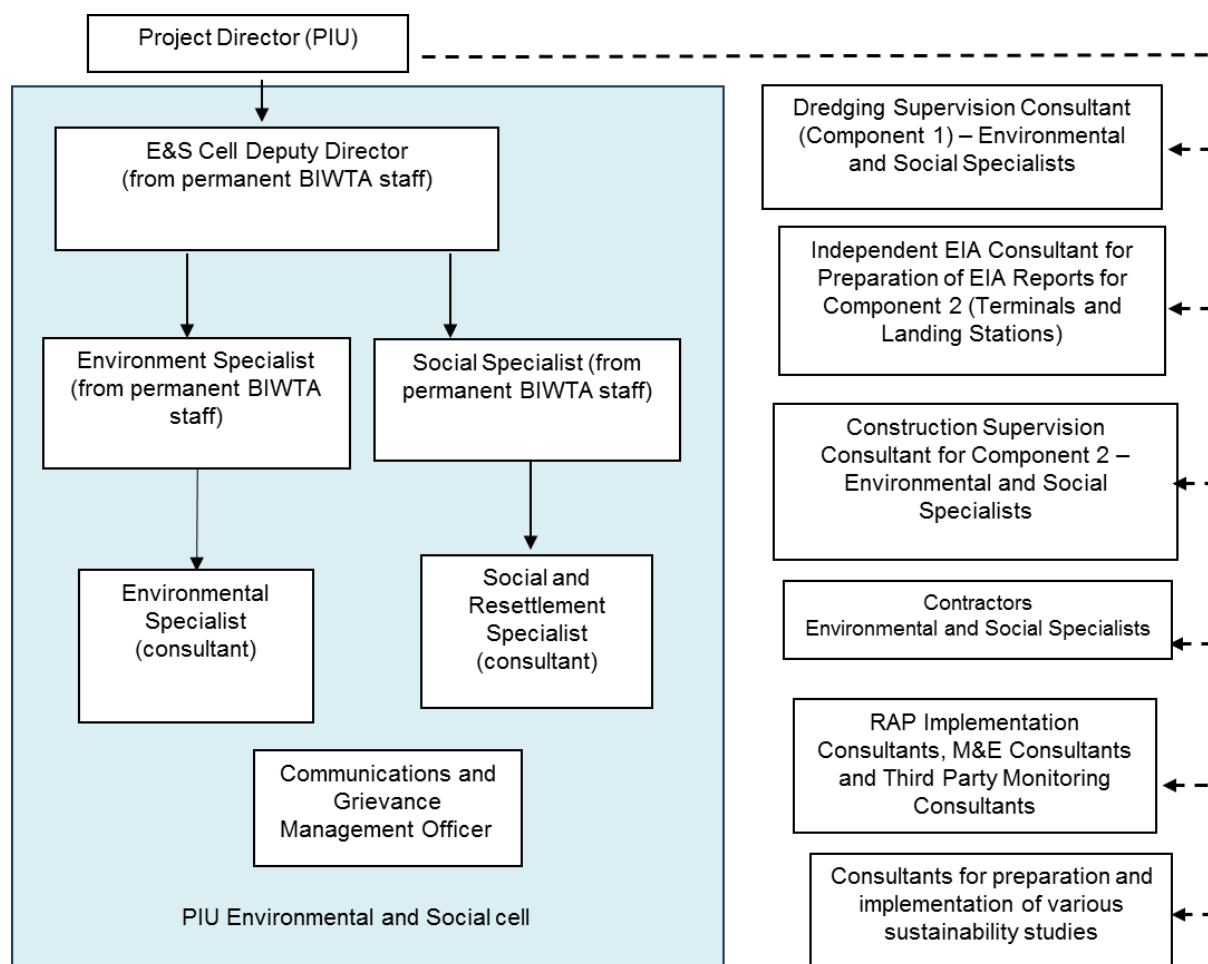


Figure 11-2 Institutional Structure for Environmental and Social Management of the Project

Institutional Strengthening Program

Following institutional strengthening and capacity building programs are proposed for PIU of BIWTA for strengthening their capacity in EMP implementation.

Step A: Creation of Environmental and Social Safeguard Unit within BIWTA

The detail of this is presented in section 10.5 (institutional arrangements)

Step B: Capacity building initiatives involving oriented trainings for the staff

Table 11-2: A tentative summary of the training requirements are presented below

Contents	Participants	Responsibility	Schedule
General environmental and socio awareness; Environmental and social sensitivity of the project influence area; Key findings of the EIA; Mitigation measures; EMP; Social and cultural values of the area; Community issues; Awareness of transmissible diseases Social and cultural values.	Selected staff of BIWTA, DSC, and Contractor	BIWTA with support from DSC	Before commencement of the project
EMP; Waste disposal; OHS	BIWTA Project team; all contractor staff / laborers at site	Contractor, with support from DSC	Before commencement of the project
Road/waterway safety; Defensive driving/sailing; Waste disposal; Cultural values and social sensitivity.	Drivers, boat crew	Contractor, with support from DSC	Before commencement of the project
Camp operation; Waste disposal; OHS; Natural resource conservation; Housekeeping.	Camp staff	Contractor, with support from DSC	Before commencement of the project
Restoration requirements; Waste disposal.	Restoration teams	Contractor	Before commencement of the project

Step C: Engagement of External Monitor for Independent reviews

BIWTA will engage External Monitors during dredging and construction period to measure the effectiveness and outcome/impact of EMP, as stated earlier. The External Monitors will submit the quarterly reports throughout the contract time, impact evaluation report at the end of each year and finally a completion Report at the end of contract period.

Step D: Formation of Grievance Redress Committee

The detail of this is presented in 9.8 (Grievance)

Step E: Establishment of an Environmental Management System in BIWTA

BIWTA is committed to ensure that its operations will not create adverse environmental impacts. In this regard, the BIWTA will need to establish and effectively operate an appropriate Environmental Management System (EMS). It is intended to serve as a basis for discussion between the lending agencies and the BIWTA to work out an appropriate EMS acceptable to both parties.

11.5.1 Documentation

The PIU with assistance from supervision consultants and contractors will produce the following environmental reporting documentation on a quarterly basis:

- **Environmental Monitoring Reports:** The environmental monitoring reports will include environmental mitigation measures undertaken, environmental monitoring activities undertaken, details of monitoring data collected, analysis of monitoring results particularly the non-compliances, recommended mitigation and corrective measures, environmental training conducted, and environmental regulatory violations observed. The environmental monitoring reports will be submitted quarterly throughout the life of the performance based contract for route maintenance.
- **Project Completion Environmental Monitoring Report:** One year after completion of dredging, the PIU will submit a Project Completion Environmental Monitoring Report which will summarize the overall environmental impacts from the Project to all the co-financiers.

11.5.2 Engagement of External Monitors (Third Party Monitoring)

BIWTA will engage External Monitors (Third Party Monitors) during dredging and construction period to measure the effectiveness and outcome/impact of EMP, as stated earlier. The External Monitors will submit the quarterly reports throughout the contract time, impact evaluation report at the end of each year and finally a completion Report at the end of contract period.

The key activities to be carried out by the Monitoring & Evaluation Consultants are:

- To develop specific monitoring indicators, checklists, and questionnaires to undertake external monitoring (a preliminary list of monitoring indicators (as shown in Table 10-6) has been given in the EMP (Environmental Management Plan) in consultation with BIWTA and WB);
- To review and verify the implementation progress of various EMP elements, particularly, mitigation plan, compliance and effects monitoring, environmental trainings, documentation, and grievance redress mechanism;
- To review and verify the functioning of the key entities – DSC (Dredging Supervision Consultant), CSC (Construction Supervision Consultant), and contractors for environmental management;
- Identify the strengths and weaknesses of the design of EMP and its implementation, and also the entities tasked to undertake various tasks detailed in the EMP;

- Evaluate and assess the adequacy of the mitigation measures proposed in the Mitigation Plan in addressing the potentially negative impacts of the project activities and propose changes as appropriate;
- Review results of internal monitoring (compliance and effects monitoring) and verify its effectiveness through community consultations, spot checks, and field observations;
- Review the process and outcome of environmental trainings conducted by different project entities in line with the training program given in the EMP;
- Review the process and outcome of the documentation and reporting being carried out by various project entities in line with the EMP requirements;
- Identify, quantify, and qualify the types of EMP-related conflicts and grievances reported and resolved and the consultation and participation procedures. Provide recommendations to strengthen the grievance management and redress system;
- Recommend and describe any additional measures to strengthen capacity of implementing entities to ensure full and effective implementation of required mitigation and management measures;
- Describe any lessons learned that might be useful for environmental assessment and management of future projects.

11.5.3 Institutional Capacity Development and Sustainability Measures

Institutional Capacity Development and sustainability programs have planned as part of the Component 3 of overall Project. The total budgeted costs of these measures are US\$50 million. A series of activities are proposed under this component that will support BIWTA's overall enhancement of its management systems and human resources capacity for modern, efficient, and high quality management of the IWT sector in line with international standards. This in turn is critical for the long-term sustainability of the investments supported through the project, as well as the sector's ongoing attractiveness to users, its potential for green innovations in support of national climate mitigation targets, and its resilience to changing conditions including those posed by climate change. Activities to be supported include: (i) the development of River Information Systems to help BIWTA improve data collection for the planning, maintenance and development of IWT, as well as enhance climate resiliency of the IWT sector in Bangladesh by creating a more systematized baseline understanding of river hydrology and navigational implications, and provision of a Traffic Monitoring System for passengers and cargo; (ii) improvement of Human Resources capacity for better management of the IWT sector through upgrading and modernizing the IWT Deck and Engine Personnel Training Centre (DEPTC)) into a regional IWT Training Center with open access to all users in the Region and the world; (iii) commissioning of a study to propose an institutional structure and reforms needed to develop an effective Search and Rescue organization; (iv) support for environmental and social sustainability, climate change resiliency, and "greening" of IWT; (v) a project preparation facility to finance feasibility, surveys, design and safeguards studies for continuous sector development; and, (vi) support for the Project Management Unit including the hiring of key staff and procurement of selected systems needed for implementation of the Project.

11.6 Grievance redresses mechanism (GRM)

Objective of the GRM

The Project will establish a project level Grievance Redress Mechanism (GRM) which will be implemented by Project Implementation Unit (PIU) at BIWTA with an aim to respond to queries or clarifications about the project, resolve problems with implementation and addressing complaints and grievances. The GRM will focus on corrective actions that can be implemented quickly and at a relatively low cost to resolve identified implementation concerns before they escalate to the point of harm or conflict. GRM will serve as a channel for early warning, helping to target supervision to where it is most needed and identify systemic issues.

The GRM will directly focus on and seek to resolve complaints (and requests for information or clarification) that pertain to outputs, activities and processes undertaken by the Project, i.e., those which (i) are described in the Project Implementation Manual; (ii) are funded through the Project (including counterpart funds); and (iii) are carried out by staff or consultants of the organization, or by their partners and sub-contractors, directly or indirectly supporting the project. It is envisaged that such cases would fall under (but are not limited to) the following categories:

- request for information, comment or suggestion, e.g., request for clarification as to the delay in reimbursing expenses of participants in a given training event;
- violation of rights or non-performance of obligations, e.g., complaint by consultant or firm whose contract is suspended as a result of presumed poor performance or non-delivery of agreed-upon outputs;
- grievances or offenses involving a violation of law, e.g., allegations of corruption; and
- complaints against project staff, members of project committees, consultants, and sub-contractors involved in project implementation

GRM will be implemented in two phases: 1) Phase 1 to support safeguards implementation, 2) Phase two of GRM will cover all components and overall project implementation. A formal grievance redress process for phase two will be outlined in the project's operational manual and a protocol will be set up and distributed to project staff and implementers. The project level protocol will build on experience of the initial GRM protocol which supports implementation of the safeguards explained below.

It is envisage that the Project Implementing Unit (PIU) will have a dedicated person who can oversee the preparation of the guidelines and rollout of the project GRM. At lower levels of the project, existing project staff can be assigned for grievance redress functions. Communities can also be trained to undertake grievance redress activities, through complementary mechanisms such as Grievance Handling Committees.

Scope of GRM

In the first phase the project will focus on establishing protocol and procedures for GRM related to safeguards as required per Bank policies. Bank-financed projects that trigger the OP 4.12 on Involuntary Resettlement require projects to establish a GRM in order to collect grievances related to the resettlement process which applies to this project. The scope of such GRM is relatively narrow, as it only solicits complaints from project beneficiaries that are affected by project activities and covered by dedicated Resettlement Action Plans (RAPs) thus

the project protocol will be extended and expanded later to cover all project related grievances throughout project cycle.

In phase two, the project-level GRM will not only aim to address social but also environmental, financial management, procurement and other issues and will build on grievance system practices set up to meet requirements of OP 4.12. It will also build on existing informal and traditional structures of grievance redress—such as village committees and local user groups involved in delivery of the project and may be a cost-effective and a more accessible approach to grievance redress. However, its impartiality would need to be carefully examined before relying on traditional systems. Given that poor and marginalized communities often face the most obstacles in accessing and using GRMs, throughout the design process special attention must be given to integrating design features that make GRMs participatory and socially inclusive.

Phase I of the GRM under Safeguard Issues and Establishment Grievance Redress Committee (GRC)

In the first phase of the GRM, the proposed GRM will be supported by establishment of Grievance Redress Committees which are expected to be effective in resolving grievances related to compensation and relocation aspects. If aggrieved, it is expected that affected people will first approach the local grievance mechanism before taking the issue to other forum. All affected persons will have full and free access to GRCs.

The Grievance Redress Committee will be established at: the local level, hereafter called Local GRC (union/municipality level); and second, GRC at the District level and thirdly at project level to give room for grievances to be fairly reviewed and resolved. These GRCs will be established through gazette notifications from the Ministry of Shipping (MoS). The APs will be informed through public consultation that they have a right to have their grievances redressed by the local committees as well as by the project management. The APs can also call upon the support of the implementing NGO (INGO) engaged to implement the RAP to assist them in presenting their grievances or queries to the GRC. Other than disputes relating to ownership right under the court of law, the GRC will review grievances involving all resettlement assistance, relocation and other support. The local GRCs (at the union/municipal level) will hear the grievances first. Only unresolved cases will be forwarded to the next tier – District Level GRC. Cases with all proceedings are placed with the District level GRC. BIWTA District level senior official (selected by the PD), with assistance from GRM dedicated staff will review them. Field investigations will be carried out, if necessary. The resolutions will be given within four weeks of receiving the complaints. Unsolved cases will be forwarded to the project level GRC for further review and resolution. Grievances will be redressed within a specified date of lodging the complaints. GRC decisions will be on a majority basis and will be disclosed and available for review by the stakeholders. If any disputant is unhappy or dissatisfied with the decision of the GRC at any level, he/she may file cases in the court.

The GRC will record the details of the complaints and their resolution in a register, including intake details, resolution process, and the closing procedures. PMU designated consultant / staff will maintain the following three GRM Books:

Opening Book: (1) Case no., (2) Date and channel of receipt, (3) Name of complainant, (4) Gender, (5) Father or husband, (6) Complete address, (7) Main objection (loss of land/property or entitlements), (8) Complainants' story and expectation with evidence, and (8) Previous records of similar grievances.

Resolution Book: (1) Serial no., (2) Case no., (3) Name of complainant, (4) Complainant's story and expectation, (5) Date of hearing, (6) Date of field investigation (if any), (7) Results of hearing and field investigation, (8) Decision of GRC, (9) Progress (pending, solved), and (10) Agreements or commitments, (11) Number of days to resolve the grievance

Closing Book: (1) Serial no. (2) Case no., (3) Name of complainant, (4) Decisions and response to complainants, (5) Mode and medium of communication, (6) Date of closing, (7) Confirmation of complainants' satisfaction, and (8) Management actions to avoid recurrence.

Report: Summary of numbers and types of complain, resolution time and level.

Grievance resolution will be a continuous process during subproject implementation and overall project implementation. The GRC and PMU will keep records of all resolved and unresolved complaints and grievances (one file for each case record) and make them available for review. The GRC will also prepare periodic reports on the grievance resolution process and publish these on their websites. PMU will consolidate reports from the GRCs on GRM and post in their website. A grievance Redress flowchart is presented in Figure 11-3 and Table 11-3.

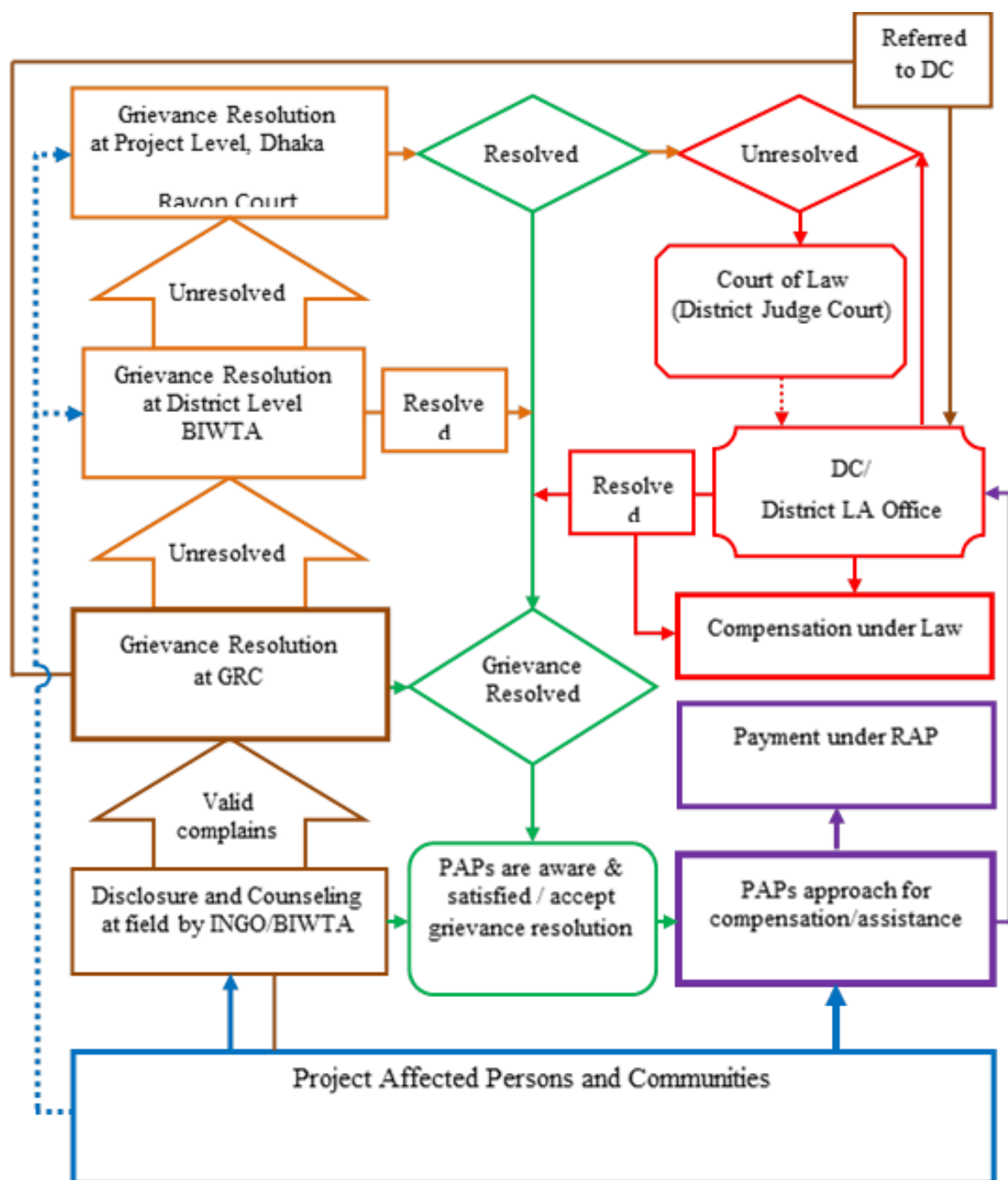


Figure 11-3: Grievance redress flow chart

Table 11-3: Steps of Grievances resolution program

Step 1	The RAP Implementing Agency (IA) on behalf of BIWTA informs PAPs and counsels them on land acquisition and resettlement policy, compensation and entitlement modalities, entitlement packages, and eligibility and process to obtain the entitlements. PAPs with clear understanding approach DC and EA for compensation under law and assistance under RAPs as applicable. PAPs with confusion and valid complaints on land acquisition and resettlement process and entitlements approach GRC for resolution.
Step 2	The implementing agency assists the aggrieved PAPs to produce a written complaint to the convener of GRC with stories, expectations and any parties. The agency counsels the aggrieved persons on the mandate and procedure of grievance resolution. GRC scrutinize the case records and sort out cases to be referred to the DC or the court of law and those to be resolved in GRC. Hearing is organized on cases with merit at the GRC secretariat or at Union Parishad Offices at local level and resolution is given by the GRC in 4 weeks of receiving the complaints. Aggrieved PAPs satisfied with the resolution approach the Executing Agency (EA) for resettlement assistance under the provision of the RAPs. The agreed resolution is forwarded to PMU for approval by the PD before processing entitlements for the entitled person. In case the resolution is not acceptable to the aggrieved person, he/she approaches the District level GRC through the local level GRC convener with assistance from the implementing agency for further review.
Step 3	Cases with all proceedings are placed with the District level GRC. BIWTA District level senior official (selected by the PD), with assistance from other officials review them. If found necessary, field investigation is carried out and the resolutions are given within 4 weeks of receiving the complaints. Aggrieved PAPs satisfied with the resolution approach the EA for resettlement assistance under the provision of the RAPs. The resolution will be sent to the Convener's office at local level GRC to communicate to the aggrieved persons for acceptance. The resolution accepted by the aggrieved person is then approved by the PD. In case the resolution is not acceptable to the aggrieved person, he/she approaches the District level GRC to produce it before the PMU (Project level GRC) for further review.
Step 4	Cases with all proceedings from local level and District level GRC are placed with the Project Director, where the Project Director with assistance from the Deputy Project Director/Senior Level Officials review to resolve the grievance in view of the merits and redirect the case records to the District Level GRC with written resolutions within 4 weeks of receiving the complaints. Aggrieved PAPs satisfied with the resolution approach the EA for resettlement assistance under the provision of the RAPs. The resolution will be sent to the

	Conveners' office of the local level GRC to communicate to the aggrieved persons for acceptance. The resolution accepted by the aggrieved person is then approved by the PD. Aggrieved PAPs may opt to approach to the Court of Law, if the resolution at project level is not acceptable to him/her.
Step 5	The resolution accepted by the aggrieved persons at any level (Local GRC, District or PMU) is approved/nodded by the Project Director and forwarded back to the Conveners' office keeping records at his/her office. Based on the approved grievance resolution, the implementing agency processes his/her entitlements and assists EA in arranging payment.
Step 6	PIU will keep track record of filed and resolved grievances and oversee response time

Phase two – Establishment of Implementation Arrangements for Setting up Project Level GRM

Experience from the phase one of GRM implemented to support social and environment safeguards will be used to extend the protocol and inform the design of project wide GRM. The project PIU will need to identify groups of users that are likely to use the GRM and assess the resources - human, financial, and technological - that are available (and required) for the GRM to function effectively while establishing the protocol to support all project components and implementation. PIU will need to develop standard operating procedures and flow charts to detail how the grievance redress process will unfold within the project's operating structures and how it will be monitored and reported on. More specifically;

- Assign a dedicated GRM officer at the PIU (e.g. drafting operating procedures, guidelines and manual, and stand-alone information for GRM staff and users); and assign grievance redress responsibilities and train staff at the local level to handle grievances
- Raise awareness of the availability of the GRM through project-related events and by posting information about the GRM in public locations / project sites(e.g. via project boards)
- The communications strategy should aim to reach out to poor and marginalized groups and communication materials should be translated into local language
- Accept grievances through a variety of locally-appropriate channels (e.g., in-person, phone – set up toll free number, email);
- Register all grievances (e.g., ensure that all complaints lodged through local authorities are logged and tracked, and that data on resolutions is made public)
- Follow a clear and transparent procedure of complaint investigation (e.g., field visits, inspection of contractors and/or local project implementation teams, discussion with relevant service providers, etc.)
- Take a remedial action within a specified amount of days
- Monitor and evaluate grievance-related data

Budget for Environmental and Social Management

The following table provides estimated costs for environmental and social management of the project, which have been allocated under the project funds.

Table 11-4: costs for environmental and social management of the project, which have been allocated under the project funds

	Description	Amount, million USD	Project Component
	Contractor's Budget (for development and implementation of management plans, staff, training, etc.)	1.0	Component 1: IWT
	Sediment, water, soil, air and noise quality monitoring during construction (quarterly for 6 years)	0.5	
	DSC Environmental and Social Staff	1.0	
	CSC Environmental and Social Staff	1.0	Component 2: Terminals
	Contractor's Budget (for development and implementation of management plans, staff, training, etc.)	1.5	
	Sediment, water, soil, air and noise quality monitoring during construction (quarterly for 6 years)	0.5	
	Administrative budget for RPF activities	3.8	
	Study, development of action plan, and capacity building of BIWTA to ensure effective and sustainable long-term maintenance of river terminals, landings, other BIWTA assets	0.5	Component 3: Institutional Capacity Development and Sustainability
	Origin destination survey of inland waterways along Dhaka- Chittagong corridor, including understanding which supply chains to promote, and logistics gaps for development	0.35	
	Social NGO to support BIWTA on implementation of Social Management Plans / RAPs for specific investments	0.2	
	Third party M&E consultant for social safeguards (including midterm and ex-post evaluations of RAP implementation)	0.25	
	Third party M&E consultant for environmental safeguards	0.25	
	Environmental NGO/firm to: (a) carry out additional baseline data collection on biodiversity at sensitive locations; and (b) develop and implement biodiversity	0.5	

	Description	Amount, million USD	Project Component
	management programs including habitat enhancement and protection for key species		
	Implementation of additional EMP programs (such as management of dredge spoils, biodiversity conservation, capacity building support to establish the permanent Environmental, Social and Climate Change Cell, etc.)	2.0	
	PIU Environmental staff	1.5	
	TOTAL	14.9	

12 CONSULTATION AND DISCLOSURE

12.1 Overview of consultation process

Consultation with various cross sections of the people is essential for better planning and implementation process of the project. People are to be meaningfully consulted at the initial stage of the project to obtain their knowledge and experience about the baseline information, potential impacts and probable mitigation measures. The proposed project Consultation and Participation (C&P) is a process through which stakeholders influence and share control over development initiatives, and the decisions and resources that affect or benefited them. It is a two way process wherein the project owner, policy makers, beneficiaries and affected persons listen to each other and discuss their views and concerns in the project planning and implementation process. Consultation & participation increase the level of support of the stakeholders to the project activities which can speed up processing and reduce challenges during implementation. Meaningful consultation hence improves the effectiveness, relevance, and sustainability of development activities in the long run. The consultation process in this project is guided by the World Bank's safeguard policies OP 4.01 and OP 4.12. The policies give high priority to public consultation and participation and encourage incorporation of community's views in design and implementation of a socially and environmentally compliant project. These policies stress on ensuring that the affected persons and beneficiaries have not only been consulted but that their opinion are acknowledged and accounted for in project designs. The Government of Bangladesh (GOB) also has some acts and policies in line with this requiring consultation with project affected people.

Two national level stakeholders' workshops were held in Dhaka. The first one, at the scoping stage of the study, was at CIRDAP auditorium, Dhaka on 14 October 2015 to disseminate project information and seeking opinion/views of the people from various cross sections including Executing Agency (BIWTA), World Bank, other line agencies, private sectors, launch owners, elite groups, etc. The second one, on the full draft safeguards package, was held on March 30 at BRAC Centre, Mohakali, Dhaka, and like the first national stakeholders workshop it was also attended by people from various sectors including Executing Agency (BIWTA), World Bank, other line agencies, private sectors, launch owners, elite groups, etc. Regional level stakeholders workshop was held at Ashuganj (Brahmanbaria) at R J Tower & Resort on 17 November and Laharhat (Barisal) on 18 November with local sand traders, Upazila Administration, Local Government Institutions, ferry ghat/terminal lease holders, water vessels owners and workers, etc. Apart from these a series of consultation meetings and focused group discussions were held at different locations along the project routes and launch/ferry terminals, proposed dredging locations, and storm vessels shelters. Separate discussions were held with physically challenged/disabled people and women, small businessmen at ferry ghats, etc. about their views on existing facilities in the terminals and vessels and scope of improvement of these facilities. A total of 32 consultation meetings and 29 focused group meetings were held until up to April, 2016 along the project routes and designated sites.

Date and venue of the meetings were disclosed to the community through publishing in the daily newspapers (Bengali and English version), public announcements such as miking, announcement in the mosque, etc. prior to consultation meetings and group discussions. Personal contact with the stakeholders in this regard has been effective. Local government institutions were also used to disseminate information among the people about the consultation meetings and group discussion.

12.2 Stakeholder Identification

A stakeholder is a person, group or institution that has an interest in an activity, plan or program. It can be affected by the organization's actions, objectives and policies. Not all stakeholders are one and the same in every case. It also includes intended beneficiaries and intermediaries, winners and losers, and those involved or excluded from decision-making processes. Categorization of the keystakeholders of the Project mentioned in Table 12.1

Table 12-1: Categorization of the key stakeholders of the Project;

Stake holders	Responsibility	Influence	Proximity	Dependency	Representation	Policy and Strategic Intent
Direct	Project beneficiaries, Affected population (Lease holders, Land owners), River Transport workers, Passengers, fishermen	Government, Non government organizations	Fishermen, Farmers, tourists, and all river users	Fishermen, river users, Ghat Owners, Launch, Ferries and other Vessels	IWM, BITWA,	GOB, Donner
Indirect	Local businessmen, local government representative and other line agencies.	Executive agency (EA),	Deputy Commissioners (DCs) and their supporting agencies, Local government	Local government, Consultants, NGOs.	Non government organizations, media, etc.	Implementing Non-Government Organization (NGOs) and Independent External Monitor.

12.3 Details of consultations

Disclosure, consultation and participation in the project processing are required to ensure that adequate and timely information is made available to the beneficiaries and affected people. It enables opportunities for the stakeholders to voice their opinions and concerns and participate in influencing decision making and project processes. The Bank operational policy requires

meaningful consultation meetings to be carried out throughout the project cycle and timely disclosure of relevant and adequate information is processed. All relevant views of affected people and other stakeholders need to be considered in decision making, such as project design, impact assessment, mitigation measures, sharing of development benefits and opportunities, and implementation.

Therefore, the EIA team organized Two national level workshops, two regional workshops, 32 consultation meetings and 29 FGDs which were held up to April, 2016 at different locations along the project routes with various levels of occupational groups irrespective of gender including businessmen, vulnerable and disabled people, etc.

The stakeholders' consultations meetings were held at or near launch/ferry terminals; proposed vessels shelter sites, potential location of dredging, etc. for information dissemination as well as to obtain stakeholder's perception and views; their expectation and concern about the project interventions, possible impacts and mitigation measures. Consultation meetings were held at national, regional and local level to address various levels of stakeholders and incorporate their opinion in project planning process.

The project activities, like activities and mitigation measures are disseminated to various stakeholders like Department of Fisheries (DoF), Department of Fisheries research Institute (DFRI) Bangladesh Water development Board (BWDB), LGED, Local Government Institution (LGI), Local community, shipping companies, Environmentalist, scientist and other professionals through KII, national workshops, regional workshops and FGD's. After the meeting at DoE 31th July, 2018 Dr Anisur Rahman, Principal Scientific Officer, BFRI, Chandpur Station was consulted over telephone by Dr SMA Rashid, River Ecologist regarding the hilsa sanctuary, hilsa migration and banned fishing period.

First National workshop - 14 October 2015:

A first (scoping stage) National workshop was held on 14 October 2015 at CIRDAP International Conference Centre, Dhaka with a view to disseminate information relating to project routes & locations, magnitude of the project interventions, social and environmental baseline & probable impacts, etc. and to obtain opinion/suggestion from the various levels of stakeholders in project planning process. The participants at workshops were invited through, invitation letters, personal contacts, emails, etc. The workshop was chaired by honorable Minister, Ministry of Shipping (MoS), Mr. Shajahan Khan, MP as the chief guest. Secretary from the MoS Mr. Shafique Alam was also present at the workshop. Representatives from World Bank, BIWTA, BIWTC, Department of Environment (DOE), development organizations, NGOs, research organizations, private sector, media and community level stakeholders participated at the national workshop. They raised their concern about the project interventions, provided suggestions in terms of selection dredging locations, development of facilities in the launch/ferry terminals and water vessels, etc. which were duly addressed and recorded by the project authority. There were power point presentations from the consultants on technical, environmental and social issues and the participants took part in the open discussion.

Md. Saidur Rahman, Superintend Engineer, BIWTA, Dredging department said that Char Nurul Islam is a part of the project and the area is very much unpredictable, siltation rate is too high, water velocity is very high during tide, river bed always changes, so Char Nurul Islam can be taken into account during EIA study. Md. Alfazuddin, Deputy Director (Survey), BIWTA emphasized on Bank protection and river control plan under the study. A K M Rafiqul Islam, Deputy Director, DOE said that identification of ecologically critical

areas (ECA) within project routes/locations should be done. He added that wet land and water bodies should not be filled up by dredged materials and a disclosure of the EIA at website for comments and suggestions would be effective. Shajadur Rahman, Superintendent Engineer, BIWTA said that a good co relation needs to be assessed for river-bay/estuary in terms of aquatic life during dredging interventions. Dr. Shamal Chandra Das, Executive Engineer, BWDB wanted to know the criteria of selecting project influenced area even and in case of tributaries and distributaries. It was disclosed that for tributary and distributary, 1 km influenced area in either side of the river has been considered.



Figure 12-1: Participants of first national workshop held on 14 October 2015.

Regional workshop:

One regional workshop was held at Ashuganj on 17 November with participation of the Upazila administration; Upazila Chairman, Union Parishad Chairmen from riverside unions, BIWTA officials, representatives from Upazila level DAE, local elites, boatmen's association, sand business dealers and community members, workers of the water vessels as well as consultants from EIA study team. A regional level consultation meeting was held at Laharhat, Barisal for the same purposes. People were informed about such regional level workshop and consultation meetings through notice published in the daily newspapers (One Bengali and one English), informing the local government representatives, personal contact,

etc. prior to arrange workshop/consultation meetings. The key concern of the regional workshop and consultation meetings was to identify specific dredging locations, which has been incorporated in management of dredged material disposal, in a separate section of this assessment. Two sand stake yards have been identified adjacent to the river and sand business men have been communicated through FGD and the workshop. Peoples' opinion was sought in the workshop about the project interventions, potential benefits, use of dredged materials in development purposes, etc. Opinion and views of the people were noted and incorporated in the EIA study report.



Figure 12-2: Regional Stakeholder workshop at Ashuganj



Figure 12-3: Regional Stakeholders consultation meeting, Laharhat Ferry Ghat, Barisal

A total of 233 people (219 male and 14 female) were present in three national and regional level workshop/consultation meetings. Apart from these, 813 people (766 male and 47 female) participated in the local level 25 consultation meetings. The 29 focused group discussions (FGDs) covers disabled people, women, sand traders, mobile vendors, shop owners, etc. at ferry ghats, launch terminals, etc. A total 296 people (211 male and 85 female) from various occupation groups were consulted in the FGDs.

Table 12-2: Number of participants in National and regional level workshop/consultation meetings

Workshops/ Consultation meetings	Venue	Date	Participants	
			Male	Female
National Workshop	CIRDAP International Conference Center, Dhaka	14 October 2015	122	05
Regional Workshop (Ashuganj)	R.J Tower Hotel & Resort, Ashuganj, Brahmanbaria	17 November 2015	67	09
Regional Consultation (Barisal)	Laharhat Ferry Terminal, Barisal	18 November 2015	30	00
		Total (233)	219	14

Local level consultation meetings along the project routes:

The participants of the meetings were informed through personal contact, miking in the mosque, local government representatives, etc. about the venue and time of the meetings. In the meetings people were welcomed to raise their voices on issues relating to necessity of dredging, management of dredged materials, existing facilities in the terminals and water vessels, etc. All the meetings were held in participatory approach ensuring both way communications. Environmental and socio-economic aspects of the project and management of dredged material disposal including specific locations were discussed at the meetings. The meetings also concentrated over dredging requirement and dredge materials management. Female, disabled and vulnerable stakeholders were encouraged to participate at the meetings and their feedbacks are duly noted and presented in the next section of this chapter. A total of 32 stakeholder consultation meetings were conducted particularly on social issues during study.



Figure 12-4: Meeting at Gopinathpur, of Sreenagar Union Raipura Upazila of Narsingdi



Figure 12-5: Meeting with UP Chairman and others at Sreenagar Union of Raipura Upazila, Narsingdi



Figure 12-6: Meeting at Karimpur, Narsingdi Sadar



Figure 12-7: Meeting at Narsingdi Jute Mill area



Figure 12-8: Meeting at Ashuganj Ferry Terminals



Figure 12-9: Meeting at Batakandi Bazaar, Comilla



Figure 12-10: Meeting at Munshiganj Launch Ghat



Figure 12-11: Meeting at Jinjira Battala, Dhaka



Figure 12-12: Meeting at Harina Ferry Ghat



Figure 12-13: Meeting at Moju Chowdhury Ghat, Laksmipur



Figure 12-14: Meeting at Baro Station Tek, Mul head, Chandpur



Figure 12-15: Meeting at Bhairab Bazaar Launch ghat

The Table 12.3 represents the consultation venues, date and times and the numbers of male and female (total 877) participants at the meetings.

Table 12-3: Consultation schedule and participants attended in local level consultation meetings

S.N.	Venue	Date & Time	Numbers of male Participants	Numbers of Female Participants
1.	Location: Sadar Ghat , Ward No – 37, Thana: Kotwali, District: Dhaka.	17.09.2015 10 AM	31	3
2.	Location: Aganagar Ward No - 05, Thana: Keraniganj, District: Dhaka.	17.09.2015 12 PM	48	3
3.	Location: Jinjira Bottola Union: Jinjira, Thana : Keraniganj, District: Dhaka.	17.09.2015 2 PM	21	3
4.	Location: Munshiganj Launch Ghat	18.09.2015 10 AM	58	6

S.N.	Venue	Date & Time	Numbers of male Participants	Numbers of Female Participants
	Ward No – 03 Thana: Munshiganj Sadar, District: Munshiganj.			
5.	Location: Munshiganj Ferry Ghat , Thana : Munshiganj Sadar, District: Munshiganj.	18.09.2015 12.00 PM	42	3
6.	Location: Narin Pur Ward No - 04, Thana: Titas, District: Comilla.	18.09.2015 3 .00 PM	19	4
7.	Location: Batakandi Bazaar Ward No - 03, Thana : Titas, District: Comilla.	18.09.2015 5.00 PM	60	3
8.	Location: Bhairab Bazaar Launch Ghat Ward No - 01, Thana: Bhairab, District: Kishoreganj.	20.09.2015 10. 00 AM	39	0
9.	Location: Ashuganj Ferry Ghat Ward No - 03, Ashuganj, District: Brahmanbaria.	20.09.15 12 .00 PM	38	1
10.	Location: Shatnol Launch Ghat Ward No- 05, Thana: Matlab Uttar, District: Chandpur.	01.10.2015 12.30 PM	19	2
11.	Location: Harina Ferry Ghat, Ward No- 13, Thana: Chandpur, District: Chandpur.	01.10.2015 4 .00 PM	23	0
12	Location: Harina Ferry Ghat (Fisherman), Ward No- 13, Thana: Chandpur, District: Chandpur.	01.10.2015 5.00PM	47	4
13.	Location: Boro Station Mul Head, Ward No- 07, Thana: Chandpur, District: Chandpur.	02.10.2015 11.00AM	15	2
14.	Location: Boro Station (Camp Office), Ward No- 07, Thana : Chandpur, District: Chandpur.	02.10.2015 12.30 PM	15	2
15.	Location: Char Bhairabi, Ward No – 06, Thana: Haimchar, District: Chandpur.	02.10.2015 6 .00 PM	39	2
16.	Location: Moju Chawdhury Ghat, Ward No- 20, Union: Chor Romoni, Thana: Lakshmipur.	03.10.2015 12.30 PM	20	1
17.	Location: Boyar Char, Chairman Ghat (Fisherman), Union: Horini, Thana: Hatiya,	04.10.2015 10.30 AM	17	3

S.N.	Venue	Date & Time	Numbers of male Participants	Numbers of Female Participants
	District: Noakhali.			
18.	Location: Chairman Ghat, 1 No Horini, Thana : Hatiya, District: Noakhali.	04.10.2015 12.30 PM	29	2
19.	Location: Tojumuddin Launch Ghat, Ward No-05, Thana: Tojumuddin, District: Bhola.	04.10.2015 1 .00 PM	15	4
20.	Location: Kaliganj Launch Ghat, Ward No-04 Ulania, Thana: Mehendiganj, District: Barisal.	06.10.2015 12.00 PM	9	0
21.	Location: Sreenagar Upazila: Raipura District: Narsingdi	19.11.2015 12.00 PM	26	0
22.	Location: Bagoir, Union: Sreenagar Upazila: Raipura District: Narsingdi	19.11.2015 02.00 PM	21	2
23.	Location: Karimpur, Upazila Narsingdi Sadar, District: Narsingdi	19.11.2015 04.00 PM	24	0
24.	Location: Gopinathpur, Upazila Raipura, District: Narsingdi	19.11.2015 03.30 PM	33	0
25	Location: Narsingdi Jute Mill gate, Narsingdi	20.11.2015 10.00 AM	10	0
26	Location Uttar Mogdhara Launch Ghat, Sandwip, Chittagong	26.12.2015 10.30 AM	22	0
27	Location: Kalapania Ghat, Sandwip, Chittagong	26.12.2015 2.30 PM	11	0
28	Location : Tomurudding Launch Ghat, Hatiya, Noakhali	28.12.2015 10.30 AM	21	0
29	Location : Tomurudding Launch Ghat Bazaar, Hatiya, Noakhali	28.12.2015 12.30 PM	18	0
30	Location; Nolchira Steamer Ghat, Hatiya, Noakhali	28.12.2015 3.00 PM	21	0
31	Monpura Launch Ghat, Bhola	29.12.2015 11.30 AM	19	0
Total			830	47
Grand Total			877	

Second national workshop, March 30 2016:

A public consultation event was held on March 30th, 2016 at the BRAC Centre in Dhaka on the Environmental and Social Assessment studies for the Proposed Bangladesh Regional Waterway Transport Project. The purpose of the event was: (a) To share findings and recommendations of EMP, EMF & RPF with the stakeholders, (b) to share and seek feedback on the proposed mitigation measures, (c) to involve the stakeholders in the project planning

process, as per the Government of Bangladesh and World Bank requirements and standards. Bangladesh Inland Water Transport Authority (BIWTA) and Institute of Water Modeling (IWM), consultant for the Environmental and Social Assessment study, publicized the event through popular daily newspapers and through sending invitations to the attendees by means of invitation cards, emails and phone calls during March 23-28, 2016.

The event was attended by senior government officials of the Shipping Ministry and representatives from relevant government departments including BIWTA, BIWTC, DoE, WARPO, BWDB, Development Partners, NGOs, Research Organizations, Private Sector, Print Media and Electronic Media. Zikrur Reza Khanam, Additional Secretary, Ministry of Shipping addressed the workshop as the chief guest while BIWTA Chairman Commodore M. Mozammel Haque presided over the workshop. There were power point presentations from the consultants on technical, environmental and social issues and the participants took part in the open discussion.



Figure 12-16: Participants of Second national workshop held on 30 March, 2016

Consultation meetings held along the branch of Upper Meghna River (Route-9):

World Bank, BIWTA and IWM officials visited the proposed identified sites for dredge disposal. The Objective of the field visit was to assess the selection process of proposed sites for disposal of dredged material. More specifically to assess availability of land and community's consent at three selected sites (1. Doribela Nagar (UP: Saifulla Kandi), 2. Selimabad (UP: Selimabad) and 3. Nala Dakkhin (UP: Nala Dakkhin) in Bancharampur and

Homna Upazilla) located along 6 km stretch of Upper Meghna River (Branch) where the river is too narrow for disposal within the river bed.

During monsoon, the banks of Titas (Branch of Upper Meghna River) swell up to 1 kilometer at all 3 locations. The private lands identified at proposed locations are close to the river banks, no more than 500 meters for location 1 & 2, and up to 1 kilometer at location 3. The project carried out rapid assessment and held consultations with the local communities, including the land owners in early March'16. The team interacted with identified land owners at location 1 and 3. The meeting with the owner at location 2 (Selimabad) could not be organised. At all the 3 locations, the proposed dredging activities seem to have a broad community support. Interaction with people, located in the nearby market areas at location 2, indicates that they seemed to be aware of the project activities and extended their support.

At locations 1 and 3, the owners expressed their willingness to give their land for disposal provided they are permitted to use the dredged materials for land filling. They indicated that they would settle with a simple agreement along these lines with BIWTA and did not require financial compensation. This approach seems feasible as the entire Bancharampur and Homna upazilla is a low-lying area. Availability of land at high elevation suitable for habitat or commercial establishment is limited. Opportunity to use the dredged material free of cost will enhance the utilization of the land. However, both these locations are inaccessible from road. There may be a need to identify other locations. The current sites are small in size - 40 decimals to 70 decimals at the maximum (the largest is the one at Nala Dakkhin, about 70 decimals). These are sufficient only, at best, for 2 consecutive years for disposal of the dredge materials. Thus, in the subsequent years, other sites have to be found. There are existing private dredge disposal sites run by sand traders on the river banks and many of the operators are likely to accept the proposed modality for taking the material. It is also important to consider that the dredging sites in the river might move to other locations during the project's duration and disposal sites will need to be identified close to the dredging sites.

Another point observed was of that water in Titas (Branch of Upper Meghna River) was found much less polluted and soil sediments in the river bed seem to contain high concentration of organic materials. IWM took soil sample from the river bed in Local 3 (Nala Dakkhin) for laboratory tests and the test results are given in the Annex C.



Figure 12-17: View of the Location 1 (Saifullahkandi)



Figure 12-18: Proposed dredging site at Location 2 (Selimabad): right in the middle of agricultural paddy field



Figure 12-19: Filling up of low laying areas with dredge materials by private operators at Location 2 (Selimabad)



Figure 12-20: Low laying area at Selimabad (potential dredge materials disposal site)



Figure 12-21: Proposed site at Location 3 (Nala Dakkhin). The road runs along the site



Figure 12-22: Group discussion in the nearby market (The bearded person with a stick is the land owner) at Location 3 (Nala Dakkhin)

Feedback on consultations

During consultation meetings people were requested to give their opinion/views about the project interventions particularly requirements of dredging and management of dredged materials, existing facilities in the terminals and water vessels for the people especially old aged, women and physically challenged/vulnerable groups. Consultation meetings were conducted in a participatory approach and people expressed their views in the meetings. The concern of the consultation participants were mainly focused on improvement and extension of terminals, safety & security of passengers, impact on livelihood, dredging and environmental issues including management of dredged materials. Location-specific People are now known about project interventions and potential impacts and mitigation measures including dredged material management, probable facilities to be provided for the passengers and others ghat users. Feedback from each of the consultation meetings are presented in Table 12.4

Table 12-4: Outcomes of the local level consultation meetings

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
1	Sadar Ghat, Dhaka	Around 30,000 businessmen depend on this ghat. Approach road is narrow. Water is very polluted at this point. Toilets facilities in the terminals and water vessels are not good enough for the female. But there is wheel chairs and patient bed to carry the disabled passengers into the launch. During Eid ceremony one Doctor sits in the terminal to provide emergency medical services to the passengers, if required.
2	Aganagar Ghat, Dhaka	There is no launch terminal, water is polluted and around 1,000 businessmen depend on this ghat. Dredging is necessary on urgent basis. Development of this ghat can increase business opportunities.
3	Jinjira Bottola, Dhaka	Depth of the river is not enough and water is polluted extremely. Lots of businessmen do their business through the river. Lots of products are supplied from this area all over the Bangladesh. A large numbers of boatman carry people from Jinjira to Sadarghat and Gudaraghat of Dhaka city. Dredging is required and development of Ghat is essential to promote business opportunities here.
4	Munshiganj Launch Ghat	There are about 300 boats and 200-250 boatmen are associated with this ghat. Most of the people are involved in business and day laboring. Approximately 1,000 business institutions/shops have been found in and around the launch Ghat. About 20,000 people live along the riverside. Char has been arisen in the Shitalakhya and Dhaleshwari river estuary. Dredging is needed to maintain navigation of the river. The waste material of dredging need to move away from the ghat so that they cannot come again to the river. The dredging should be done during the winter season.
5	Munshiganj Ferry Ghat	There are not so many activities seen in this ferry ghat. Around 100 businessmen depend on this ghat. Water is

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
		polluted due to the cement factories. Polluted industrial waste directly goes to river. Dredging is required and take the dressed materials away from the ghat as it is mostly contaminated.
6	Naranpur, Comilla	People have welcomed the project. If the ghats are maintained properly, more people will be travelling through the river routes. Toilet facilities and safety/security are necessary to improve for the river users/ passengers.
7	Batakandi Bazaar	There are no ghats in this area. People desired one Ghat in this area so that businessmen and local people will be benefitted. There are lots of seasonal crops in this area and it is really expensive to transport through the road. River erosion is also a major problem in this area. Dredged material may be used for improvement of river bank.
8	Bhairab Bazaar Launch Ghat	. During the winter time, it is hard to transport goods to Chittagong and Dhaka. Dredging of the river route of Shurma, Doulatkhan and Chatak is urgent. Development of ghat is urgent as well. There is no signaling system here but it is very important to establish a signalling system.
9	Ashuganj Ferry Ghat	Near about 1,500-2,000 laborers depend on this ghat for their livelihood. They have a good communication with India through this ghat to carry their goods. The ghat is well known for the transportation of different goods and products, Many mills & factories have been built around the Ghat, as a result all the chemical impurities of the factories directly go to the river.
		It is basically the cargo port. Dredging is necessary and Businessmen want to buy dredged materials. It is also discussed in the regional workshop here that the dredged materials may be used to develop a 6 km connecting road from Ashuganj to Nabinagar. There were also options to improve river bank and deposit dredged materials in a suitable location so that people can take it for raising play ground, yards of community properties, etc.
10	Shatnall Vessel shelter	Constructing the vessel shelter will change the livelihood of the people living in the adjacent villages/ communities if it is used all the year round. People welcomed this project. Present launch ghat is really small and there is no jetty and passengers waiting room. River erosion in this area is also a major problem.
11	Harina Ferry Ghat (Common people including passengers)	There are about 8,000-10,000 people living on this river embankment. Ferry moves to Harina and Alur bazaar from this ghat. A lot of raw materials are transported regularly through this ghat. Dredging is urgently necessary here. Due to massive river erosion, ghat has been changed 7 to 8 times. There is no jetty also. Project should a plan to develop the ferry terminals and necessary facilities in this ghat for the passengers.

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
12	Harina Ferry Ghat (with businessmen & Fishermen)	Around 700 people are depending on fishing in this area. If the river transport and security are improved, their livelihood will be changed in positive way. Ghats and connecting routes are needed to develop. Dredging is also required. Dredged materials may be used for rural road development and dyke improvement.
13	Chandpur launch Ghat	This is one of the most important ghats in Bangladesh. People can move to Dhaka, Barisal or Chittagong from Chandpur by water transport. Everyday about 120-150 launches move through this ghat. There are approximately 1,000-1,200 business units/shops around this ghat. Every day about 20,000-25,000 people passes through this ghat. The depth of river is well enough. Facilities for women and disabled people in the launch ghat and water vessels needed to be improved.
14	Boro Station Mul Head , Dakatiya	If the vessels shelter is constructed here, business activities and tourism will be increased. Regular maintenance of the vessels shelter is important. It can also be used as terminal all the year round.
15	Sreenagar, Raipura, Narsingdi	The participants welcomed the project and stated that dredging is an urgent requirement in the area. There are some sand businessmen in the area, who will be involved during dredge material disposal during implementation of the project according to project requirement.
16	Char Bhairabi	There is no government land at the river bank to deposit the dredged materials. There is no passenger shade and electricity supply in this area. A vessel shelter at the opposite side of the ghat will lead to change the livelihood of the community people.
17	Moju Chowdhury Ghat	There are about 500-700 permanent shops and 300 temporary shops depends on this ghat. Hilsha fish is available here. Development of this ghat is really important. Dredging is necessary and businessmen love to buy the dredged materials.
18	Boyar Char, Chairman Ghat	There are 1,500 fishermen live here and they are dependent on the river. A lot of fishes are supplies from here to the entire Bangladesh by water ways. River sand quality is much better in this region. The land is cultivated as double crops in this area. Such as paddy, wheat, maize, sugarcane, vegetables etc. River transport cannot move without high tide so, dredging is essential.
(Fisherman Community)		
19	Chairman Ghat (Owner Association)	Approximately 15,000-20,000 fishermen live in this area. There are about 600 business units around this place. About 2,000-2,500 homestead surrounding the Ghat. There is abundance of Hilsha fish. Now this Ghat is remained as unused for 20 hours. Dredging is necessary to maintain

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
		navigation. Improvement of the ghat is also necessary.
20	Bagoir, Sreenagar union, Raipura upozila, Narsingdi	The locals welcomed the project as dredging is an urgent requirement in the area. There are wet lands (20-30 acres) and fellow lands under private ownership. The owners will happily comply if the project wants to use sand filling from dredged material to increase heights of their low lands.
21	Tajumuddin launch Ghat	Everyday 400-500 people use this route. Most of the passengers go to the Dhaka and Chittagong. The people move from here to Char Jahir Uddin, Char Mozammel, Kolatoli, Monpura and other s ghats in the region. People even come from 15 km away to use this Ghat. In this area there are no other means of communications without water ways. Dredging is essential nearer to this ghat to maintain navigability of the river. River erosion threat is a common issue here. Navigability of the river is too low.
22	Karimpur, Narsingdi Sadar, Narsingdi	The respondents of this consultation meeting welcomed the project as dredging is a unique requirement for river navigation in the area. But there are no large stake yards to be designated for drdged materials in the area. Most of the free space are private property with the size of 10-20 decimals.
23	Gopinathpur, Raipura, Narsingdi	They stated that there are free land areas in Sreenagar mouja, but the land belongs to private owners. The owners will cooperate for their own benefit.
24	Kaliganj Launch Ghat	All of the ships from Chittagong to Dhaka and Barisal use this route. There is no jetty in the ghat which is really essential. Dredging is urgently required in the 3 km area up to Gobindopur Char. The present condition of Ghat should be improved as early as possible. If the Ghat is improved, there must be a chance of increasing business sector. A vessel shelter can be made in the “Village Asha” adjacent to the launch Ghat of Ulania bazaar.
Vessel Shelter		
25	Laharhat launch terminal	The participants at the Laharhat consultation meeting were concern about facilities in their terminal and signalling system. The local religious leader, river transport workers, BIWTA staff, representatives from gypsy community and local shop owners participated at the meeting. They urgently demanded piling and approach road to the terminal. About 10,000 passengers use this terminal every day, which increases up to 50,000 during Eid and other festive seasons. But there is no signalling system; the locals urgently requested for installation of signalling system at this busy terminal. The locals also pointed out erosion problem and requested to ensure river bank protection schemes to the area from the project.

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
26	Location Uttar Mogdhara Launch Ghat, Sandwip, Chittagong	The participants of the Uttar Mogdhara Launch Ghat expressed happiness with the project interventions and they welcomed the project. The local passengers, BIWTA staff, river transport workers participated at the meeting. It is very important ghat for the transportation system of this area .But there is only two steamer/trawler(Small engine based water transport) service in a day which is really insufficient. Because of that people depend on speed boat service which is expensive and unaffordable to the local people but they are bound to use speed boat service. This is a busy ghat but there are no any facilities for the passengers. There is a passenger waiting room but that is far away from the ghat. There is no navigation problem around the ghat. People want more water transports for their easier communication facilities. A lot of people are depending on this ghat for their daily earnings. People suffer more during the festival period due to minimum transport facilities. This is an important ghat to maintain the communication especially with the Chittagong city. River erosion is another problem of this ghat. Thousands of people use this ghat everyday.
27	Location: Kalapania Ghat, Sandwip, Chittagong	The respondents of this consultation meeting welcomed the project as dredging is a unique requirement for river navigation in the area. Ghat owner, passengers, ghat workers and local businessmen participated in this consultation meeting. In this ghat river erosion is common problem. In every year river erosion occurs here. It is remarkable that there is neither any structure of ghat nor any passengers' facilities at all. Water transport is depending on the high and low tide, otherwise transport cannot run through the river during low tide. Only two or three water transport including a speed boat are providing the transportation service one in a day during the period of high tie.. There is no launch service. Small engine trawler and speed boat is only water transport. By this ghat people can move to Chittagong and Char Laxmi(Noakhali). People demand the protection of the riverbank, dredging, ghat facilities and more water transportation facilities. According to their opinion it makes their life easier. Flood is common during the rainy season in every year.
28	Location : Tomuruddin Launch Ghat, Hatiya, Noakhali	People warmly receive the project information and welcome the project urgently. Tomurudin Launch ghat is an important ghat for the Hatiya especially for the economic activities. But this ghat is not fulfilling all required facilities. There is a ghat but they cannot use that ghat because of the navigation problem of river. There is a 'under water char" in front of the ghat, so heavier water transport cannot move to the ghat. There is a small good

SL. No.	Venues of Meeting	Outcomes of Consultation meetings
		looking ghat structure but jetty is not useable. Dredging is urgently required in front of the ghat. There also a passenger waiting room with the sanitation facilities but it is not close enough to the ghat. In every year accident occurred in river because of natural causes. So, they demand there to construct a vessel shelter. Only one launch move from here every day. Without this launch service there is other transportation service. People almost move to fight to use this only launch service everyday. In the period of festival people use this service dangerously. It is remarkable that People of Hatya, Monpura, Tojumuddin, Doulatkhan and many other chars/islands depend on this launch service being operated from Tomurudding Launch Ghat. So, people demand more water transport service, ghat facilities and vessel shelter at Hatya.
29	Location : Tomuruddin Launch Ghat Bazaar, Hatya, Noakhali	Tomuruddin launch ghat Bazaar was established on the based on tomuruddin launch ghat. Local businessmen, traders, facilitated people and ghat workers were participated at the consultation meeting. They demand to increase the ghat facilities. According to their opinions, the economy of Hatya is largely depending on this ghat. Thousands of people are depend on this ghat for their daily earning. So, the development of this ghat can make a vital role to run the economic development of hatiya.
30	Location; Nolchira Steamer Ghat, Hatya, Noakhali	There is no any structure at ghat area for facilitating passengers. Water vessels to carry people or goods are very insufficient. Only one engine boat is available here. Using this ghat for goods and passengers transportation. People demand civic facilities at the Ghat including passenger waiting room, jetty, etc. About 2000-3000 people use this ghat everyday. There is river erosion tendency in the ghat in every year. Navigation is quite okay and therefore dredging is not required. About 30 small shops are being operated here. Almost thousands of people depend on this ghat for their livelihood.
31	Monpura Launch Ghat, Bhola	Local people, businessman, ghat workers have participated at meeting. This ghat is important for the economy of Monpura. There is no structure at ghat area for facilitating passengers. River erosion severely occurs here in every year. People demand the riverbank protection for stabilizing the river bank. This is only one ghat that is being used for the launch services. Other than launch service there is no any water transport facilities therefore people demand more water transport facilities for this ghat. About 2000-3000 people use this ghat everyday. About 40 small shops are located here where at least 40-50 families are getting livelihood support.

Focused Group Discussions (FGDs)

A total of 29 focused group discussion (FGD) meetings were conducted throughout the project routes and selected locations with passengers and various occupational groups. The groups were selected based on project impacts with special emphasis on vulnerability, disability and obstructions relevant to using water transportations and female groups and other worker groups. Among the meetings, 7 were conducted only with female respondents, 19 were conducted with male occupational groups and there were presence of both male and female respondents in 3 meetings. Among the total 29 meetings, four meetings were held with disabled people (male and female) in the launch terminals.



Figure 12-23: FGD with physically disabled people at Laharhat



Figure 12-24: FGD with physically disabled people at Ashuganj;



Figure 12-25: FGD with disabled people at Sadarghat, Dhaka



Figure 12-26: FGD with sand businessmen, Boulpara, Narsingdi



Figure 12-27: FGD with Gipsy community at Laharhat, Barisal



Figure 12-28: FGD with female group at Ashuganj

Focused group meetings were held with various occupational groups including female groups, disabled people, gipsy, shop owners, mobile vendors, students, etc. Some physically disabled people were identified near the terminals, who mostly use the water transport to go here and there. Some of them are beggars by occupation but stay in and around the terminals. Four FGD meetings have been conducted in various locations with physically challenged/disabled people. A total of 211 male and 85 female respondents participated in the 29 FGD meetings from which 40 disabled people (27 male and 13 female). Feedbacks from FGDs are incorporated in the next section of this chapter.

Table 12-5: FGD Venue Date and Participants:

Sl.	Venue/ Upozila/District	Date	Participant Group	Male	Female
1	Sadar Ghat, Kotwali, Dhaka	17.09.15	Boatmen	11	0
2	Aganagar, Keraniganj, Dhaka	17.09.15	Shopkeeper	08	0
3	Jinira Bottola, Keraniganj, Dhaka	17.09.15	Shopkeeper	12	00
4	Launch Ghat, Munshiganj	18.09.15	Passenger	0	9
5	Ferri Ghat, Munshiganj Sadar, Munshiganj	18.09.15	Shopkeeper	08	0
6	Narin Pur, Titas, Comilla	18.09.15	Housewives	0	6
7	Batakandi Bazaar, Titas, Comilla	18.09.15	Shopkeeper	13	0
8	Launch Ghat, Bhairab, Kishorganj	20.09.15	Passenger	10	0
9	Ferry Ghat, Ashuganj, Brahmanbaria	20.09.15	Laborer	12	0
10	Satnol Launch Ghat, Matlab Uttar, Chandpur	1.10.15	Shopkeeper	10	0
11	Harina Ferry Ghat, chandpur, Chandpur	1.10.15	Fishermen	12	0
12	Harina Ferry Ghat, Chandpur, Chadpur	1.10.15	Shopkeeper	11	0
13	Boro Station Mul Head, Chandpur, Chandpur	2.10.15	Housewife	0	08
14	Boro Station, Chandpur, Chandpur	2.10.15	Vendor	09	0
15	Char bhairabi, Haimchar, Chandpur	2.10.15	Passenger	10	0
16	Moju Chawdhury Ghat, Char Romoni, Lakshmipur	3.10.15	Student	0	10
17	Boyar Char, Hatiya, Noakhali	3.10.15	Fishermen	11	0
18	Charman Ghat, Hatiya, Noakhali	4.10.15	Launch and Ferry Worker	9	0

Sl.	Venue/ Upozila/District	Date	Participant Group	Male	Female
19	Tojumuddin Launch Ghat, Tojumoddin,Bhola	4.10.15	Passenger	0	11
20	Kaliganj Launch Ghat,Mehendiganj,Barisal	6.10.15	Launch and Ferry Worker	12	0
21	Sadar Ghat , Ward No – 37, Kotwali, Dhaka	13.11.15	Physically Disabled	07	06
22	Ashuganj Cargo Terminal Ashuganj, Brahmanbaria	14.11.15	Boatmen Community	11	0
23	Ashuganj Rail Station, Ashuganj, Brahmanbaria	14.11.15	Physically Disable (Male)	8	0
24	Ashuganj Rail Station, Ashuganj, Brahmanbaria	14.11.15	Physically Disable (Female)	0	7
25	Sand Businessmen of Ashuganj Ashuganj, Brahmanbaria	15.11.15	Sand Businessmen	08	0
26	Ashuganj Cargo Terminal Ashuganj, Brahmanbaria	15.11.15	Physically Disabled (Passenger)	06	02
27	Sand Businessmen of Ashuganj Ashuganj, Brahmanbaria	15.11.15	Sand Businessmen	08	0
28	Laharhat Ferry Ghat, Bondar Thana, Barisal	18.11.15	Bede community (Gipsy)	0	19
29	Barisal Launch Ghat, Barisal Sadar, Barisal	18.11.15	Physically disabled	05	07
Total				211	85
Grand total				296	

FGD Feedback:

The FGDs concentrated on specific groups and they had specific expectations from the project. Peoples from various cross sections have opined on their own ways about the project interventions, positive or negative impacts, existing facilities and their expectations from the project, etc. The sand traders at Ashuganj, Raipura and Narsingdi are welcoming the project as the project means more business to them. The locals also supported their opinions as these areas need dredging for river navigation. The shops and business owners at project sites are also looking forward to the project as it will increase passengers, which will be positive for their business. The female respondent groups complained about sanitation system at the launch terminals and ferries. They demanded better sanitation system, separate counter, waiting area and resting zones for female passengers maintaining privacy. The disabled persons mostly stated that they do not use river transport system as the entrance and exit from the vessels are not suitable to disabled passengers. In case of accidents, they are at life risk as there is no other way than swimming out of the rivers. Although some terminals have wheel chairs, they are mostly used to take sick passengers to the vessels. There is no sanitation facility specially designed for disabled people even for long distance traveling in the vessels or terminals.

Table 12-6: Detail of FGD activities

S L.	Group	Number of Group	Number of participants			Opinion Of Participants in Focus Group Discussion
			Male	Female	Total	
1	Shopkeeper	06	62	0	62	Shopkeepers opined in favor of the project but they want to see the launch ghat improved with more facilities such as toilets, sufficient space for shops on a designated area so that they will be bound to shift their structure frequently. They expressed that the project will increase their business opportunities and new venture of business will be open after completion of the project.
2	Launch Passenger	05	37	11	48	There is no sufficient facility for the passengers particularly female, old aged disabled peoples in the terminals and water vessels. They face many difficulties when they cross the river on boat or travel by launch. They want proper safety and security in terminals and water vessels. It is mentionable that the present scenario is very pitiable and not sufficient to use mass

S L.	Group	Number of Group	Number of participants			Opinion Of Participants in Focus Group Discussion
			Male	Female	Total	
						people.
3	Physically Disabled	04	27	13	40	There is no special facility for the disabled people in the launch terminals and water vessels. But they want separate place in ghat and launch terminals for their easy movement. Wheel chair and bed facilities are available only for patients and for emergency situation. There are no doctors permanently on duty. Disabled persons want proper safety and security in terminal and launch as well. Disable persons do not know the facilities about river transports. Most of the people think that road transport is easier than river transport especially for the disables persons as they cannot swim. They want separate space/seat for them in the launch/ferry and easy riding facility such as smooth way, wheel chairs, etc. If such facilities are provided for the disable people then they may comfortably use the river transport.
4	Fishermen	02	23	0	23	Fishermen communities are mostly living along the river or within one km from the river. They want modern signalling system and safety and security during fishing. Some time they are to face trouble from pirates or even some political persons/Mastans who made them bound to pay money for fishing. They welcomed the project but requested to keep in mind about fish moving routes, season and fishing areas during dredging so that their livelihoods will not be disturbed.
5	Launch and Ferry worker	02	21	0	21	Launch and ferry workers expressed their views in favour of the project. They are concern about dredging and

S L.	Group	Number of Group	Number of participants			Opinion Of Participants in Focus Group Discussion
			Male	Female	Total	
						signalling system in the river routes as there are some incidents of collision among the water vessels. Improved signalling system may decrease accidents. They want sufficient personal protective equipment (PPE) for their safety in the launch and other water vessels. PPE can also be available for the passengers.
6	Housewives	02	0	14	14	Females particularly housewives of the project routes move here and there by launch along with husband or even only with children for their needs. Safety and security, separate space for them in the launch terminals and vessels, separate ticket counter, etc. are their needs.
7	Mobile Vendors	01	09	0	09	Usually mobile vendors deal in the ferry/ launch ghats as well as in water vessels. They always move from one ghat to another and sell their goods. They need safety and security in the ghats as well as in the transport. Sometime they face trouble by the policemen and guard of the ghats and vessels.
8	Day Labor/ Cooli	01	12	0	12	Day laborers of the ghat and water vessels carry luggage and goods of the passengers. They are not paid by launch owners or terminal lease holders, But they have some time association for their own interest. They want safety and security in the ghats and launch/ferry.
9	Boatmen Community	02	22	0	22	Boatmen are engaged to carry goods and passengers from distant places to the launch terminals and vessels. They have welcomed the project and suggested for dredging in some particular locations. They need a specific location to anchor their boats

S L.	Group	Number of Group	Number of participants			Opinion Of Participants in Focus Group Discussion
			Male	Female	Total	
						in the adjacent area of the launch ghats.
10	Student	01	0	10	10	Students are usually going to school/college by the launch in some areas along the routes. They want safety and security particularly for the female students in the terminals and vessels. They also demanded development of the ghats and improvement of health and hygiene facilities in the terminals and water transports.
11	Sand Businessmen	02	16	0	16	Sand business is very popular all along the project routes. As per dredging requirements a huge quantity of dredged materials will be available at Narsingdi area. The sand businessmen of this area expressed their positive views to buy sand through the proper authority. They have suggested deposit dredged materials in a suitable location so that it will not go back to river and people can use it for community purposes
12	Gypsy (Bede) Community	01	0	19	19	There are two Gypsy (Bede) communities all along the project routes from which one group at Laharhat was consulted in FGD to know their views about the project. Although they will not be directly impacted by the project but they have expressed their positive views about the project. They wanted better facilities in the launch terminals and water vessels in terms of health and hygiene and safety & security.

12.4 Information disclosure, stakeholder engagement and Consultation

This chapter incorporates details of information disclosure to the public consultation sessions held with different stakeholder groups through print and electronic media, official documents and websites. The focus group discussions were with stakeholders who were likely to be affected by the implementation of the proposed project whereas the organized stakeholder consultations included other stakeholders representing the government institutions, NGOs, professionals and water sector organizations.

12.4.1 General

The purpose of public consultation meetings was to invite comments and detailed suggestions on any environmental and social issues considered relevant by the people living in the area of the Project corridor. The public consultation programme is an essential part of the environmental and social assessment process and has been undertaken both formally and informally throughout the study to ensure that the knowledge, experience and views of stakeholders and the general public are taken into account during the EIA activity. The information shared and recorded has, where relevant, been applied to justify planning, dredging, alignment, and timing changes, in order to reduce predicted negative effects. This approach satisfies statutory consultation requirements of DOE.

During the consultations, communities' suggestions and concerns have also been noted apart from opinions on the proposed venture and the key associated activities. The key objectives of the consultations carried out for the Dhaka Chittagong Inland Water Transport Corridor Project include the following:

- i. Build up awareness among the local people and community members about the project, its nature and implementation process.
- ii. Facilitate the stakeholder to identify the problems and prospects of the project and conflict of interest among the groups.
- iii. Learn about the present socio-economic conditions of the study area
- iv. Learn about people's participation on the impact of proposed interventions.
- v. Obtain people's suggestions on the enhancement measures of the positive impact; and
- vi. Identify solutions to the apparent problems related to the project and ideas on mitigating the negative impacts.

12.4.2 Consultation Methodology

A total of 32 public consultations and 29 Focus Group Discussions were conducted at 60 different locations which were within the project influence area along the proposed river routes. Using a simple questionnaire format, benefits and disadvantages of the project, various environmental and social issues as impact, mitigation measures during the dredging period, were discussed. The main focus was to dig out information on how does dredging and maintenance of work of the project can impact the surrounding environment and to get people's perception about this project. The participant's opinions and comments were spontaneous and the facilitators had the full cooperation of participants.

Information Provided

Part of the consultation process involved disseminating factual information regarding the Project, with the aim of developing positive and constructive relationships with stakeholders and decreasing the likelihood of incorrect perceptions.

Information Recording and Responsibility

The Consultant assigned a dedicated secretary for each consultation, whose responsibility was to record participant comments and submit a report. The Consultant provided answers of most of the queries and concern arose by the participants and specifies actions to be taken. Each consultation had minutes recorded and attendance taken with signatures.

Stakeholder Consulted

Stakeholders include all those who affect and are being affected by policies, decisions or actions within a particular system. Stakeholders can be groups of people, organizations, institutions and sometimes even individuals. In case of the proposed Project, the stakeholders include the people living within the Project area particularly those who reside within and in the immediate vicinity the project area. The stakeholders identified and consulted during the present EIA include communities to be benefitted and/or affected by the Project, local leaders, community members and other local representatives.



Figure 12-29: Community Consultation Meetings at different locations along the project influence area

12.4.3 Summary of Comments by Participants

The summary of the issues raised and suggestions forwarded by the stakeholders during the consultations have been summarized in Table 12.7 below. Also given in the table is the proposed action to address the concerns raised.

Table 12-7: The issues and suggestions forwarded during Community Consultations (FGDs)

Environmental and Social Aspects	Description of Views and Concerns	Action Plans
Overall	River bank erosion, water logging, flooding and salinity intrusion are the main community concerns in the project influence area.	Mitigation measure should be taken up at the earliest with the active involvement of the local community.
Erosion	Dredging is very problematic as it will induce more river bank erosion to extreme extent. On varying scale river erosion destroys homestead and cultivable land	River bank protection is included in the report
Flooding	Frequency increasing, more areas inundated for a long period	The proposed interventions will address these issues
Water logging	water logging takes place due to lack of proper drainage system and sometimes embankment obstructs flow of water, cultivation is hampered	Site selection for disposal of dredge materials in consultation with inhabitants. Dredge materials disposal will avoid existing drainage system.
Surface water pollution	The surface water is polluted at some locations due to effluent release from the nearby industries, dumping of municipal and domestic wastes in the river.	EMP will include measures to minimize such impacts. Monitoring will also be carried out.
Air and noise pollution	Local communities could be adversely affected by such pollution.	EMP will include measures to minimize such impacts. Monitoring will also be carried out.
Fish availability	Dredging activity will affect fish migration and reduce its cultivation	Dredging operation will be conducted in such manner so that turbidity and sediment concentration do not exceed standard limit. Dredge material disposal will avoid important fish habitat, spawning ground and the operation will be restricted to required area only.
Illegal dredging	Illegal dredging causes the river bank erosion to extreme extent at some places along the project area.	Enforcement of law by DOE and BIWTA as well as affected people are to identify the offenders and inform law enforcing authority for appropriate measures.
Disposal of dredge materials	Dredge materials are released in the river which is not beneficial.	In stream disposal will prevent river erosion. Care will be taken

Environmental and Social Aspects	Description of Views and Concerns	Action Plans
		not to avoid sensitive area.
Navigation route improvement	Siltation in the main channel and submerged char land is problematic for navigation which needs to be dredged to improve the navigation route.	Problem area will be identified and dredged to improve navigability.
Navigation Safety	Navigational signs and lights are either inadequate or non-functioning.	Adequate navigation aids will be in place before commencement of dredging operation.
Monitoring of Charland	Monitoring of charland is required.	Char land will be monitored as per monitoring plan.

12.4.4 Summary Key Informant Interview (KII)

Mr. Enam al Haque, Co-Founder, Bangladesh Bird Club

Comments: The chars and mudflats of the Lower Meghna estuary are of global importance as many of the global critically endangered migratory birds winter here. For example, the tiny Spoonbill Sandpiper that breeds in one of the most remote places on earth, in the Russian Far East along a narrow strip of coastal tundra hugging the frigid ocean travels each year nearly 5,000-mile migration to tropical mudflats in Bangladesh, and a few other sites in Southeast Asia. Only 120-200 pairs of adult spoonbill sandpipers are known to survive. If the mudflats in the Lower Meghna estuary are impacted by the deposition of dredged materials of for dredging activities or if the birds are disturbed during their wintering here then their survival will be in question.

Improving the navigation route is important for the economy of the nation but at the same time utmost care has to be taken that the habitat is not disturbed or affected.

Mr. Mukit Mazumdar, Chairman, Prokriti-O-Jibon Foundation (=Nature Foundation)

All habitats are important for the wildlife but the Lower Meghna is unique and has to be protected at any cost. No disturbance or any activity that puts the mudflats and the habitat altered that affects the migratory birds will be tolerated.

Dredging may not be done close to the chars or mudflats nor any dredged material is to be deposited on the mudflats or chars. It will be good if the Lower Meghna estuary is completely declared by the government as protected.

The migratory birds utilize the mudflats and chars usually till March and if dredging is planned after March in the estuary it may not disturb the migratory birds but again that time of the year is important for the hilsa fishes, so we have to be very careful.

Md. Istiak Uddin Ahmad, Country Representative, IUCN-Bangladesh

Improving the navigation route for inland water transport is important and necessary for the country. However, the EMP and the BMP should look into every aspect so that the

environment particularly the Lower Meghna estuary, the hilsa fishery and other critically endangered species and sensitive habitats are not affected.

The DOE will definitely look into the EIA/EMP however; monitoring has to be conducted diligently and remedial measures taken immediately.

Mohammad Abu Sayed, Executive Engineer, Barisal O&M Division

A verbal conversation was held with Mohammad Abu Sayed, Executive Engineer to discuss about the cross-dam construction at Maskata River to find out whether it will hamper the project activity (construction of vessel shelter). Cross-dam will construct at a narrow channel located beside char developed near the patarhat launch ghat.

There is a plan to connect the developed char in the mainland Cross dam will accelerate sedimentation process and helps to merge the char with mainland very quickly. The cross dam will not hamper navigation because the channel where cross dam will be located is very narrow. Moreover, vessel shelter will be constructed near patarhat launch ghat so, cross-dam will not obstruct the construction of vessel shelter.

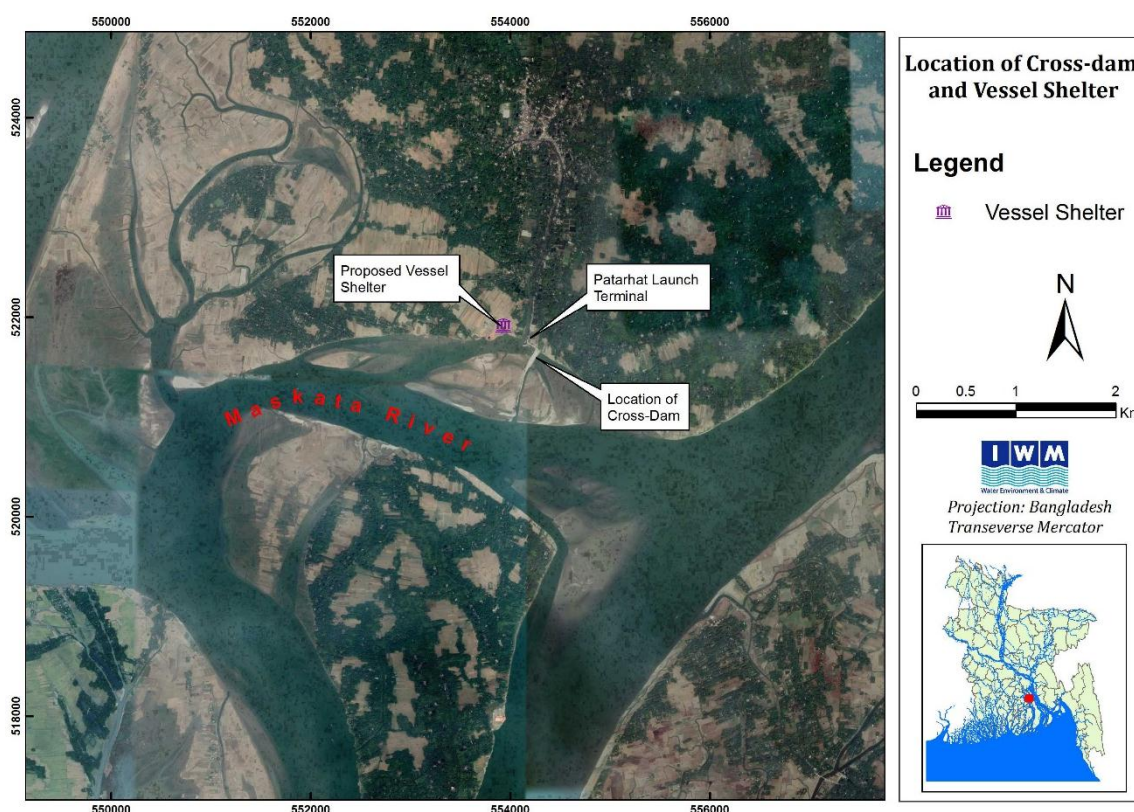


Figure 12-30: Location of vessel shelter and construction of cross-dam

Disclosure Requirements

Once finalized, the EIA report and Bengali translation of its executive summary will be disclosed to the public and will also be available on the official website of the BIWTA. EIA will also be sent to the WB InfoShop.

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

The EIA reveals that there will be negative and positive impacts due to the proposed dredging operation, construction of vessel shelters, provision of navigation aids and landing facilities at the ferry crossings.

The positive environmental impacts of the Project are development of all weather navigation routes for transportation of passengers and cargo not only within the country but also to the neighbouring countries and generation of employment opportunities during construction operation and maintenance stages as well as induced economic growth and activities.

The major negative environmental impacts of the project are loss of benthic flora and fauna, obstruction to navigation traffic, loss of land, alteration of habitat, health, hygiene and sanitation of construction workers, public nuisance, blocking of natural drainage, noise and air.

An EMP has been formulated to mitigate the negative impacts (Oil spill, displace of benthic habitat, increase of turbidity during dredging, exhaust emission) during various phases (pre-dredging/construction, during dredging/ construction and Post dredging/O&M) of the Project to acceptable levels. Also public consultations, including consultation workshops at regional and national level have been organized in addition to preparation of resettlement policy framework as per World Bank guidelines to address resettlement and compensation issues.

To ensure that these enhancement and compensation measures are implemented correctly and negative impacts avoided, the EMP along with adequate budget is to be included in the contract documents of the Project with a separate line item on environmental management in the BOQ. The main monitoring parameters include monitoring of dredging and dredge material disposal, biological monitoring and enhancement, environmental quality monitoring (air, noise, surface water, river bed sediment), health and safety, etc. However, major concern is biodiversity depletion due to dredging activity. EMP guidelines (Table 10-1) clearly mention the procedures and standard which must be followed during implementation phase. There is no possibility of food chain disruption if enhancement measures are undertaken during river bed excavation, dredge material transport and oil spill management etc. However, most of the potential impacts are short-term that can be avoided or mitigated by adopting mitigation measures and relevant ECoPs.

To keep the project influence area environmentally friendly, BIWTA should ensure that the Contractor prepare site specific EMPs including Emergency response plan, Oil Spill Contingency Plan and Workers Health and Safety plan and Environmental Pollution Abatement and Mitigation Measures Plan, regular and effective monitoring of environmental quality parameters as indicated in this EIA report.

Based on the assurance of minimal disturbance to the natural environment and implementation of EMP in every step of the project activities, the proposed dredging and vessel shelter activities can proceed and DOE may issue necessary environmental clearance to such a nationally important project. BIWTA should follow the guidelines illustrated in the EMP and other legal and administrative requirements to carry out the activities for

improvement of navigation.

Large volume of spoils will be generated due to dredging and related activities. The dredged spoil is to be disposed safely and productive manner with minimal or no damage to environment. This dredged earth can be utilized for port yard development.

13.2 Recommendations

The implementation of the project is suggested to proceed following the recommended mitigation measures as outlined in the EMP. The EMP shall be included in the bid document of civil works and need to become part of the civil works contracts. The timely implementation of EMP will reduce negative impacts. The EIA is a living document and will need to be updated prior to starting the intervention by BWTA to reflect any significant changes in the project scope of work with recommended mitigation measures or to respond to the regular environmental monitoring results, collection and analysis of detailed bio-physical and environmental data.

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