People's Republic of Bangladesh
Ministry of Shipping
Ministry of Road Transport and Bridges
Chittagong Port Authority
Roads and Highways Department

Preparatory Survey on the Matarbari Port Development in People's Republic of Bangladesh

Final Report

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The Overseas Coastal Area Development Institute of Japan
Oriental Consultants Global Co., Ltd
Nippon Koei Co., Ltd
PADECO Co., Ltd

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1.00 USD = 82.891 BDT = 106.106 JPY

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Abbreviations

Abbreviation	Description
ADB	Asian Development Bank
ADCP	Acoustic Doppler Current Profiler
AIS	Automated Identification System
ARIPA-2017	Acquisition and Requisition of Immoveable Property Act-2017
BAFFA	Bangladesh Freight Forwarders Association
BBA	Bangladesh Bridge Authority
BBS	Bangladesh Bureau of Statistics
BCIC	Bangladesh Chemical Industries Corporation
BCMCL	Barapukuria Coal Mining Company Limited
BCT	Bay Container Terminal
BEZA	Bangladesh Economic Zones Authority
BHP	Break Horse Power
BIG-B	the Bay of Bengal Industrial Growth Belt
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transportation Company
BLPA	Bangladesh Land Port Authority
BMD	Bangladesh Metrological Department
BPDB	Bangladesh Power Development Board
BPL	Below Poverty Line
BR	Bangladesh Railway
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BWDB	Bangladesh Water Development Board
CCL	Cash Compensation under the Law
CCT	Chittagong Container Terminal
CCTV	Closed-circuit Television
CD	Chart Datum
CDL	Chart Datum Level
CDM	Cement Deep Mixing
CFS	Container Freight Station
CNG	Compressed Natural Gas
CPA	Chittagong Port Authority
CPGCBL	Coal power Generation Company Bangladesh Limited
CTT	Coal Transshipment Terminal
CY	Container Yard

DC	Deputy Commissioner
DEG	Diesel Engine Generator
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DOE	Department of Environment
DoFo	Department of Forest
DOS	Department of Shipping
DT	Displacement Tonnage
DTCA	Dhaka Transport Coordination Authority
DWT	Deadweight Tonnage
EA	Executing Agency
EBIT	Earnings before Interest and Taxes
EBITDA	Earnings before Interest, Taxes, Depreciation and Amortization
ECA	Ecological Critical Area
EGCB	Electricity Generation Company of Bangladesh
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EMoP	Environmental Monitoring Plan
ERL	Eastern Refinery Limited
EZ	Economic Zone
FEU	Forty Foot Equivalent Unit
FGDs	Focused Group Discussions
FIRR	Financial Internal Rate of Return
FRP	Fiber-Reinforced Plastics
FSRU	Floating Storage and Regasification Unit
FY	Fiscal Year
GCB	General Cargo Berths
GDP	Gross Domestic Product
GHz	Giga Hertz
GoB	Government of Bangladesh
GPS	Global Positioning System
GRM	Grievance Redress Mechanism
GRT	Gross Resister Tonnage
GT	Gross Tonnage
HHs	Households
HYV	High Yielding Varieties
HWL	High Water Level
IALA	the International Association of Marine Aids to Navigation and

	Lighthouse Authorities
ICD	Inland Container Depot
ICT	Inland Container Terminal
ICT	Information Communications Technology
IEA	International Energy Agency
IEE	Initial Environmental Examination
ILO	International Labour Organization
IMF	International Monetary Fund
ISLWL	Indian Sea Low Water Level
ISPS	International Ship and Port Facility Security Code
ISSA	Inland Ship Safety Administration
IUCN	International Union for Conservation of Nature
IWT	Inland Water Transport
JICA	Japan International Cooperation Agency
JTWC	Joint Typhoon Warning Centre
KCT	Karnaphului Container Terminal
kHz	Kilo Hertz
kN	Kilo Newton
KPC	Kuwait Petroleum Corporation
LARAP	Land Acquisition and Resettlement Action Plan
LBT	Laldia Bulk Terminal
LED	Light Emitting Diode
LGD	Local Government Devision
LCT	Landing Craft Tank
LGED	Local Government Engineering Department
LMT	Laldia Multi-Purpose Terminal
LNG	Liquefied Natural Gas
LOA	Length Overall
LPG	Liquefied Petroleum Gas
LWL	Low Water Level
MHC	Mobile Harbour Crane
MHWS	Mean High Water Spring
MICS	Model for Intermodal International Container Cargo Shipping
MOC	Ministry of Commerce
MoEF	Ministry of Environment and Forest
MOF	Ministry of Finance
MOL	Ministry of Land
MOR	Ministry of Railways
MOS	Ministry of Shipping

MOU	Memorandum of Understanding
MPA	Mongla Port Authority
MSL	Mean Sea Level
MUSCCPP	Matarbari Ultra Super Critical Coal-Fired Power Project

Source: JICA Survey Team

Executive Summary

1. Introduction

In Bangladesh, export and import cargoes have increased by 10% in the last 5 years. However, as almost all cargoes (98%) are handled at Chittagong, the capacity of the terminal facility has already been exceeded. Accordingly, expansion of the port is required to meet the demand as vessels are commonly forced to wait for berthing. As this situation is detrimental to the economic growth of the country, the Government of Bangladesh has been preparing the seventh five-year development plan (from 2016 to 2020) which calls for new port infrastructure for the port of Chittagong including a coal terminal in the Matarbari area (water depth – 15.3 m) to be developed by a Yen Loan. The Government of Japan and the Government of Bangladesh have strengthened their bilateral relationship through the Bay of Bengal Industrial Growth Belt Initiative (BIG-B).

In future, a special economic zone will be developed in this area including a logistics park, power plants, LNG terminal etc.

In the course of the survey, the Prime Minister's Office determined the future concept on the Matarbari port development, leading to the commencement of the "Data Collection Survey on Feasibility Confirmation of the Matarbari Port Development in the People's Republic of Bangladesh" (hereinafter referred to as "the Survey") for investigating the further detailed plan of Matarbari port development.

This project has been implemented based on the result of "Data Collection Survey on the Matarbari Port Development in the People's Republic of Bangladesh" conducted from December 2016.

The purpose of this survey is to examine the scope of the proposed project including procurement method, project cost, construction cost, the implementation body, the management system and required environmental and social consideration to determine whether the project can be carried out under yen loan assistance.

2. Port Development

2.1 Port Policy and Trend of Maritime Logistics

2.1.1 Port Policy Direction

A major strategic challenge for the Seventh Plan is to set investment priorities in a way that Bangladesh gets best results from its limited resources. While there has been improvement in Chittagong Port container handling efficiency, further efforts are needed to increase efficiency in line with good international practices.

Chittagong Port will continue to be the leading seaport of Bangladesh, in anticipation of the growing demand for port services emerging from growing income and international trade, including from neighboring countries related to the implementation of the Government's regional connectivity agenda, and the specific needs of the power sector emerging from the substitution of imported coal for domestic gas, substantial new port capacity will be needed during the Seventh Plan and beyond.

The Matarbari port and the coal associated transshipment terminal are critically linked to the Government's successful implementation of the power generation plan and would have the highest priority in the public investment Program for transport infrastructure during the Seventh Plan. Alongside, the Government is also taking steps to strengthen the land ports to facilitate trade with neighbors. This will be an important priority for the Seventh Plan.

2.1.2 Trend of Maritime Logistics

(1) Container trades

1) Ship deployment in the container services currently calling at Chittagong Port

Shipping lines' container services calling at Bangladeshi ports consist of 2 major categories; one is the feeder services connecting with Singapore, Colombo and Indian coastal ports. The other is the mainline services directly connecting with East Asian and Southeast Asian ports.

As of August 2017, the Bangladeshi ports (Chittagong and Mongla) are covered by 3 mainlines and 20 feeder services with the maximum size of 2,548 TEU.

2) Congestion at Chittagong Port

The container ships entering Chittagong Port are currently forced to wait at the anchorage for berthing for 3 to 7 days due to the chronic berth congestion. To compensate the costs for waiting at Chittagong Port, shipping lines started to collect USD 150/TEU of "Congestion Surcharge" from the consignees and shippers from July 2017. This additional cost might be affecting the competitiveness of exporters/importers in Bangladesh.

(2) Non-Container Trades

As for non-container ships, the maximum deadweights by ship type were investigated in the previous study as per the table below. The maximum deadweight is 178,373 at Chittagong and 92,485 at Mongla.

Deadweight and Number of Callings by Port / Ship Type (2016)

(DWT)

Port	Bulk carriers	Liquid bulk tankers	LPG tankers	Vehicle carriers	RoRo ships	General cargo ships	Full container ships	Total
Chittagong	178,373	164,746	29,565	12,077	55,649	27,352	37,157	178,373
Mongla	92,485	49,452	7,031	21,214	-	37,332	24,157	92,485
Payra	58,923	-	-	-	-	-	-	50,398
Total	178,373	164,746	29,565	21,214	55,649	37,332	37,157	178,373

Source: Lloyd's List Intelligence "Seasearcher

(3) Coastal shipping

1) Containers

a) Current status of coastal container shipping

Coastal shipping for containers is developed mainly for imports from Chittagong Port (NCT) to the river ports near Dhaka. The number of containers carried by coastal shipping is approx. 26,000 TEUs in 2017.

Currently Pangaon ICT and Summit Alliance (SAPL) are in operation, and Rupayan Port & Logistic Services Ltd. and AK Khan Container Terminal are under construction. In addition, 2 more river ports are planned but currently uncertain to be constructed; Kumudini Container Terminal and Ananda Container Port.

Currently 9 ships with the capacity from 108 to 186 TEU are deployed by 6 private operators. Additional 4 ships are supposed to be deployed in 2018.

b) Constraints in promoting coastal container shipping

There are some constraints in promoting coastal container shipping as follows;

- Considerable amount of investment is required to develop a river port and purchase ships.
- Total transportation cost per container is more than that of covered van and rail.
- Occasional cancellation of sailings especially in the monsoon season (approx.. 17-18% of cancellation in a year)

As the countermeasure of the above, enlargement of the ship size up to 250 TEU would be required to maintain the profitability, and the sea worthiness against Beaufort Scale 7 would be ensured. Since the coastal shipping is supposed to be developed by the private sector, the private operators need to be encouraged to build new ships conforming to those specifications.

c) Future perspectives of coastal container shipping

Due to the increasing traffic of covered vans, the capacity of existing roads will sooner or later be saturated. To mitigate the road congestion, a modal shift to mass transportation (ships and railways) is desired. The modal shift will bring other benefits; the unit transportation cost from factory to loading port could be reduced by use of mass transportation modes.

When the cargo volume increase and ships/railways are able to provide punctual and reliable services, shipping lines would extend their place of receipt from the legacy sea port toward an inland point (dry port or ICD) in order to gain competitiveness in their services. Shipping lines will receive export containers at dry ports near Dhaka and carry the containers in bond at their own cost and responsibility to Chittagong and Matarbari Ports. By that time, the customs procedures are expected to be relaxed to allow shipping lines to carry bonded cargoes of multiple shippers by a simple bonded-transportation procedure.

2) Non-container cargoes

Currently barges are carrying non-container cargoes which directly trans-loaded from bulk carriers or general cargo ships off-shore of Chittagong Port (so called "mid-stream operation"). Major commodities are steel products, steel scrap, clinker, wheat, sugar, gravels etc. Those are mostly carried to the dedicated berths of private companies. Volume of those non-container cargoes is also expected to increase in future.

2.2 Cargo Demand Forecast

2.2.1 Container Cargo Demand Forecast

(1) Cargo Throughput

Chittagong Port handles 98% of the country's container cargo while Mongla Port handles the remaining 2%. Since the year 2012, annual container throughput at Mongla Port has remained unchanged at 43,000 TEUs, while container throughput at Chittagong Port has increased steadily by 12.3% in 2014, 16.9% in 2015 and 16.0% in 2016; total container throughput in 2016 was recorded at 2,347,000 TEUs.

(2) Container flow simulation model

Future container cargo throughput is estimated by applying a simulation model "International Intermodal Container Shipping Model" developed by the National Institute for Land and Infrastructure Management, Japan, which consists of two sub models on shipping network and land transportation network behind ports. The simulation model estimates container cargo distribution on each shipping link and land

transportation link based on origin and destination of container cargo, cost and time of each link and transport resistance of each link. Container cargo volume originated from one country and destined to another country is estimated based on the economic growth of both countries. Container cargo growth rate of a developing country is higher than the rate of developed countries while both rates are closely related with each other. Volume of import container cargo is estimated based on GDP growth of Bangladesh and export container cargo is estimated by summing up container cargoes from Bangladesh to destined countries.

(3) Scenarios for the Container Cargo Forecast

Container cargo throughput of Bangladesh is forecast to substantially increase to 10.3 million TEUs in 2041. The simulation model estimates shares between ports of Chittagong, Matarbari and Payra based on three scenarios. In the Base Case scenario, Payra port would be developed with a channel depth of -10m, and inland waterway transportation cost from Matarbari would remain at the present level. In Case A scenario, Payra port would be developed with a channel depth of -14m and maintenance dredging cost would be recovered through a channel entrance fee. In Case B, the inland waterway cost in Bangladesh would be reduced by 40%. In Case C, bonded cross border transportation would be realized between Bangladesh and Bhutan and Northeast India.

(4) Container Cargo Forecast in 2026

In the Base Case scenario, container cargo volumes at the three ports in 2026 are estimated as follows: 600 thousand TEUs will be handled at Matarbari Port, 3.4 million TEUs will be handled at Chittagong 480 thousand TEUs will be handled at Payra. Container cargo demand for Matarbari Port is estimated at 690 thousand TEUs in the Case A scenario, 1.1 million TEUs in the case B scenario, and 630 thousand TEUs in the Case C scenario.

(5) Container Throughput in 2041

In the year 2041, the simulation model forecasts that container cargo demand for Chittagong Port would increase to 6.9 million TEUs, while it would reach 550 thousand TEUs at Payra Port and 2.6 million TEUs at Matarbari Port. As future capacity of Chittagong Port is assessed at about 5 million TEUs, the excess volume would be handled at Matarbari Port or Payra Port.

2.2.2 Bulk Cargo Demand Forecast

(1) Coal

Coal import has reached 1.4 million tons at Chittagong Port and 110 thousand tons at Mongla Port. Import of coal is estimated to increase to supply coal fired power plants planned in Bangladesh. Coal transshipment terminal planned at Matarbari area is expected to import 9 million tons of coal in 2026, 14 million tons in 2031 and 41 million tons in 2041.

(2) LNG

As indicated in the study entitled "Power System Master Plan (PSMP) 2016", import of LNG is estimated at 500 mmcfd (about 3.8 million tons) in 2026 and 4,200 mmcfd (about 32 million tons) except import by FSRU project.

(3) Crude Oil and Oil Products

Import of crude oil will be carried out by large tankers moored at SPM, which will be developed in the outer anchorage area of Matarbari Port. Export of oil products is planned by a refinery to be established in

the Matarbari area, amount of which would be 8.9 million tons in 2026 and 27 million tons in 2041.

(4) Cement Clinker

Import of cement clinker has reached 19 million tons at Chittagong Port and 1.6 million tons at Mongla Port in 2016; future volumes are forecast to increase to meet the demand for cement production. Amount of clinker import is estimated at about 65 million tons in 2041, half of which would be handled at Matarbari Port.

(5) Fertilizer, Food Grain

Fertilizer of 1.6 million tons has been imported at Chittagong Port and the same amount at Mongla Port in 2016. It is estimated that import of fertilizer would not significantly increase due to the fact that agricultural land is limited. Import of wheat and sugar is estimated at 4.9 million tons and 3.4 million tons respectively in 2026, and 6.2 million tons and 5.0 million tons in 2041.

(6) Steel Products and Scrap Iron, Import of Vehicles

Import of steel products and scrap iron is estimated at about 9.9 million tons in 2026 and 17.8 million tons in 2041. Import of completed vehicles by RO/RO ship is estimated at about 90,000 - 224,000 units in 2016 and 90,000 - 298,000 units in 2041.

2.3 Port Development Plan

2.3.1 Regional Development Plans and Other Related Projects

There are several proposals for development in Matarbari and Moheshkhali Islands. BEZA has 14 area development plans for establishing economic zones and tourist attractive places. CPGCBL has an expansion plan of their power plant facility in Moheshkhali.

In order to effectively develop these plans, inter-institutional coordination would be necessary and the Government of Bangladesh is now arranging for the establishment of a coordination committee called "Moheshkhali Coastal Development Committee (MCDC)", which is chaired by PMO.

Transportation infrastructure such as road and railway network in Matarbari and Moheshkhali Islands is currently in poor condition so that development of transport infrastructure in these islands is necessary for the success of such developments.

(1) Railway Development Project

Development Plan of the Dohazari-Cox's Bazar Railway Line, which will have dual gauge, is commenced in September 2017. In addition, the Ministry of Railways has conducted a study called "Dhaka-Chittagong-Cox's Bazar Rail Project Preparatory Facility" under ADB loan No. 3295-BAN (SF), which includes the component of expansion of the railway network from the Dohazari-Cox's Bazar Line into Matarbari and Moheshkhali Islands. Moheshkhali Island; this Matarbari Port Development Project requires coordination with the railway project.

(2) Matarbari Ultra Super Critical Coal Fired Plant

The objective of the project is to counter the rising demand for power while mitigating greenhouse gas emissions in Bangladesh by constructing the first ultra-supercritical coal-fired power plant (capable of producing 1,200 megawatts of power in total) in the Matarbari area of Moheshkhali Upazila, which is located in Cox's Bazar District in Chittagong Division, thereby contributing to nationwide economic development and climate change alleviation.

Japanese ODA loans have been disbursed for the first phase of the project (loan signed in June 2014 for

41.498 billion yen) and the second phase (loan signed in June 2016 for 37.821 billion yen). As of April 2018, the construction of a temporary dike, the dredging of the basin, land reclamation, and soil improvement works has been already being carried out.

(3) SPM Pipeline Project

Bangladesh Petroleum Corporation plans to install a SPM buoy to import crude oil in the offshore deep water area of Matarbari, and connect it to their tank in Maheshkhali area by underwater pipeline. Crude oil will also be pumped out through another underwater pipeline to the Chittagong area.

Taking into account that the depth of anchor dragging is about 2 m and over excavation of dredging work is about 1m in case of sandy seabed, necessary depth under the seabed may be about 3m (CDL-19.0m or under). In case of silty seabed, the depth of anchor dragging is about 5 m and over excavation of dredging work is about 1 m, so that necessary depth under seabed may be 6 m (CDL-22m). Necessary depth under the seabed should be carefully examined reviewing the result of the soil test at the crossing point.

The pipeline belt area on land should have enough width to ensure that the pipeline is not affected by land reclamation outside the boundary.

2.3.2 Requirement of Facilities

Container cargo at Matarbari Port is estimated at about 0.6 to 1.1 million TEUs in 2026 and 1.4 to 4.2 million TEUs in 2041. Coal for power generation will be imported at the Coal Transshipment Terminal (CTT) planned in the Matarbari area. LNG will be imported from the FSRU terminal and new onshore terminal to be developed in the Matarbari area. Crude oil will be imported through SPM to be developed in the near future, and the import of oil products will remain at the present level due to the increase in domestic production. Oil products will be exported by new refineries to be built in the Matarbari area. Demand for cement clinker is large, so it will be transshipped from mother vessels to barges in anchorage. Demand for food grain will also increase, so that wheat and some grain from remote counties will be imported by large bulkers if a deep sea port becomes available. Import of iron products, scrap metals will also increase beyond the capacity of Chittagong port.

2.3.3 Prediction of Vessel Type and Size

(1) Container ships

1) Methodology of calculation

Located remote from the east-west trunk line, Bangladeshi ports are mostly served by feeder lines connecting with a nearby hub port. However, once the cargo volume grows to a certain level, some feeder lines could be replaced by mainlines. Possibility of mainline ship callings will increase in connection with the growth of import/export cargo volume, once a sufficient depth is secured. Assumption of maximum ship sizes for Matarbari Port was investigated in the previous study by the calculation of "marginal laden TEUs" required for an extra calling by extended steaming from Singapore and Colombo. The result of the previous study could be applied to this Survey also, as hereinafter stated.

2) Prediction in the previous study

Minimum laden TEUs required to compensate the extra costs are given by dividing the total amount of extra costs (ship deviation costs and port charges) with the net profit rate (USD 150/TEU irrespective of trade lane) as per Table below.

Marginal Laden TEUs Required for an Extra Calling by Size

TEU Capacity →	2,500	3,800	5,400	8,200	10,000
Extra call (Singapore/Chittagong/Singapore)	2,022	2,756	3,528	5,135	6,344
Extra call (Colombo/Chittagong/Colombo)	1,771	2,410	3,092	4,513	5,580

Source: JICA Survey Team

On assumption that the marginal laden TEU is proportional to the yearly laden throughput, a simulation on the relation between yearly throughput and calling ship size could be roughly calculated as per Table below. The figures imply that, if the laden throughput reaches 5.7 to 6.5 million TEUs in total of Chittagong Port and Matarbari Port, there will be a possibility that a large container ship of 8,200 TEU type could call at either Chittagong or Matabari Port. Furthermore, 10,000 TEU type may call when the laden throughput reaches 7 to 8 million TEUs.

Laden Throughputs Assumed to Receive an Extra Calling by Size

('000 TEUs)

TEU Capacity →	1,610	2,500	3,800	5,400	8,200	10,000
Intra-Asia or North America Trades	1,745	2,568	3,501	4,480	6,521	8,057
Europe Trade	1,745	2,249	3,061	3,927	5,732	7,086

Source: JICA Survey Team

(2) Non-container ships

Dry and liquid bulk cargoes are usually transported directly from the origin ports to the destination ports without transshipment in between. It should be noted that every bulk commodity has a particular ship type suitable for ocean transportation; for example, a large cape size is suitable for iron ore, a small cape size is suitable for coal, Panamax is suitable for grain, handy size is suitable for cement etc. The ship type for each bulk commodity has been determined by the world trade and shipping industry in consideration of the lot size of the commodity, loading/unloading facilities at origin/destination ports and other long business practices. Therefore, in proportion to the growth of trade volume, the ship size required for that commodity could be enlarged within the range of each particular ship type, but it would not go beyond it.

Among the vehicle carriers currently moving in the world, Panamax is the most common size. However, it would be necessary to assume for the vehicle trades that short-distance transport will increase in future due to the localization of car manufacturing bases. In this sense, ship size enlargement will not necessarily happen for the vehicle carriers.

2.3.4 Alternatives

Taking into account industrial development plans in Matarbari and Moheshkhali area and geographical features, two locations are recognized as possible port development sites. One is the estuary of the Kohelia River, and the other is area adjacent to the coal port of CPGCBL power plant in Matarbari.

Plan A is designed to build a commercial port in the estuary of Kohelia River and utilize the waterfront for dedicated berths of backyard industries. Plan B is designed to develop a commercial port that is separated from the flow of the Kohelia River. Plans C and E are designed to expand the coal port of CPGCBL to be developed in the near future. In Plan C, port waters to connect BPDB power plant with the coal port of CPGCBL will be developed. In Plan D, a commercial port will be constructed with minimum investment and a short construction period.

Comparison among the four alternative plans revealed that Plan E will be advantageous in the first stage

of port development while Plan A can play a key role in industrial development of Matarbari and Moheshkhali area.

2.3.5 Port Development Plan

(4) Phase 1 of the First Stage Development

Phase 1 of the first stage development consists of the development of one multi-purpose berth with a length of 300m and back area of 12ha, and one container berth with a length of 460m and back area of 20ha. Approach channel is designed to have a width of 350m and a depth of CDL-16.0m. Phase 1 is expected to be completed by the middle of year 2023.

(5) Phase 2 of the First Stage Development

Phase 2 of the first stage development will expand the turning basin to the south and add three full size container berths, which will have a length of 1,050m and back area of 50ha. Future expansion area will be used for truck parking, warehouses, logistic park, ancillary services, and further expansion of container berths if necessary.

The expansion of turning basin to the south enables the development of CTT terminal and LNG terminal, which will accommodate 80,000 DWT coal bulkers and 145,000 (260,000) m3 type LNG carriers. For the navigation and berthing of LNG carriers, safe maneuvering is an important issue which requires deployment of patrol boats, tug boats as well as studies on wave conditions, tidal current, and safety regulations.

(6) Second Stage and Industrial Port Development

The second stage of port development is recommended at the mouth of Kohelia River. In addition to the phase 1 and 2 of the first stage, three full size container berths are proposed on the west side of commercial port with a length of 1,050m and area of 53ha. On the east side of commercial port, multi-purpose berths and bulk berths are proposed with a length of 1,200m and area of 60ha. Depth of the entrance channel and basin is -16m, which is the same as the first stage. Commercial port area has more space for future expansion, so that four additional full size container berths and four multi-purpose/bulk berths can be developed next to the proposed development.

Based on the previous study "Data Collection Survey on Integrated Development for Southern Chittagong Region", industrial port is proposed next to the commercial port. Since the master plan of industrial area development has not yet been established, the proposed plan is tentative and will require further study from viewpoints of commodities and volume of maritime cargo, vessel type and size of call, cost allocation between industrial port and commercial port, and so forth.

(7) SK GAS‐LPG Project

SK Gas has a plan to develop a gas loading pier with a depth of -16m. Their target vessel size is 43,000 DWT and LOA is 230m. The gas discharging piers for two 3,000 DWT vessels will be developed in the sea area of -12m. Their engineering, procurement and construction (EPC) will start in August 2018 and be completed in 2020.

BEZA stressed that SK gas project should not interfere with the ongoing Matarbari port projects. Both sides agreed to continue discussion on the possibility.

(8) KISC（Kunming Iron and Steel Holding Company）

KISC is planning to construct an iron mill in Matarbari area, and develop an ore carrier berth for 200,000DWT. Larger berth than the multipurpose berth planned by JICA will be necessary.

In the long term plan of Matarbari Port development, the 3rd phase development will be done in the mouth of Koheria River, and in addition to the commercial port facilities, industrial port facilities are planned. This kind of large scale project can be developed in land along Koheria River, which is acquired by BEZA.

2.4 Port Facility Plan

2.4.1 Mooring Facility

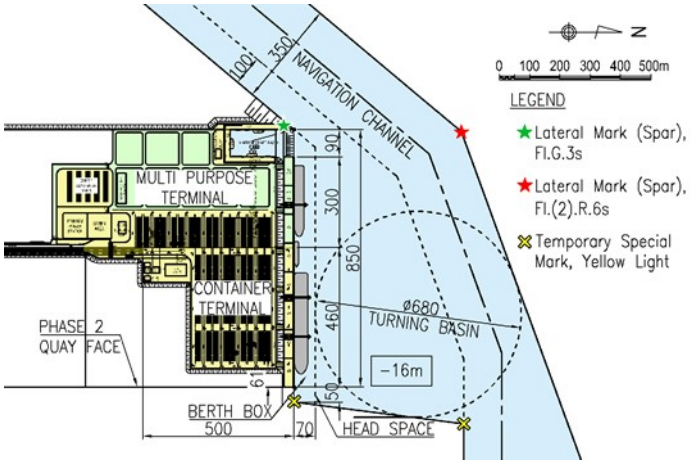
(1) Outline of the Study

A characteristic of Matarbari Port's natural condition is a large daily astronomical high tide (HWL, CDL + 4.88 m) and a surge by cyclone 4.5 m by 50 years return period. When high tide and surge overlap, the sea level rises to CDL + 9.4 m (CDL: Chart Datum Level). In addition, the objective ship considered a large ship size difference of 8,200 TEU type (100,000 DWT) as a maximum vessel type of container ship and bulk ship to 250 TEU type (2,500 DWT). To cope with this, the top height of mooring facilities was CDL + 9.0 m. Also, the horizontal seismic coefficient increases to kt = 0.25 based on the seismic zone coefficient of the Chittagong District where Matarbari Port is located. As a result of evaluation based on these natural conditions and ship size conditions, the main external force for determining mooring facility structure is the horizontal seismic force (about 27,000 kN per pier upper deck block unit), which is much bigger than the ship berthing force (reaction force of rubber fender) of about 1,600 kN, and the mooring force (1,000 kN).

According to the results of the soil survey through rotary boring conducted by the Study team, the foundation soil of the proposed site for the mooring facility is from a soft layer with an N value of 10 or less on some surface layers, to a silty sand layer with an N value of about 20 to 40 in the middle layer. There is a lower layer (bearing layer) at a depth of about -30 m to -35 m.

(2) Layout Plan of Mooring Facilities and Selection of Quay Structural Type

As for the facility arrangement, as shown in the figure below, the navigation channel width was 350 m with the margin of the maximum ship length (338 m). The diameter of the turning circle was double that of the ship's length of 680 m. A ship will enter the port with assistance of a tugboat, and will be basically head-in berthing/mooring along the starboard side. Berth box width of 70 m and head space of 50 m were considered as the margin of water area. The total length of the quay is 760 m, that is, 460 m for the Container berth and 300 m for the Multipurpose berth (bulk ship). The planned water depth was set at CDL-16 m with a margin of 10% for the draft.



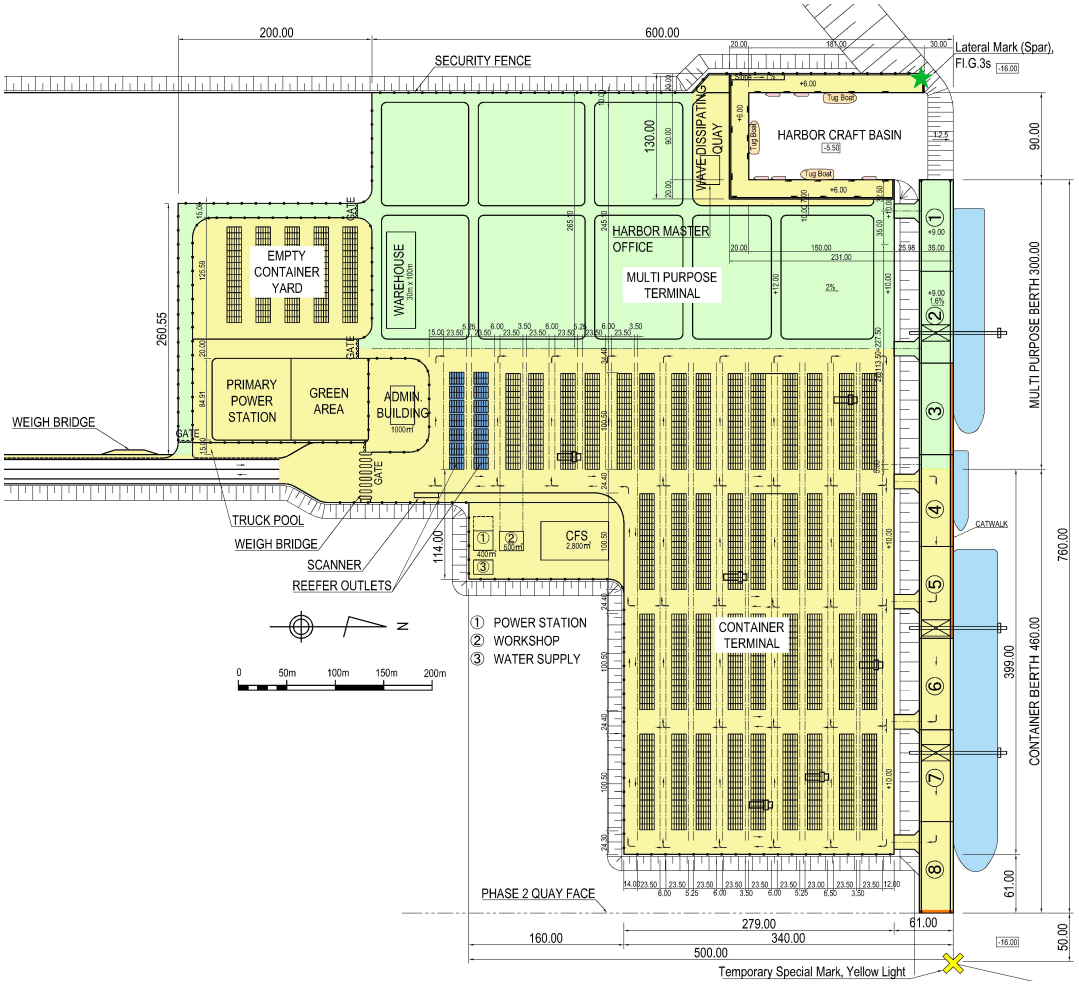
General Layout Plan of Mooring Facilities and Water Area

As a result of comparing the four structural types (i. e., steel pipe sheet pile wall, caisson, batter piles pier, and vertical piles with struts pier) for the mooring facilities, and considering the construction cost, construction period, and seismic resistance, it was concluded that the strut type is the optimal alternative.
Also, the pier arrangement was a detached pier, with the pier and the back yard to be connected by access bridges.

(3) Harbor Craft Basin/Inner Breakwater
Harbor Craft Basin is provided in the vicinity of the port entrance for the harbor service boats, such as tugboats. The basin entrance is 90 m wide, water depth of CDL-5.5 m, and the quay top elevation is +6.0 m.

2.4.2 Yard and other Facilities

The number of container ground slots by RTG (rubber tired gantry - crane) (6 + 1) was 3,936 slots, and that for the reefer container was 168 slots. Estimated annual terminal capacity, including reefer container, was approximated at 703,000 TEU / year. Terminal gate is for 6 lanes + 1 lane for the truck scale. Empty container yard and power receiving area were set up within 4 ha. ·A customs inspection area is proposed near the roundabout at the south end of the port site.
Multi-purpose Yard (11.8 ha): The objective cargo volumes are 600,000 tons/year of grain and 1,200 tons/year of steel products. Facilities for handling, storage, and milling of grains were assumed to be constructed and operated by the private sector.



Matarbari Port General Layout Plan

2.4.3 Cargo Handling Equipment

As Bangladesh is prone to many earthquakes, Chittagong Port, which was developed on soft ground, could potentially suffer serious damage in the event of a large earthquake followed by a tsunami. In such a scenario, economic activities of Bangladesh could be temporarily paralyzed.

For this reason, it is necessary to thoroughly examine the seismic resistance of the deep-water port in Matarbari which is also expected to provide a backup function in the event of a disaster.

At the container terminal (CCT) of Chittagong Port, quayside container cranes with a seismic isolation device have already been installed; it has also been decided to use seismic isolation devices for the quayside container cranes which will be introduced to NCT.

The quayside gantry cranes installed at the quays of the container terminal and multipurpose terminal should be equipped with a seismic isolation device for the following reasons.

- Since Matarbari Port will be the only deep-water port in Bangladesh, the maximum value of 1.5 of the importance coefficient is used in the design seismic intensity.
- Ordinary cranes are designed with Kh = 0.2 according to JIS standards, but the design seismic intensity is assumed to be larger in this case.
- Although it is possible to respond by raising the design seismic intensity, the seismic isolation device is more reliable.
- Gantry cranes with a seismic isolation device have already been introduced at Chittagong Port.
- There is a high probability of a large earthquake.

In addition, as a countermeasure against storm surges, the main electrical equipment such as motors, brakes, etc. among the devices installed at the bottom of a crane will be waterproof equivalent to IP65.

For cargo handling equipment such as RTG and Reach Stacker installed in the storage yard, since the installation position is about 2 m higher than the level of the quay, IP65 waterproof specification is not applied.

The required functions of cargo handling equipment are shown in the following table.

Required functions of cargo handling equipment

Cargo handling equipment	Required function	Necessary device and equipment	Remarks
Quayside container crane (QC) Multi-purpose Gantry Crane (MPGC)	Ability to maintain and perform functions even in the event of an earthquake	Seismic isolation device	After the occurrence of an earthquake, large damage such as collapse of the crane, derailing, plastic deformation of the structure can be avoided and original functions can be maintained.
	Ability to minimize damage due to sea water at high tide	Main electrical equipment such as motors, brakes, etc. among the devices installed at the bottom of a crane will be waterproof equivalent to IP65.	Even when suffering damage from the storm surge, it is possible to use the crane immediately
Rubber Tyred Gantry crane (RTG)	Must be able to withstand wind during cyclones to prevent overturning and drifting from anchor position	Crane anchoring device	Damage due to cranes colliding with one another or turning over due to strong winds can be avoided.

Source: JICA Survey Team

2.4.4 Channel, Basin and other Marine Facilities

Construction of northside Training Dike up to water depth of MSL-14m (CDL-11.32m) were planned to implement as a countermeasure works by MUSCCPP. Considering of securing safe stopping distance for the ship to enter the new port, additional about 400m extension of the above northside Training Dike is recommended. Because necessity of extension of this dike is necessary for the new port operation, construction of these extension part of dike by new port project are considered appropriate. Expansion of the channel by 100m and deepening are necessary and channel expansion to the southside is planned considering the layout plan of adjacent structure respect to the 100m expansion of the channel.

Northside Training Dike and southside Sand Protection Dike will work as not only countermeasure works against channel and basin sedimentation but also the breakwater to maintain the calmness of the basin area. For the function of the countermeasure works against channel and basin sedimentation, necessary crown height are determined by considering the minimum requirement of the crown height of impermeable core structure of HWL (CDL+4.88m), resultant crown height of dike structure of CDL+8.68m to CDL+8.98m depending on the necessary size of the wave dissipating concrete blocks. Basin calmness analysis by nonlinear wave transformation method by Boussinesq model were done and confirmed that the necessary working rate of port unloading and loading operation are assured by the above mentioned conditions of the crown height of countermeasure structures. As at the time of extreme storm surge conditions, overtopping wave from northside Training Dike and southside Sand Protection Dike are not neglible for the basin and channel calmness, wave deformation analysis by same nonlinear

wave transformation model by Boussinesq model were used and confirmed that the necessary calmness of basin and channel area and the safety of the berth structure during the storm surge are obtained.
As the shape of the channel and basin area are long and narrow rectangular shape, harbor osclillation sometimes becomes the serious problems for the moored vessels and cargo handling operation. To see the harbor resonance phenomenon, numerical simulation of wave deformation analysis by Boussinesq equation for the anticipated wave conditions, wave period 30 to 300 seconds with time interval of 30 seconds, are done and obtained the amplification factor of the berth area.

2.4.5 Navigational Safety Aids

Vessel Traffic Management System (VTMS) should be installed into Matarbari Port. A control station which has a server, monitors, and communication equipment will be situated in the administrative building, and a tower which has radar, AIS receiver, VHF and cameras is constructed on the roof of the administration building or next to the building.
Lighted buoys are necessary along the channels to the point of approximately 10 km beyond the area where channel dredging is necessary. Instead of the lighthouses at the tip of the breakwaters, the installation of pillar-type buoys are proposed due to the structure of breakwaters. The coordination with the power plant project is necessary.
The deployment of service vessels is necessary at Matarbari Port. Three tugboats, one pilot boat, and one survey boat should be installed by the commencement of the port. Additionally, security boats, water supply boats, buoy lifting boats, ambulance boats etc. should be examined carefully.

2.4.6 Security Facilities

The implementation of security facilities should be complied with the ISPS code. Regarding to the perimeter of the terminal, it is recommended to construct concrete walls similar to Chittagong Port, in order to secure the property. CCTV system and gate control system should be installed into Matarbari Port. Additionally, a necessity of firefighting vehicles and security vehicles is pointed out. Other than those, several items are proposed to strengthen security without disturbing efficiency and user-friendliness of the port.

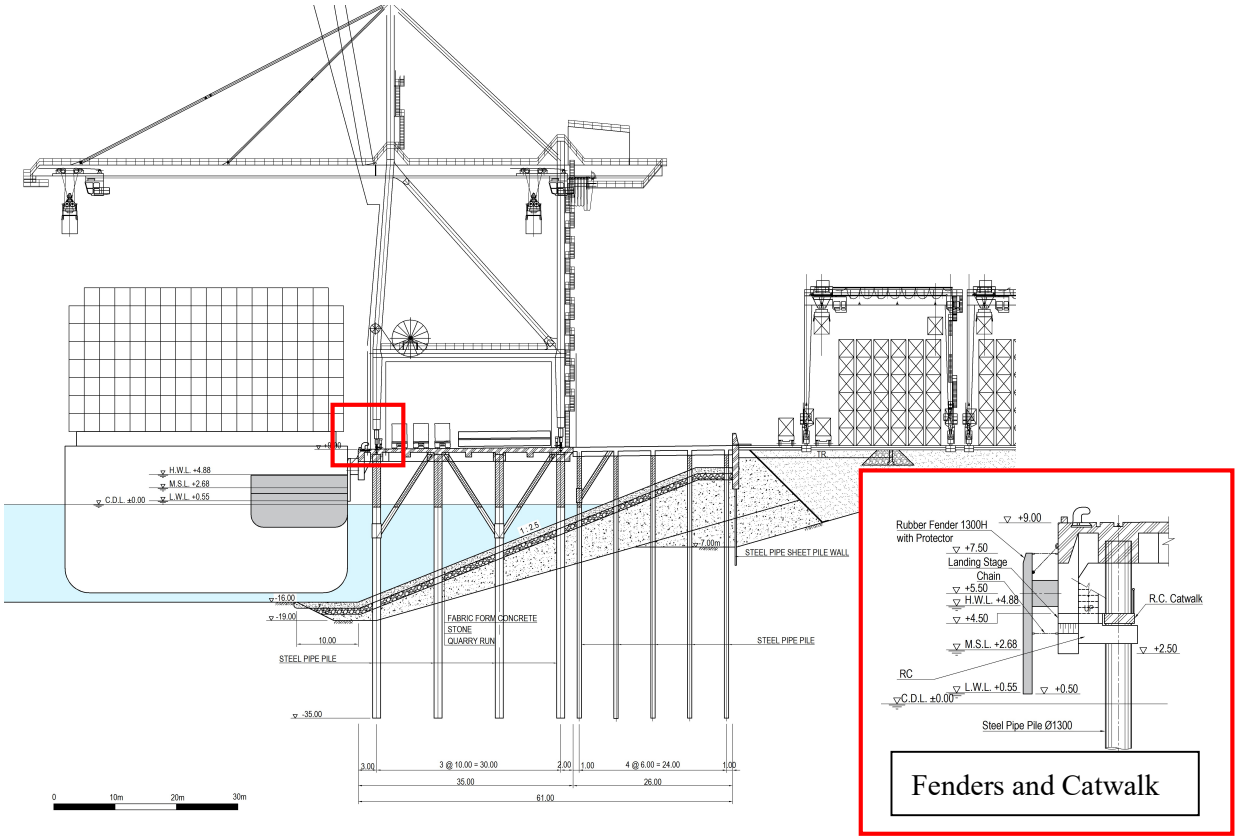
2.5 Preliminary Design, Specification and Quantity

2.5.1 Mooring Facility

- By setting the quay design as a strut-type detached pier arrangement, the seismic force caused by the dead weight of the quay superstructure will be reduced and counter the seismic force with the strut structure.
- Pier piles are spaced at intervals of 10 m and 7.5 m in cross-sectional and longitudinal ways. The struts are placed in both ways to counter the seismic forces. And the members have a pile diameter of 1,300 mm and a strut diameter of 700 mm. As corrosion prevention measures for steel materials, use of cathodic protection, anti-corrosive paint, among others are recommended.
- To deal with large ship size difference and tide level difference, a fender with vertically oblong frontal protector is provided. Small mooring bollards for small boats, and a catwalk for mooring line work were also provided at middle level (CDL + 4.5m.
- The quay deck top height was suppressed to CDL + 9.0 m, while the rear revetment height was set at +10.0 m. In addition, the parapet wall for preventing overtopping wave was set at +12.0 m. Back yards have a slope from CDL + 10.0 m to +12.0 m, to prevent submergence from high tides of storm surge. As a

result, rainwater in the yard can be drained to the sea through natural gravity flow.

- The slope underneath the quay structure is protected by replaced quarry materials and strengthen the lateral resisting force of the vetical piles. As for the area with soft subsoil, the thickness of quarry layer is increased.



Typical Cross Section of Quay and Fenders and Catwalk

2.5.2 Yard and other Facilities, including Soil Improvement and Drainage

(1) Geotechnical issues to be investigated

The consolidation settlement of port yard area is estimated to be several cm to 15 cm. The presumed thickness of liquefaction is about 6 m at the west end of the terminal yard, and about 1 m to 4 m in other areas.

(2) Yard pavement: Concrete interlocking block pavement for yard; PC slabs for RTG traveling lanes. RC sleepers are provided for container slots.

(3) Storm drainage system: Rainfall intensity 159 mm/hour for 10 years return period was considered. The rain water will be discharged to the sea through U-ditches and pipes by gravity flow.

(4) Water supply / fire-fighting system: Two deep wells in the vicinity are assumed as water source. An underground water reservoir with a capacity of 600 m^3 for one day consumption, including water supply for ships, and distribution facilities with pressure control tanks will be set up. For firefighting, water supply volume up to 200 m^3/40 min was assumed to be supplied by the above-cited reservoir and distributed to fire hydrants.

(5) Sewage treatment: A treatment facility with a capacity of about 80 m^3/day was assumed for wastewater generated from buildings, workshop, etc.

(6) Power supply / lighting: Total power demand was estimated at 4.4 MW. The maximum demand is for quay cranes and reefer container outlets, accounting for over 80% of the total demand. Power of 11 kV will be provided by REB (Rural Electrification Board), supplying 6 kV to the cranes and to other 400 V demand at the substations. Three emergency DEG generators are installed. Yard lighting provides high mast lighting and street lighting.
(7) Buildings: Administration building, CFS, Warehouse, Terminal gates, Workshop, Harbor Master office, etc.
The major terminal facility items and quantities are summarized in the table below.

Major Port Terminal Facilities and Relevant Quantities

Facilities	Particulars
Container/Multi-purpose quay	L=460m; 300 m=760 m, Water depth CDL-16 m
Quay ancillary items	Rubber Fender: 52 sets, Catwalk 321 m, Bollards
Access bridges	L=26 m, B=15 m, 6 units
Harbor craft basin/Quay/Inner breakwater	Steel Pipe Pile Sheet Pile Wall, Wave Dissipating Quay:
Revetment	389 m (west) + 699 m (Quay) + 279 m (east)
Terminal area	Container: 20.2 ha, Multi-P: 11.8 ha, Empty Container: 4 ha
Administration building	1,000 $m^{2,}$ 4 stories, RC, Pilotis type
Harbor Master's Office	600 m^2, RC
CFS and Warehouse	2,800 m^2 and 3,000 m^2 , Steel Frame
Workshop	400 $m^{2,}$ RC
Power house, Yard/Street Lighting	400$m^{2,}$ Power Centre (11 kV) , Emergency DEG 3 sets
Water supply system, Fire fighting system	Deep well x 2, Reservoir 600 m^3 Distribution system,
Container terminal gate	6 lanes+ 1 lane for Weighbridges (for Im./Exporting activities)
Storm drainage system, Sewerage system	
Security system	CCTV, Fence, Guard houses, Scanner: 1 set

2.5.3 Cargo Handling Equipment

Cargo handling equipment and related equipment planned to be introduced in Phase 1 are shown in the following table.

Cargo handling equipment and other related equipment

Terminal	Cargo handling equipment & Related equipment	Quantity	Main specifications	Remarks
Container Terminal	Quayside Container Crane (QC)	2	40LT, 30m Span 51.5m Outreach With 20-40 FT Telescopic Spreader	Equipped with a seismic isolator Major electric products such as motors of traveling equipment are waterproof IP65 equivalent. Equipped with Snag load protection device
	Rubber Tyred Gantry Crane (RTG)	6	40LT, Correspond to (6+1) rows 1 over 5 Hybrid type	Equipped with crane anchoring device With transfer crane automatic steering system
	Reach stacker (RS)	2	40LT, 6 stacks	
	Yard Chassis (YS) (with Tractor head)	12	Tractor head, 40FT chassis (20FT x 2 containers loading)	
	Spare Spreader for QC	2	20-40 FT Telescopic Spreader	
	Spare Spreader for RTG	2	20-40 FT Telescopic Spreader	
	Spreader Testing Panel for QC and RTG	1	Testing panel to maintain and inspect the spreaders of QC and RTG	Mount frame for maintenance of spreader is outside the scope of the budget.
Multi-purpose Terminal	Multi-purpose Gantry Crane (MGC)	1	30m Span 51.5m Outreach 40LT for Container handling 30Ton for Cargo handling by Lifting beam with 3hooks Correspond to container handling.	Equipped with a seismic isolator Major electric products such as motors of traveling equipment are waterproof IP65 equivalent. Equipped with 30T Lifting beam Container handling is possible by changing from Lifting beam with hooks to a spreader.
	Spreader for MGC	1	20-40 FT Telescopic Spreader	(Same specifications as Spreader for QC)

(Remarks: Cargo handling equipment and related equipment not listed in the above table should be prepared by the counterpart.)

2.5.4 Channel, Basin and other Marine Facilities

Considering the design ship for new port, necessary dimension of channel and basin are determined by referring the design standard of Japan. Construction of northside Training Dike up to water depth of MSL-14m (CDL-11.32m) were decided as a countermeasure works by MUSCCPP. Detail design of these structures are done by following the design considerations and procedures of MUSCCPP D/D study, Rubble Mound Sloping Dike structure were selected as the structural type of countermeasure structures

rather than the originally proposed structural type of Steel Pike Pile Wall structure. Soil improvement works by sand replacement were proposed at the locations to prevent the sub-surface sliding failure due to the existence of very soft silty layer at the shallow location. Typical cross sections and quantities of volume of these structures are also shown.

2.5.5 Navigational Safety Aids

VTMS consists of X-band radar, five cameras (including two night view thermal cameras with high resolution), AIS receiver, VHF radio telephone station, and a control station.

As the lighted buoys, the pillar-type buoys are installed; and the buoy body is made of steel while the leading lights are made of aluminum. The lighted buoys and leading lights have solar battery system. It is recommended that the interval of the flushing of lighted buoys and leading lights is the similar to that of Chittagong Port for convenience of vessels.

Three tugboats with 4,400 Horse Power and Azimuth Thrusters are proposed. The speed of pilot boat should be faster than that in Chittagong Port in order to transport pilots to/from the channel entrance as fast as possible. The survey boat should be equipped with necessary items such as multi-beam sonar as well as search lights since the survey boat should be used as a patrol boat in some occasions.

2.5.6 Security Facilities

As the components of CCTV system, necessary numbers of PTV cameras with night view are installed in order to secure the terminal while the alarm system must be installed in the control room, which let security officials know the intrusion of people from the perimeter of terminal or suspicions behaviors. The installation of cable protection ducts made of ceramic are recommended for the protection of optical cables and AC cables.

The gate control system is equipped with the function which can manage the entry and exit of all vehicles and pedestrians with examining their identities and belongings. The pre-registration of vehicles and pedestrians is desirable.

2.6 Construction Plan

2.6.1 Mooring Facility

(1) Soil Improvement of the Terminal (under quay area)

In conditions of the earthquake, liquefaction for the sub-soil will be occurred and had a bad influence to the quay structure and slope stabilities under the quay. Therefore, the existing soil material formed the slope under the quay are replaced to the crushed rocks with brick stones to be stable the slope and quay structure.

Crushed stone/ brick stone and sand Replacement : 320,000 m3

Productivity: 320,000m3/1000 m3/day =320 days :320/25day =13 months

(2) Berth Construction (Multipurpose and Container)

Berth structure of the container and multipurpose berths with 6 parts of access bridges were planned as concrete deck on the steel pipe piles with steel strut beam. Retaining wall made by Steel pipe sheet pile is also installed by piling machine on land at the same time with piling work of quay structure.

Productivity of Pile Driving Work: (416 nos + 90 nos/ 2 nos) /25 days =18 months

The pile caps and beams for the half of deck concrete are planned to be constructed using the pre-cast concrete method and the slab concrete works by casting in-situ at site could produce 30m3 per day on average. The construction period for the Concrete deck works are calculated as follows:

Concrete Deck Slab Work: 16,000 m3(1/2 slab) /30 m3 / 25 days = 22 months

Pre-cast Concrete Elements : 21,500m3/40m3/25days = 22 months

(3) Harbor Craft Basin

Harbor Craft basin is divided into three quay structures, such as double SPSP wall quay for Inner breakwater part having 181m in length, SPSP wall quay having 150m in length and Wave dissipating Concrete Block wall having 90m in length. After soil Improvement works, the double SPSP wall quay for Inner breakwater part would be started and followed the SPSP wall quay and Wave dissipating Concrete Block wall construction.

Productivity of the double SPSP wall quay for Inner breakwater part:

1m/day = 181m/1/25day+ 1months for accessories =8 months

Productivity of the SPSP wall quay :2m/day+ coping = 150m/2m/25day + 2 months = 5 months

Productivity of Wave dissipating Concrete Block wall : 90m/1m/25 +1month = 5 months

2.6.2 Yard and other Facilities

(1) Temporary Works

As the temporary works for the construction of the terminal yard, the berthing facilities, terminal facilities and terminal utilities, temporary facilities and mobilization of construction equipment would be required on the basis of the Matarbari site conditions and the port development plan for the Package 1 construction.

(2) Terminal Reclamation

The Suitable materials having about 2,900,000 m3 in volume for the terminal reclamation reclaimed by the Matarbari Coal Fired Power Plant (CFPP) project at the temporary stockpile yard is planned to transport to the terminal area by dump trucks. Moreover, the sand dike around the terminal reclaimed area is also planned to construct approximately 2,600 m by this project.

Material transporting volume by dump-trucks : 2,900,000 m3

Productivity: 2,900,000m3/10 m3/10 trip /50 trucks =580 days : 580/25day =23 months

Sand Dike (including Geo-textile-tube) : 2600 m

Productivity: 2,600m/ 10m/day =260 days : 260/25day =10 months

(3) Terminal Buildings and Utilities

For terminal buildings and utilities both of Container and Multipurpose terminal, those construction period will be taken about 6 months for small gate, 8 months for CFS, Warehouse and Main gate, 10 months for Sub-station, 12 months for Administration building and 16 months for Drainage, water supply and Power supply works.

(4) Yard and Road Pavement

Yard and road pavement in the terminal is divided into following three parts such as General Pavement for Yard and Road for Container Terminal, Road for Multipurpose Terminal, RTG and Container Staking Base and Open Storage Yard for Multi-purpose Terminal

The pavement works are started after completion of the reclamation works of Multi-purpose terminal.

Productivity of the ICB pavement works for General Pavement: (100 m2/ day / team x 5 team) : 211,800m2/500m2/23day = 19 months

Productivity of RTG and Container Staking Base: 5,200m2/150m2/25day =15 months

Productivity of Open Storage Yard for Multi-purpose Terminal : (500m2/day) : 93,200/500/25= 8 months

2.6.3 Channel, Basin and other Marine Facilities

Channel and Basin of the Terminal is located at extension area of those of MUSCCPP. Preliminary calculated volume of dredging/disposal is approximately 14 million m3, in which 8.5 million m3 will be dredged from extended channel/basin and 2.4 million will be dredged from deepening channel area. Expected actual dredged volume is 14 million m3 including excess dredging and sedimentation as calculated below.

Considering the target date of the Terminal opening, procurement of the reclamation material and dredging in front of the berth structure will be the critical activities to accomplish the project schedule. Therefore, earlier commencement of Dredging work is desired. One of the options for the earlier commencement of Dredging work is shifting scope of Dredging work to MUSCCPP. This option plan has advantage and risk, but in view of the Project schedule, this option plan has more advantages than original plan and is recommended. CPA, MUSCCPP and other related authorities of GoB shall discuss and determine the application of the option.

Considering efficiency and schedule of the work, dredging of the extension area as D2, D3 and D6 shall be executed by Cutter Suction Dredger (CSD) and deepening of existing channel as D4 and D5 shall be executed by Trailer Suction Hopper Dredger (TSHD). When TSHD is used, dredged material will be stored in TSHD. After that, sandy material will be pumped up into pipeline same as CSD or discharged into the off-shore dumping area directly. As huge volume of reclamation material is required for the Terminal construction and Road construction works, dredged material will be separated into suitable sandy material for reclamation and unsuitable silty material to be disposed into disposal area. Sandy material suitable for reclamation will be pumped up to stockpile area from dredger directly.

Disposal method of silty dredged material has two alternatives such as on-shore disposal method and off-shore dumping method. Off-shore dumping method has financial and schedule merit. Therefore, off-shore disposal area will be applied as a first priority. However, considering the environmental impact on the surrounding sea, this method will be applied for a half of disposed material and another half of dredged material will be disposed into the on-shore disposal area.

Potential locations for off-shore dumping with deeper than 30m are located approx.60km far from the site to South-West. The environmental simulation has been carried out and it has been found that increasing of turbidity will not serious considering the baseline turbidity of sea around this area. However, transport and dispose dredged material to dumping area far from 60km has cost/schedule risk especially during the monsoon season.

On the other hand, on-shore disposal area may be located on south side of the Terminal area. Required area of the disposal area is approximately 100ha and its height shall be higher than 5m. Necessary facility for the disposal area is disposal pond, discharge channel and environmental protection sheet.

Reclamation material will be transported by dump truck to the reclamation area and leveled/compacted by bulldozer.

Breakwater construction work is composed of Soil improvement, Installation and levelling/forming rock material and Fabrication and installation of Armor Block. Soft soil of existing ground in the location of breakwater will be excavated and replaced by sand material to avoid ground sliding. Excavating method

may be same as dredging and replacement sand will be installed by sand barge.
Rock material will be transported from stockpile area to construction site by material barge and installed/leveled/formed by backhoe barge. When backhoe barge is difficult to apply due to water depth, clamshell bucket attached on the crane barge may be applied. As rock material will be imported from overseas, stockpile of rock is necessary to avoid schedule impact. Armor concrete block will be fabricated in the fabrication yard at site or imported from overseas and installed by crane barge into the designated position.

2.6.4 Cargo Handling Equipment

Work Schedule of Cargo Handling Equipment is estimated as the following.

Work Schedule of Cargo Handling Equipment

2.6.5 Navigational Aids and Others

In general, installation of navigational aids and others is divided into five periods; namely, detail design, preparation, transportation, installation and training.
VTMS, lighted buoys, leading lights and service boats should have been installed before the commencement of the operation of the neighboring power plant. Detailed coordination should be done by both parties in an early stage of the detailed design.
On the other hand, security equipment is not related to the power plant while the installation of security facilities would be divided into two packages; namely one for multi-purpose terminal which starts operation first, and the other for container terminal which starts operation after.

2.7 Preliminary Cost and Schedule

2.7.1 Procurement of Materials and Construction Equipment

1) Availability of materials

Basically, selected dredged sand will be used for Reclamation work. Dredged sand of this area is too fine to be used for Sand Mat of PVD method but suitable for reclamation.
Assumed available volume of dredged sand is approximately 7.0million cubic meters which is more than required filling volume for the terminal.

Aggregate

Coarse aggregate and fine aggregate can be obtained in the Northern part of Bangladesh. However, its capacity of production seems small and condition of its transportation seems not suitable. Therefore, it had better import these materials from oversea such as Indonesia, Malaysia, or other country.

Availability of Rock

Rock material can be obtained in the Northern part of Bangladesh, too. However, produced size of rock is comparatively small which is not suitable for applying to Breakwater construction work. Therefore, rock materials should be imported from oversea such as Indonesia, Malaysia, or other country.

Availability of Steel Sheet Pile (SSP) and Steel Pipe Pile (SPP)

Structural steel materials such as SSP and SPP is not produced in Bangladesh. These materials should be imported from Thailand, Vietnam, Indonesia, Malaysia, Korea or Japan in which quality of steel material is well controlled.

2) Availability of construction equipment

Foundation piles can be installed by crane barge with piling hammer or piling barge. However, considering big and long SPP with severe allowable tolerance of their position due to applying the strut type, piling barge is recommended to be used. Piling barge should be imported from oversea.

Crane Barge is one of the most useful equipment for marine construction works. Generally, lifting capacity of crane barge is from 50 ton to 300 ton. This equipment should be imported from oversea as there is no crane barge with heavy duty crane in Bangladesh.

Most of materials for marine construction work will be transported by material barge. Local source of material barge is available but when big capacity of barge is required, it should be imported from oversea.

Excavator can be supplied by local sources in Bangladesh. However, heavy duty excavator such as bigger than 3.0m3 or amphibian excavator (picture-right) is not available and should be imported from oversea.

Dump truck with its capacity of 10ton can be supplied by local sources in Bangladesh. However, heavy duty dump truck such as bigger than 40ton (picture-right) is not available and should be imported from oversea.

PVD should be installed by PVD machine. To keep verticality of PVD, PVD machine with adjustable boom is suitable. PVD machine should be imported from oversea.

There is no dredger of which capacity is enough for this project in Bangladesh. Therefore, TSHD (picture-left) and CSD (picture-right) should be imported from oversea.

Crawler crane (picture-left) and mobile crane (picture-right) should be imported from oversea as there is no crane with appropriate capacity for this project in Bangladesh.

Cranes of local source can be used for temporary works.

2.7.2 Preliminary Cost

Preliminary Cost which is estimated in this Section consists of construction cost, contingency and consultant service cost are shown below

Following general condition has been applied to estimate the preliminary cost.

- Overhead and management fee is included in the construction cost
- Contingency is 5% of the construction cost
- Consultant service fee is 5% of the construction cost
- Tax will not be considered in this Section.

Normal market price at the project site has been applied to unit price.

Price fluctuation will not be considered.

Interest of the rent money will not be considered.
Construction works will be carried out by the experienced parties which have appropriate technical skill and experience.

- Normal and reasonable execution method and construction schedule as mentioned in this report will be applied.
- Applied exchange rate: 106.106JPY=1USD, 1.28006JPY=1BDT (Apr 2018)

2.7.3 Demarcation between Matarbari coal fired power plant project and Port development project

(1) Initial Investment

1) Training Dike and Breakwater

CPGCBL plans to extend the training dikes using the two dry seasons of 2018 and 2019, and the preparation of construction material has been started. Those dikes are composed of the North Dike (1,753 m in length, CDL+7.88 m to 8.98 m height) and the South Dike (710 m in length, CDL 8.98 m). The north dike will be extended to the point of - 14m sea depth, increasing the total length to 1753m.
The south dike should be completed in the dry season of 2019 to protect the dredged channel from the sand drift from the south. Those dikes are extended by CPGCBL to protect the sand drift and siltation after the dredging of channel.
Large size container vessels require a long stopping distance, therefore the north dike will be extended an additional 397 m as the breakwater.

(2) Approach Channel and Basin

CPGBCL is going to develop the approach channel (250 m in width, CDL-15.3 m in depth) for 50,000DWT coal carrier. On the other hand, CPA will expand the channel (350 m in width, CDL-16 m in depth) for 8,000 TEU container vessels. Additional cost for expansion, reclamation and disposal of the sand and soil should be shouldered by CPA loan but the works should be done by CPGBCL integrally.

1) Implementation of Construction Works

Dike and breakwater construction and channel dredging are carried out to counter drifting and reentering soil. Those works should be done in the short term by CPGCBL.
After that, CAP bears that cost by CPA loan. Ownership of those facilities will be determined based on the share of initial investment.

(3) Maintenance and Cost Allocation

1) Training Dike and Breakwater

There is a possibility that settlement could occur at the training dike and breakwater, and that armored concrete blocks could be damaged by high tide and waves. After extremely high tide and waves, it might be necessary to conduct emergency repair of the dike and breakwater.
The repair cost should be shared based on ownership, but the repair works themselves should be done by CPA.

2) Maintenance Dredging of Channel and Basin

The maintenance dredging of the channel and basin is the most crucial issue for both CPGCBL and CPA port development projects. Based on the tentative result of the JICA committee for the port development

in Matarbari, the annual maintenance volume is estimated to be around 5 million m3 at maximum. The survey team explained the results of the sedimentation simulation to relevant counterparts, but they didn't accept the results on the grounds that, in their opinion, such a large amount of sedimentation could not happen in Matarbari because there is no river flowing to this port.

The survey team recommends additional simulations and discussions should be carried out using the new site information and data after the monsoon in 2018.

There are 3 options for cost allocation of maintenance dredging between CPGCBL and CPA.

A) Cost allocation based on each dredging area
B) Cost allocation based on each dredging volume
C) Cost allocation based on Vessel GRT

From a financial viewpoint, Case A and B are preferable. Both CPGCBL and CPA should discuss the allocation options based on the future simulation result.

3) Maintenance of Navigation Aids

Navigation Aids are fabricated and installed by CBGBCL loan and the ownership will be transferred to CPA. CPA will carry out maintenance works for the equipment.

4) Maintenance of Port Access Road

The maintenance of port access road will be done by RHD budget. Environmental monitoring during construction and operation should be the responsibility of RHD.

5) Environmental Monitoring

Each project owner (CPGCBL, CPA and RHD) will be responsible for environmental monitoring during construction based on the laws in Bangladesh and JICA Guidelines for Environmental and Social Considerations. Environmental monitoring during operation regarding the disposal of maintenance dredging spoil, and sedimentation and erosion of coastal line will be done by both CPGCBL and CPA. Cost allocation should be based on initial investment.

2.7.4 Preliminary Schedule

Preliminary construction schedule is estimated based on the design and execution plan. Total construction period is estimated 36 months. It is estimated that Multi-purpose berth will open in January 2023, and container terminal will be open in August 2023.

2.7.5 Measures for Construction Safety

1) Background

Safety in any Construction Work is the most important and serious matter for all of the concerned organizations and individuals involved.

In this Section, an effective safety plan for the construction works will be discussed and recommended, using "Safety Risk Analysis Method", with due consideration of Project Component, respective Work Plans, Site conditions as well as Related Laws/ regulations in the Country.

2) Safety Risk Analysis

Risk Analysis Method is one of the mathematical methods to find out significant safety risks in the construction project. We can find significant safety risks through this method so that effective safety control plan and counter measures can be established.

In this method, Safety Risk is obtained by "probability of occurrence" times "severity of damage if it was happened". Probability and severity is generally indicated as grade 1 to grade 5.

Considering the risk factors such as work method, used equipment, characteristics of site and other conditions, major possible risk and its grade are determined and shown as "Risk Analysis Table".
In the Risk Analysis table, "A" shows grade of "Probability of occurrence", "B" shows grade of "severity of damage", and "C" shows "Total Grade" which is calculated by A times B.
There are many safety risks on the project. It is difficult to consider all risk and take counter measures for all of them. Therefore, the Significant Safety Risks are selected among all the risks and counter measures for these Risks will be recommended.

3) Counter Measures against Safety Risk

Generally, counter measures against the safety risks are divided into six groups such as;

- Establishment of the Safety Management System
- Important facilities for which special attention is required
- Necessity of Safety Facilities
- Prevention of Human Errors
- Retention of Safety Risks
- Removal of Safety Risks.

4) Particular care for the Special Significant Safety Risks

According to study of previous samples of Significant Safety Risks, it is found that some Special Significant Safety Risks require the particular cares. Recommended particular cares are studied in this section.

Particular cares for the risk of "Accident of lifted material drops down"
Particular cares for the risk of "Electric shock accident"
Particular cares for the risk of "Accident by ground condition"
Particular cares for the risk of "Heavy equipment accident"
Particular cares for the risk of "Traffic Accident"
Particular cares for the risk of "Water Traffic Accident"
Particular cares for the risk of "Accident of temporary facility collapse"

5) Emergency Plan

In the case that any accident happens, quick and effective response is necessary to protect human resources and prevent secondary accident. It is recommended to prepare the Emergency Plan prior to the commencement of the works.
Emergency Plan consists of following action plan.

- First aid
- Action for preventing secondary accident by such as power cut, installation of barricade, suspending of surround activities
- Contact safety officer (safety responsible person)
- Contact ambulance, hospital, police or fire service
- Contact the Client and the Engineer
- Report to the related authorities, the Client and the Engineer

It is necessary to understand that main purpose of the Emergency Plan is to protect human resources and prevent secondary accident in preparing the Emergency Plan.

6) Related local laws and regulations

There is no related local law or regulation with concrete manual or guidance for construction safety. However, there are some Safety Manuals which can be applied to the project. Safety Manual provided by government of Vietnam and Japan is usable such as;

- Construction Safety Manual by MLIT in Japan
- Safety and Health Manual in Construction by MOC in Vietnam and JICA
- Safety Manual of Construction Equipment by MLIT in Japan

As above manuals are prepared for general works with general site condition, each construction project should establish his own construction safety plan based on its specific site condition. The contractor should consider his actual construction work methods, equipments and conditions for the preparation of the Construction Safety Plan by referring the above manuals.

7) Conclusion

Human life is definitely more important than any other factors of the project such as cost, schedule or quality. When accident is happened, every related party should have penalty in view of financial and/or social status. Considering these meanings, "Safety" should be taken care of extremely.

However, many accidents including several serious accidents happen in the construction project all over the world.

Every related person should understand that most of the accidents have clear cause(s) and there should be a chance or chances for somebody to aware of these cause(s).

Important thing is to take good care of these chances and to take necessary counter measure(s). For this purpose, every related person need to have interest of safety itself and courage to take action when he is aware of safety risk factor at any stage.

2.8 Maintenance and Management of Facilities

2.8.1 Channel and Basin

Brief review of previous study of channel and sedimentation study at MUSCCPP were done in this section. Because the severe oceanographical conditions of tidal current and rough sea state during Monsoon Season, two Monitoring Pockets were prepared and sedimentation at these Pockets and Temporary Channel were monitored and found that the observed depositions were far exceeded the predicted volume by the numerical simulation method used at the Detailed Design stage of MUSCCPP. Under these conditions, JCIA has set up the Supporting Committee, composed of academic and governmental committee member to discuss this phenomenon because the channel and basin sedimentation needs the maintenance dredging work and affect the sound operation of new commercial port that will co-use the navigational access channel and basin area with MUSCCPP. As the conclusion of the co-study of the consultant of MUSCCPP and JICA Supporting Committee, expected amount of channel sedimentation of 4.2 million m3, 1 million m3 for sand and 3.2 million m3 for silt/mud, are obtained by applying the countermeasure structure of North side Training Dike up to water depth of MSL-15m (CDL-12.32m) and south side Sand Protection Dike. Because the numerical simulation model has the uncertainty of reliability, especially in the estimation of the mud/silty material deposition, continuous monitoring of oceanographic conditions as well as the topographical change during the construction period are under study after the strong recommendation by JICA Supporting Committee. Considering above difficult situation of the sedimentation phenomenon and the necessary huge amount of

initial investment cost for construction of countermeasure works, construction of northern Training Dike with water depth up to MSL -14m (CDL-11.32m) as the first step of countermeasure works was decided by MUSCCPP.

Numerical simulation model that was studied by consultant of MUSCCPP with the technical support by JICA supporting committee were used to estimate the channel and basin sedimentation that can be used as the expected maintenance dredging volume. Continuous effort to improve the accuracy of the numerical simulation method by monitoring of oceanographic conditions as well as the topographical changes at the site during construction period. By using updated information and considering the proposal by JICA supporting committee, update of the estimate of expected channel and basin sedimentation is now under study.

2.8.2 Offshore Disposal of Dredged Soil

According to the construction plan of channel and basin dredging works, part of the silty material that are not suitable for the land reclamation works are planned to dump offshore. Before selecting the candidate site for dumping of dredged soil material, regulations and related laws of dredged soil material dumping are surveyed and found that there are no legitimate restrictions in Bangladesh but the at most attention of the Sonadia Ecologically Critical Area are strongly recommended by the environmental specialist of IUCN Bangladesh. Considering these situations, candidate site for dumping, about 60km south of project site with water depth around 30m were selected and turbidity diffusion of Suspended solids (SS) by dredging work and dumping of dredged soil material have been studied by numerical simulation model analysis. Numerical simulation model composed of two parts, one is to reproduce the tidal current conditions and the other is to calculate the advection and diffusion of SS material in the tidal current field. Numerical simulation conditions such as turbidity source basic unit by dredging work and dumping works are determined mainly based on "Guideline of prediction of effect of turbidity diffusion by port construction work, April 2004, Ministry Land, Infrastructure, Transport and Tourism (MLIT, Japan)". Numerical simulation results of turbidity diffusion by dredging works and dumping of dredged soil material indicated the range of affected area are relatively small area and the expected maximum turbidity are negligibly low compared with the high ambient SS concentration.

2.8.3 Shoreline Deformation and Countermeasure

Construction of the port, together with the dredging of the navigation channel and basin arear will have the potential to affect the wave and tidal current conditions and most typically the long-term coastline changes of the adjacent coast area. Effects of the port construction on wave and tidal current conditions of the adjacent coastal area are evaluated to identify the affected coastal area by comparison of the wave and tidal current distribution before and after construction of the port. Comparison of the numerical simulation of wave and tidal currents showed that the very small change of the wave field and tidal current field occurred within the very limited vicinity of the port area.

1-line shoreline model is used to predict the long-term coastline changes of the coastal area that are likely to be affected by the construction of the port. Comparison of the long-term shoreline change between with and without the construction of the port are made to see the effect of construction of the port on beach process. About 30 years of past coastline changes by the analysis of satellite images data are used to confirm the validity of the 1-line coastline model and the concerned area for the calculation of the

long-term coastline change by 1-line coastline model. Matarbari island coast area are selected for the 1-line shore line change analysis by considering the geographical conditions of the nearby site and the long-term shoreline changes results from the obtained satellite image data. According to the results of 1-line shoreline change model, shoreline progress of 730m at the southern side of south Sand Protection Dike and shoreline retreat of 850m at the north side of north Training Dike after 50 years are obtained because of dominant longshore sand transport from south to north. As the accretion at the southside of the port will affect the channel sedimentation soon, excavation of accreted sand is considered necessary. As for the predicted erosion at adjacent part of northern Training Dike, predicted value of erosion is rather large due to the limitation of the 1-line shoreline change model considered but the loss of sandy beach to the north side of port after completion of the construction of port is expected to occur very soon and some countermeasures such as bypass of sand are necessary in case the loss of sandy beach imply the severe adverse effect.

2.8.4 Beach Profile Survey

Beach profile survey has been conducted in two different seasons (monsoon and non-monsoon season) to understand the seabed profile of each season around Matarbari Area. The survey results were used for basic information of shoreline deformation estimation.

2.9 Port Management and Operation

2.9.1 Port Management

(1) Port Management Body and Port Limit

As of May 2018, it has become clear that CPA will be port management body for Matarbari Port, and a notification on the definition of its port limit in the official Gazette is currently being prepared.

(2) Other Port Management Duties

In order to achieve the mission of CPA, designation of harbor master, tariff setting, etc. need to be carried out before the port enters into service. The tariff level of Matarbari Port should not be higher than that of Chittagong Port since it is necessary to attract users once Matarbari Port begins operations. In addition, it is necessary to set up Matarbari Port Office of CPA for efficient operation, maintenance and management of Matarbari Port.

(3) Administration Services of Relevant Organizations

Prior to the commencement of operations at Matarbari Port, it is necessary to coordinate with CIQ (Custom, Immigration, Quarantine), Coast Guard, etc. as these entities will provide key administration services.

(4) Project Implementation System

The Interim PIU for Matarbari Port Development Project was set up based on CPA Order No. 17/2017 dated 22 November 2017.

PIC or Project Implementation Committee will be set up as per GoB rules after DPP or Development Project Proposal for Matarbari Port is approved. PIU will also be set up within CPA after DPP be approved.

2.9.2 Port Operation

(1) Role Allotment between CPA and Private in Port Operation and Maintenance

There are 3 options in terms of role allotment between CPA and private in port operation and maintenance at Matarbari Port as follows:

- Option 1: Similar but more efficient role allotment than in Chittagong Port (Tool Port Model, Berth Operator System).
- Option 2: Long-term concession to private operator based on the PPP Act 2015.
- Option 3: Start with Option 1 immediately after entering its operation and then consider adopting Option 2.

The survey team proposes Option 3 for the first phase of Matarbari Port. As for the second phase of Matarbari Port, Option 2 (Landlord Model, etc.) is proposed.

The survey team proposes as well that devanning/unstaffing operation and custom appraisement operation, which currently are carried out in container yard (CY) of Chittagong Port, should not be carried out in CY of Matarbari Port. Instead, devanning/unstaffing operation should be carried out at consignee's premises or private Off-Dock facilities (ICDs/CFSs) and custom appraisement operation should be carried out at a dedicated custom appraisement facility.

(2) Technical Assistance on Port Operation and Management

The survey team proposes the technical training for CPA staffs as the technical assistance on port operation and management.

2.9.3 Port Promotion

Since Matarbari port is a newly developed port, the study team examined measures to promote the utilization of Matarbari port based on interviews with potential port users such as cargo owners and shipping lines.

Establishment of complemental facilities is necessary; namely, the Inland Container Depots (ICDs) are necessary around Matarbari Port which complement the function of the port from several perspectives such as depots of laden containers, storage of empty containers, and vanning/devanning facilities. Especially, devanning function is essential in order to prevent devanning activities inside the port which causes inefficient logistics.

In order to utilize the new port in a maximum efficiency, traffic lanes should be streamlined in and around the new port with introduction of necessary rules. The necessity of efficient space for vehicles is pointed out to prevent traffic jams.

Transport to/from hinterland is important. The improvement of existing roads is desired in the long-run. On the other hand, in short-term, since the number of traffic of covered vans will be increased in the existing roads, proper traffic controls should be implemented if necessary. Additionally, the use of inland water transport and railway transport should be considered with the development of infrastructure and equipment.

Transparent and efficient procedures should be implemented at the new port. As an option, it is recommended that ICT technology should be introduced.

Other than those measures, strategic tariff setting, cooperation with the industrial zones, and strategic planning are to contribute to the port promotion.

2.10 Outline and Cost of Port Consulting

2.10.1 Packaging, Procurement, Standard and Major Facilities

The port project is planned to locate by the Matarbari Coal Fired Power Plant (CFPP) which is under construction. The common facilities (works for CFPP and Matarbari Port Project) such as Dredging of access channel/basin and Breakwater will be constructed by CFPP in order to prevent the duplicate expenses for the equipment mobilization costs and shorten the construction period.

Civil and marine works such as reclamation work, berth construction, terminal construction including buildings and utilities, extension of Breakwater would be the Port Project as Package 1.

And, the procurement of equipment and boats shall be the Port Project as Package 2 as the difference of procurement method.

Hence, scope of each package is described below.

- **Package 1: Civil Works for Port Construction**

(Procurement Method: ICB without PQ, Standard: FIDIC SBD Works)

1) Construction of a container and multipurpose terminal (Length: 760 m, Depth of berth: CDL -16m)
2) Reclamation for a multipurpose and container terminal with soil improvement
3) Construction of Harbor Craft Basin (Tug-boat Quay: 400m)
4) Yard pavement for container and multipurpose terminal (approx. 33 ha)
5) Terminal office building, terminal gates, workshop and other necessary buildings with utilities
6) Terminal utilities (drainage, power supply, water supply, firefighting system, security system, communication system, deep well with reservoir tank and cold ironing /Shore power)
7) Seawalls, revetments and terminal fence and boundary fence
8) Rain water reservoir and re-use system

- **Package 2: Procurement of Equipment**

(Procurement Method: ICB without PQ, Standard: FIDIC SBD Design Build)

1) Quay Gantry Crane (QGC) for Container: 2 units
2) Quay gantry Crane (QGC) for Multipurpose Berth: 1 unit
3) Rubber Tired Gantry Crane (RTG): 6 units
4) Reach Stacker: 2 units
5) Tractor and Chassis: 12 units
6) Emergency Generator: 4000 KVA
7) Tug-boat: 2 units
8) Pilot- boat: 1 unit
9) Security-boat: 1unit
10) CCTV system: 1 system, Terminal Operation System (TOS): 1 system
11) Vessel Traffic Management (VTM) System: 1system
12) Solar sun light power system

2.10.2 Outline of Port Consulting Service

The necessary consulting services such as Detailed Design for Civil Works, Concept Design for Procurement of Equipment, Tender Assistance and Construction Supervision for the implementation of the Project

1) Contents of Consulting Services

a) Detailed design (Package 1)
b) Concept design (Package 2)
c) Tender Assistance
d) Construction supervision (Package 1)
e) Construction supervision (Package 2)
f) Facilitation of implementation of Environmental Management Plan (EMP), Environmental Monitoring Plan (EMoP)
g) Technology transfer

2) Additional Site Survey and Study

a) Bathymetric Survey
b) Topographic Survey
c) Geotechnical Investigation (Drilling Investigation） 6 points x 40m drilling
d) Ship Maneuvering Simulation（Vessel entering to channel, Berthing using Tug-boat and others, 4 cases）
e) Sedimentation Simulation
f) Silt Diffusion Analysis for off-shore dumping
g) Diving Investigation on Construction Supervision for berth construction (1month)

3) Expected Time Schedule of Consulting Services

Safety Facilities

Key Activities	Date	Duration in Months
Commencement of Consulting Services	1 October 2018	
Detail design and preparation of drawings and tender documents	From: 1 October 2018 To: 31 July 2019	10
Tender process and Contract negotiation	From: 1 August 2019 To: 31 July 2020	12
Commencement of the construction works	1 August 2020	
Supervising of the construction works and procurement works	From; 1 October 2020 To: 31 March 2024	42
Defect Notification Period	From: 1 April 2024 To: 31 March 2025	12
End of Consulting Services	15 April 2025	-

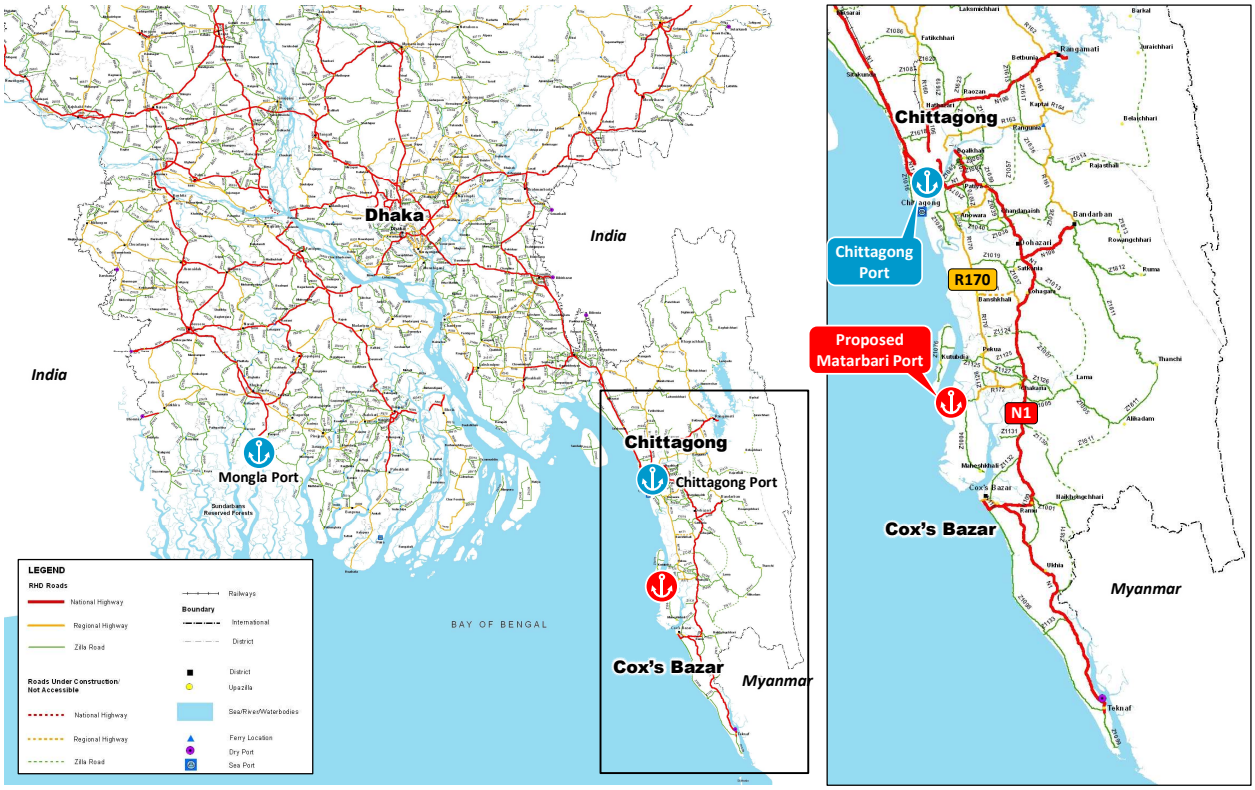
3. ACCESS ROAD DEVELOPMENT

3.1 Present Situation of Road Transport Infrastructure

Present Road Network in Bangladesh

The road network of Roads and Highways Department (RHD) consists of 21,302 km of National, Regional and Zila Roads, which constitutes 6% of the total road network in Bangladesh. The road condition has been improved and over 90% of the roads have been paved since its formation was 62% in 1991. The Asian Highways are the most important corridors not only for the domestic economic activities but also for multinational economic organizations such as South Asian Association for Regional Cooperation (SAARC), South Asian Sub-regional Economic Cooperation (SASEC), The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC) and Bangladesh-China-India-Myanmar (BCIM). From these developments, Bangladesh acts as a contributor to better multinational regional functionality and as a gateway to the hinterland countries and induces synergetic economic growth in the country.

At the Matarbari Port Development Project site, National Highway No.1 is the most important arterial road and is designated as the Asian Highway (AH) No.41. This highway functions as port access from AH1 or AH2 to Chittagong and Mongla Ports.



Source: Bangladesh RHD Road Network

Bangladesh Road Network

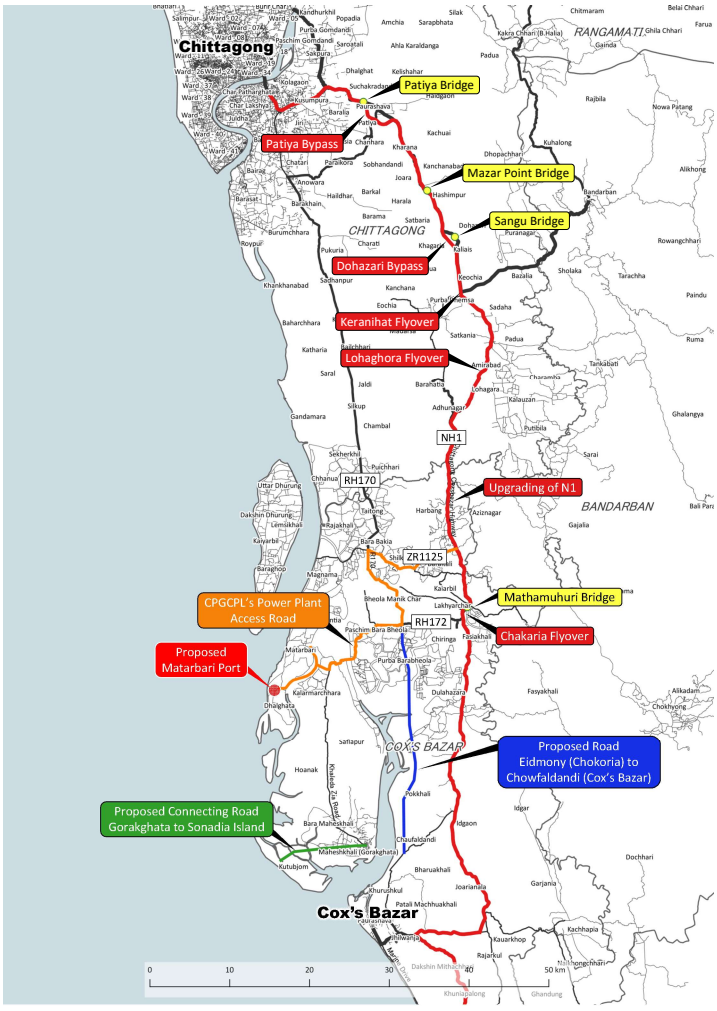
Existing Road Development Plans and Proposals

National Land Transport Policy (NLTP) is the government's strategic development policy that presents the long-term vision for establishing a national land transport system, which is safe, inexpensive, modern, technologically dependable, environmental friendly and acceptable.

The Road Master Plan was prepared in 2009 in response to the direction provided by the NLTP in order to materialize the necessary developments in the road sector for achieving the aforementioned vision. The major challenges under the Master Plan are: i) improvement of important national highways, ii) enforcement of axle load control, iii) improvement of traffic safety and iv) mitigation of traffic congestion by reinforcing the road network in consideration of non-motorized traffic (NMT) and slow-moving vehicle traffic (SMVT).

As part of the road development plans in the Southern Chittagong Region, there are two (2) major on-going road projects and three (3) proposed road projects in the project area.

- The Cross-Border Road Network Improvement Project (JICA supported)
- CPGCBL's Matarbari Ultra Super Critical Coal Fired Power Project including provision of an access road (JICA supported)
- Proposed upgrading of National Highway No.1 (from Chittagong to Cox's Bazar)
- Proposed Road connecting Eidmony (Chakoria) to Chowfaldandi (Cox's Bazar)
- Proposed Road connecting Gorakghata to Sonadia Island



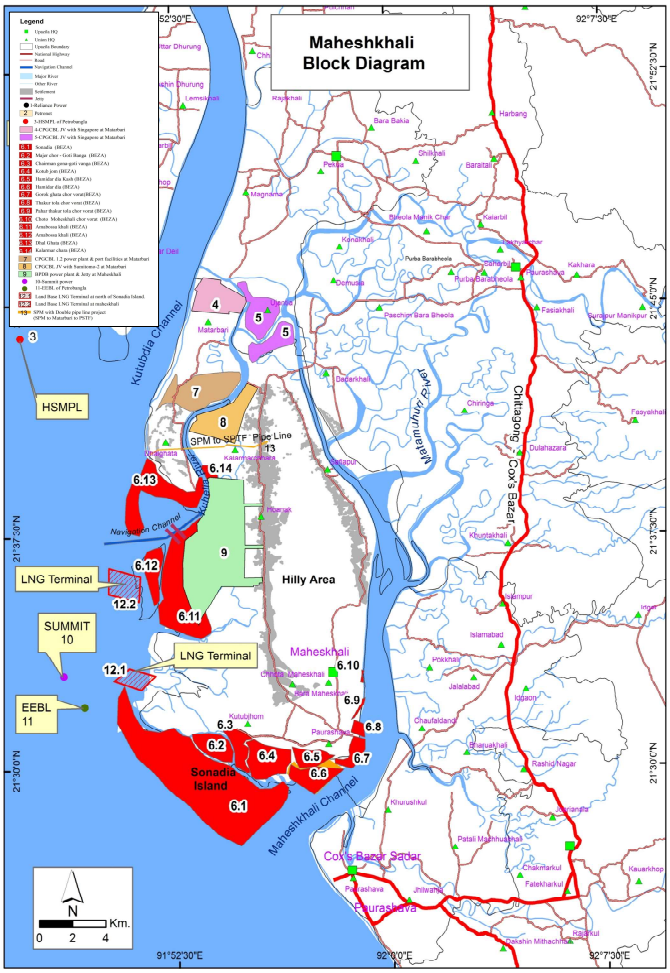
Source: JICA Survey Team

On-going and Proposed Projects

Existing Regional Development Plans and Proposals

The Bangladesh Prime Minister's Office is overseeing large-scale developments in Matarbari and Maheshkhali and positioning these places as hubs of power generation and economic activity. The proposed Matarbari Port is expected to function as the gateway not only for domestic/international freight transport but also importation of the materials necessary for the proposed power plants.

In addition to road accessibility, railway transport to the area is also under consideration in connection with the on-going Dohazali-Cox's Bazar Railway Project.



Source: Maheshkhali Development Committee

Maheshkhali Block Diagram

3.2 Road Freight Transport Planning

Required Developments for Road Freight Transport

To ensure good road freight transport, the international corridors under the multinational agreements should be taken into consideration. Bangladesh is expected to function as a gateway of the freight transport route into the hinterland countries. It is critical that good connectivity from Matarbari Port to N1 (AH41) and from Chittagong through N1 (AH41) are provided.

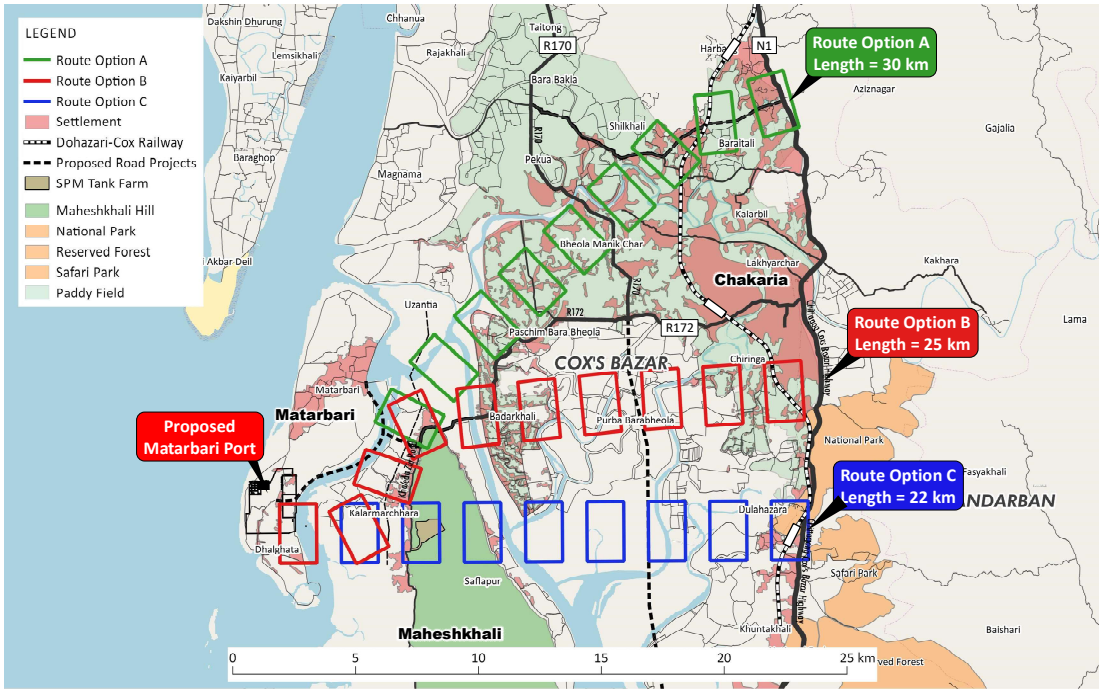
Port Access from National Highway

Three alternative routes were examined and a comparative analysis was undertaken to decide upon an optimum route. Below are our findings:

- Route Option A is the shortest route to the north, but requires land acquisition of a large number of private property, which has a risk of delaying project implementation;
- Route Option B is a short route to N1 which avoids Mahaeshkhali Hill, and has the advantage of minimizing negative impacts to environmentally protected areas and private property. Furthermore, it also provides good accessibility to both Matarbari Port and CPGCBL's Power Plant; and
- Route Option C is the shortest route to N1 passing through the Maheshkhali Hill, and has an advantage of minimizing construction costs and social-environmental impacts. The challenge is that the route needs to cross the Maheshkhali Hill and accessibility to CPGCBL's Power Plant would not be favorable.

As a result of discussions among concerned ministries, agencies and local government, it was agreed that the Route Option B is the optimal route for the following reasons:

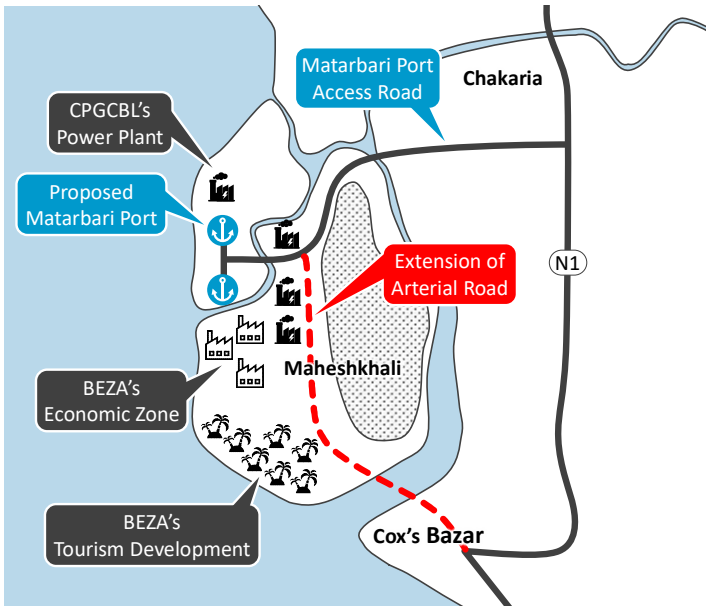
- One access road should be constructed providing good accessibility to both Matarbari Port and the CPGCBL's Power Plant instead of constructing two access roads;
- The Matarbari Port Development Project is a Fast Track Project for the Bangladesh Government and early implementation is required. Social-environmental impacts such as land acquisition and resettlement of owners would be minimized and consequently ensure smooth implementation of the project;
- Natural environmental impacts would be minimized. Cutting of the Maheshkhali Hill, which would need the approval of the Prime Minister's Office (PMO) of Bangladesh, can be avoided for smooth implementation of the project. After completing the evaluation, it was revealed that Maheshkhali Hill is an environmentally protected area by law).



Source: JICA Survey Team

Alternative Route Options

Also, the Matarbari Port Access Road should be designed and constructed with an aim of attaining compatibility with the arterial road link into the southern area of Maheshkhali as well as a road connection to Cox's Bazar in future. It is recommended that the forthcoming master plan of the Maheshkhali development should select the position of the road link extended from the Matarbari Port Access Road.



Source: JICA Survey Team

Possible Future Extension of Road in Maheshkhali

Traffic Demand Analysis

In this study, three (3) major types of traffic were considered for traffic demand analysis.

- Traffic demand generated from the Matarbari Port
- Diverted traffic from existing roads
- Traffic demand generated by the ongoing development activities

After traffic surveys and analyses of future development plans were conducted, the design traffic of the project road was calculated. The daily traffic on the access road was calculated as 6,582 PCU in the year 2026, which will rise to 12,103 PCU in the year 2035. During peak hours 592 vehicles (1,200 PCU) will use the project road by the year 2026 whereas 958 vehicles (1,970 PCU) in the year 2035. According to the Japan's port access road design manual, a 2-lane road can accommodate traffic up to the year 2027 while according to Roads and Highways Department (RHD) Geometric Design Manual (2005), a 2-lane road can accommodate the traffic up to the year 2035. However, if the development plans such as economic zones are executed earlier, traffic on the project road will definitely increase and the demand for upgrading to a 4-lane road will actualize sooner.

The traffic demand result was also used to determine the design of the intersecting point between the project road and the N1. Under this study, traffic surveys were not carried out on the national highway; therefore, traffic survey data of RHD (2016) and detailed design of the Cross Border Road Network Improvement Project were analyzed and future traffic of N1 was estimated. During peak hours the intersection needs to accommodate 3,202 PCU by 2026, which is expected to increase up to 4,622 PCU by 2035. Therefore, a signalized intersection is proposed with a free left turning lane from Matarbari to Chittagong in 2026. However, in 2035 the intersection needs to be upgraded in order to accommodate heavy traffic in the Chittagong- Matarbari direction.

Estimated Daily Traffic of Access Road

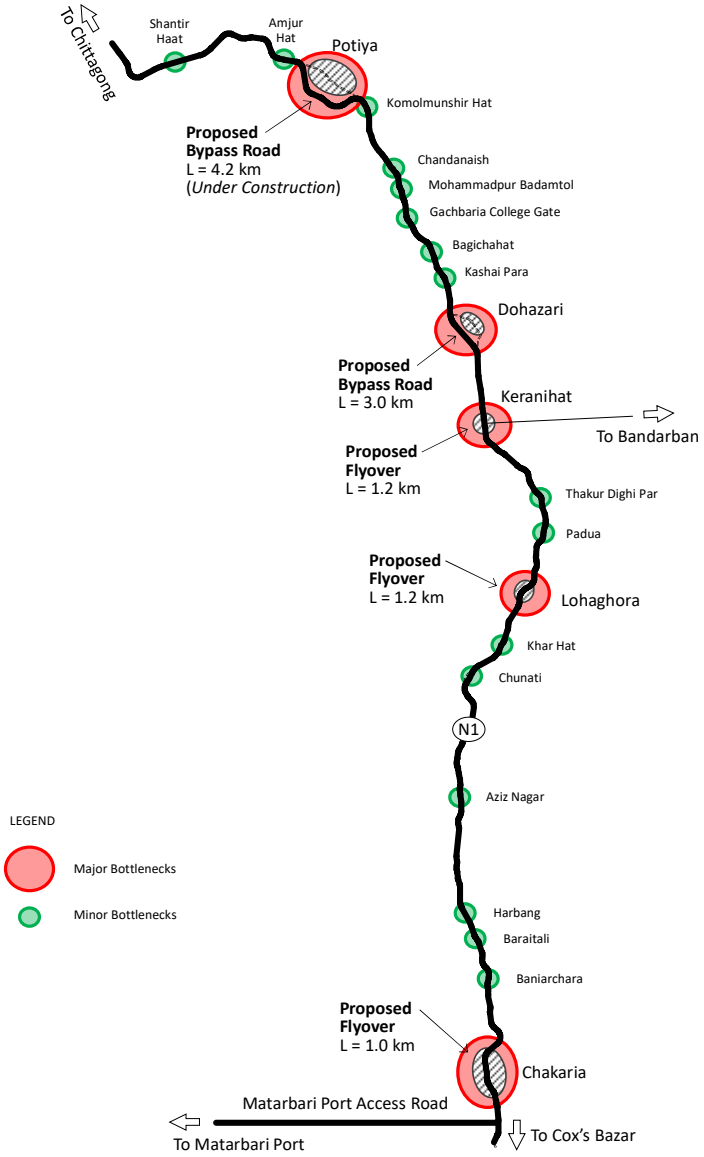
	Veh Type	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Port Related Traffic	Truck	1,565	1,691	1,828	1,977	2,138	2,292	2,455	2,631	2,818	3,019
	Car.	730	792	859	933	1,013	1,088	1,169	1,256	1,349	1,448
Diverted Traffic from Present Road	Car	53	54	55	57	58	60	61	63	64	66
	Utility	26	28	29	30	31	32	33	34	36	37
	Truck	107	111	114	118	122	125	128	132	135	139
Power Plant Related Traffic	Car	616	616	616	616	616	881	881	881	881	881
	Bus	47	47	47	47	47	66	66	66	66	66
Total (veh/day)		3,144	3,338	3,549	3,777	4,025	4,544	4,794	5,063	5,349	5,655
Total (PCU/day)		6,582	7,035	7,527	8,060	8,639	9,508	10,093	10,719	11,388	12,103
Peak Hour Flow (veh/hour)		592	627	664	705	739	835	864	894	925	958
Peak Hour Flow (pcu/hour)		1,200	1,281	1,368	1,463	1,543	1,685	1,751	1,821	1,894	1,970
Required No. of Lanes (Ref: Japanese Port Road Standard[1])		2	2	4	4	4	4	4	4	4	4
Required No. of Lanes (Ref: RHD Standard[2])		2	2	2	2	2	2	2	2	2	2

Note: 1: If peak hour flow is more than 650 veh, 4 lane is necessary
2: If peak hour flow is more than 2,100 pcu, 4 lane is necessary

Improvement of National Highway

For providing a smooth traffic condition for the fright transport form Matarbari Port, it's urgently necessary to implement the road widening project of N1. The following methods would be essential to advancing project implementation:

- To implement full-scaleFull-scale project scopes at the identified major bottleneck sections only such as Patiya, Dohazari, Keranihat, Lohaghora and Chakaria, should be implemented.
- To widen Widening at the minor bottleneck sections only and to provide provision of wider shoulder lanes at the other sections to be used as the as the usage of Slow-Moving Vehicle (SMV) lanes as a minimum investment for improving the traffic situation.



Source: JICA Survey Team

National Highway No.1 (Chittagong-Chakaria Section)

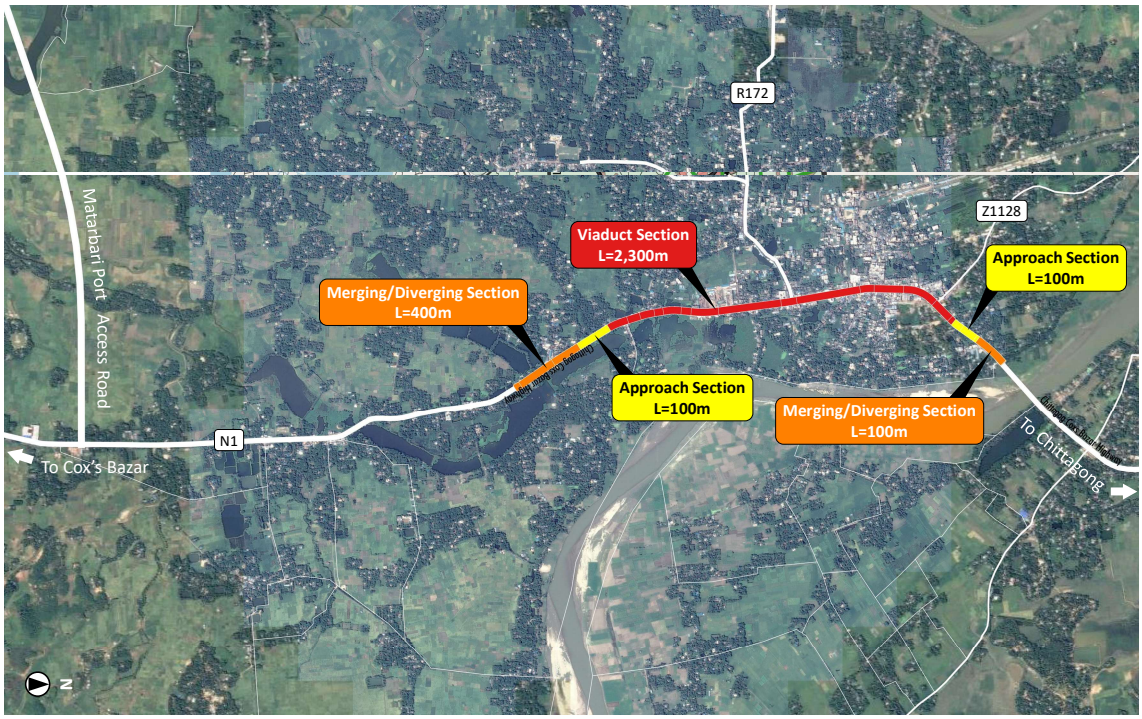
Rough Benefit Estimates for Different Cases

Unit (mil. USD)		Case 2	Case 3	Case 4
Improvement Method	5 Major Bottleneck Sections	Bypass or Flyover	Bypass or Flyover	Bypass or Flyover
	Minor Bottleneck Sections	* * *	4-lane Widening	4-lane Widening
	Other Sections	* * *	Shoulder Paving	4-lane Widening
Benefit	Travel Time Savings	127	464	572
	Vehicle Operating Cost Savings	43	137	152
	Total Benefit	170	600	724

As a case study for traffic improvement of N1, the Chakaria Section was examined under this study as a reference for the implementation stage, even though the scope ofwork of the Matarbari Port Development Project does not include N1 improvement. The result of comparative analysis concluded that the flyover construction option would be the most preferable mainly because of the ease of implementation with minimum requirements of land acquisition. However for the purposes of traffic improvement at this section, investment should be made in further engineering studies because a flyover alternative would require a larger budget than a bypass due to the length of flyover bridge needed.

As the result of the preliminary engineering study, the following scope of work would be recommended. However, further studies should be undertaken at the implementation stage.

- Length of flyover: 2,300 m
- Approach section: 100 m
- Merging & diverging section: 400 m and 100m



Source: JICA Survey Team

Proposal for Chakaria Flyover

3.3 Natural Condition Survey

Under this study, the following surveys are undertaken for preliminary design purposes.

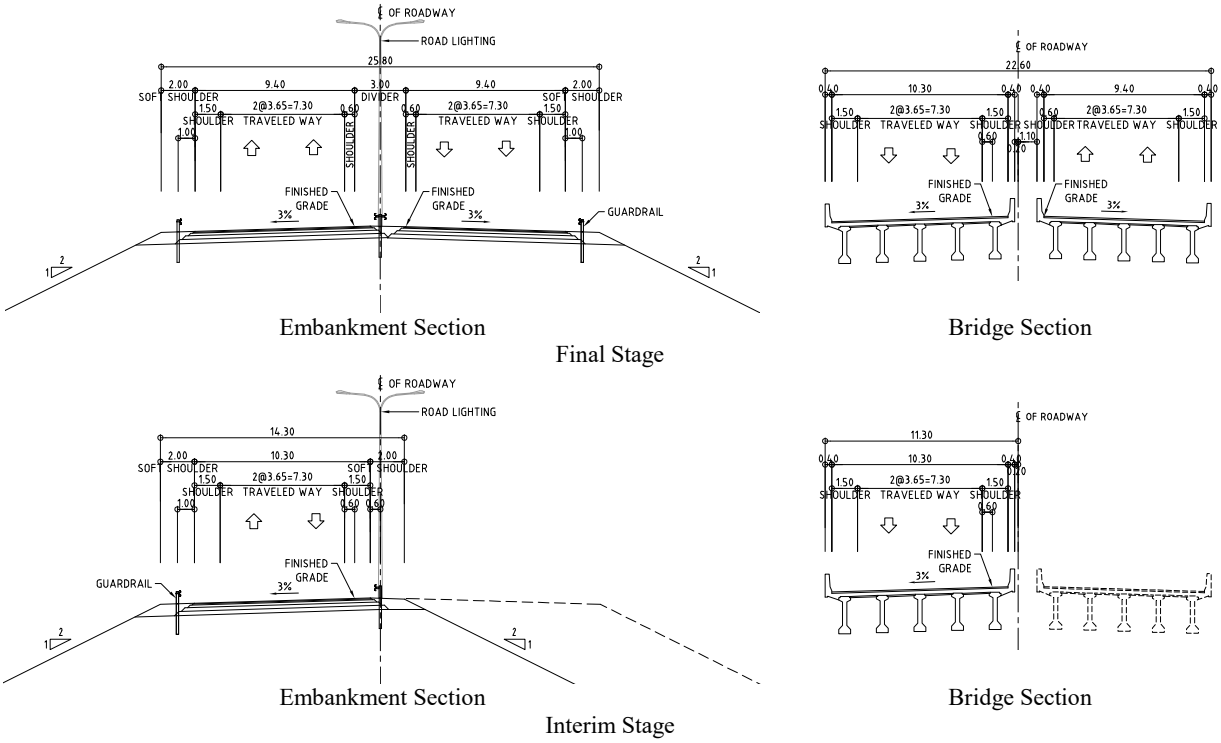
- Topographic survey: Benchmark installation for improving accuracy of digital terrain data, river cross section survey for hydrological studies
- Geotechnical investigation: Borehole drilling at 59 locations along the access road, material testing for embankment materials available near the project site
- Satellite imagery and digital terrain data: Purchase of 40 cm resolution satellite images and 0.5m high-definition digital terrain models covering 500 m^2 area of the project site

3.4 Preliminary Design

(1) Highway Design

Cross Section Elements

The following figure represents the typical cross sections of each road section. At the embankment sections, service roads will be provided in order to avoid community severance along the road. Considering that the expected traffic volume generated by Phase 1 of Matarbari Port Development Project is not significant, it can be accommodated in 2-lanes and phased construction would be preferable. The phased construction would be in such a manner that half of the road is constructed at the initial stage and other constructed at the final stage. However, the shoulder width at the initial stage should be 1.5 m on both sides of the usable section for safety reasons, although the inner shoulder width required at the final stage is only 0.6 m.



Embankment Section — Bridge Section

Final Stage

Embankment Section — Bridge Section

Interim Stage

Source: JICA Survey Team

Typical Cross Sections of Matarbari Port Access Road

Alignment Design

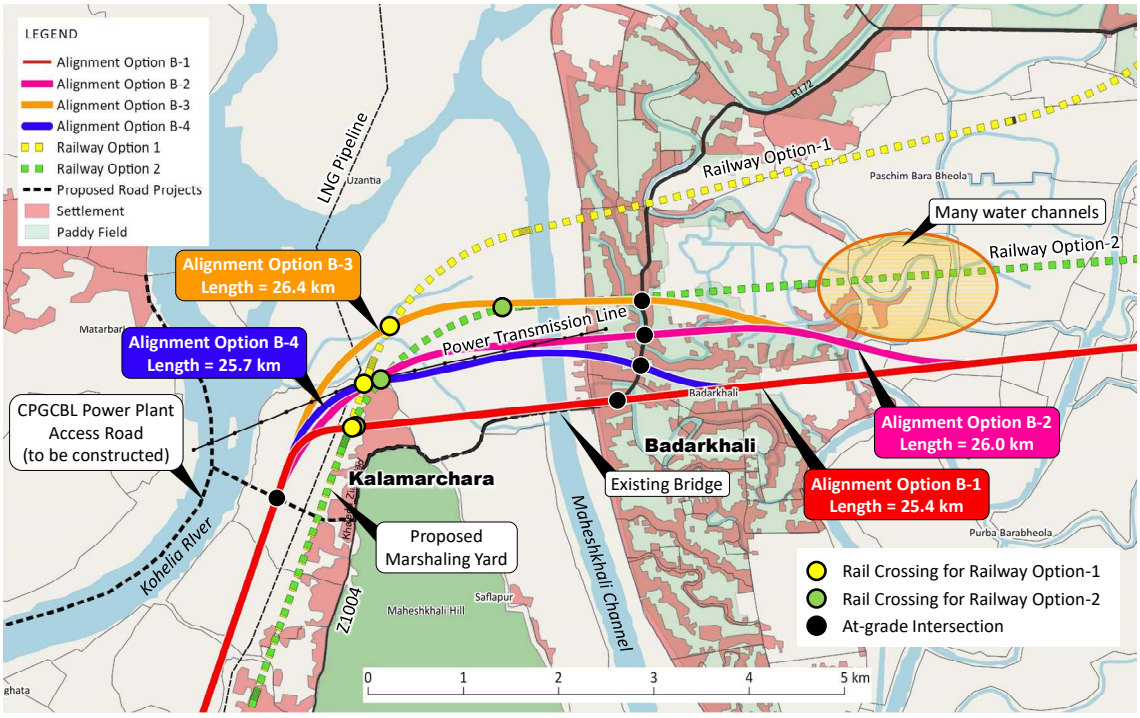
The available space for the selected route (Route Option B) is limited due to the settlement in Chakaria especially at the area near N1 as well as the existence of many water channels. Basically the alignment can be designed to avoid occupied areas but that would mean passing through the highly populated area in Badarkhali and the north of Maheshkhali. Focus was therefore placed at this section of the alignment.

As a result of the comparison of three alternative alignments, the Alignment Option B-1 was evaluated as the optimal alignment for the Route Option B because of the following reasons:

- Alignment Option B-1 can cross the proposed railway to Matarbari Port at the same elevation but the other alternative routes need grade separation, which would necessitate the need for at least 1 km-long viaduct costing more than US$ 60 mil.

- Alignment Option B-1 has a certain level of social impact but the construction cost is the least.
- The project implementation schedules of the Matarbari Port Access Road and the railway project are currently differt while the Access Road Project is urgent. It is important to have flexibility of design for both the access road project and the railway project, and recommend grade separation of the railway crossing is avoided.

However, as the result of the stakeholders' meetings held at the project sites, local residents of Utternalvila Baruapara Village under Kalamarchara Union of Maheshkhali and Badarkhali of Chakaria requested the JICA Survey Team to reconsider the road alignment of Alignment Option B-1 to avoid the high-density populated areas. Therefore, another alternative option, namely Alignment Option B-4, was also considered and was decided upon as the final alignment of the Matarbari Port Access Road having the advantage to mitigate adverse social-environmental impact. The Alignment Option B-4 has obtained consensus from the local people.

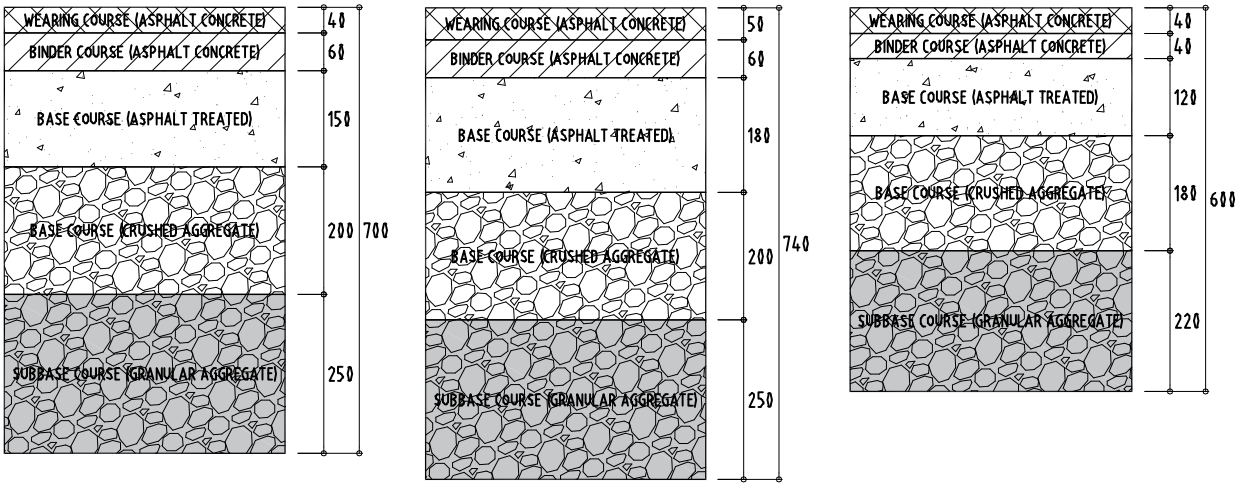


Source: JICA Survey Team

Alternative Alignments for Route Option B

Pavement Design

A Flexible pavement design (or commonly referred to as asphalt concrete pavement) has been selected for the Matarbari Port Access Road instead of applying a ridged pavement design (or called concrete pavement) because the project road will retain residual settlement of the embankment and the flexible pavement has the advantage of retaining smoothness of the pavement surface given such conditions. Pavement design was undertaken based on the "AASHTO Guide for Design of Pavement Structure 1993" using 10-year accumulated future traffic volume on the road from 2026 to 2035 and the parameters used in Bangladesh. The calculated pavement thickness for each layer is shown below:



Port Access Road **National Highway No.1** **Other Intersecting Roads**

Source: JICA Survey Team

Designed Pavement Layers

Considering that the project road will serve a lot of heavy vehicle traffic, application of porous asphalt would require contemplation even though this type of pavement has not been applied in Bangladesh.

(2) Bridge Design

Bridge Type Selection

The two (2) bridges across Kohelia River and Maheshkhali Channel need to be designed as long-span bridges because these rivers are classified as Class II waterways of BIWTA requiring a minimum vertical clearance of 12.20 m and a minimum horizontal clearance of 76.22 m. The condition of the river and the required design conditions are as follows.

- The river and canal width is about 300 m.
- Required classification of waterways is Class II, the necessary clearance is 76.22 m in the horizontal direction and 12.20 m in the vertical direction.
- The bridge on the Maheshkhali Channel will be located about 600 m upstream of the existing bridge (span length: 43.5 m @ 8).
- The ground conditions at the river crossings are viscous soil with a Standard Penetration value of N about 10 on the upper layer, and the underlying support layer (sand layer) at the position of GL - 25 m to 30 m is a soft ground.

As for the river crossing part of these two bridges, a span length of about 80 m is required to secure the BIWTA's clearance. Therefore, two bridge categories were considered namely; Steel Plate girders and the Prestressed Concretes types. Under the Steel plate girder type, a steel box girder and a steel narrow box girder could be adopted. On the other hand a PC box girder bridge from the Prestressed Concrete bridge category would be an economical bridge alternative for a span length of 80 meters, As a result of a comparative analysis, the steel narrow box girder bridge was selected as the optimum option for long-span bridges for the following reasons:

- The steel/concrete composite deck is more durable than the conventional deck slab;
- The weight of steel narrow box girder is relatively light and it has an advantage against the soft ground conditions;
- The number of parts and the painted surface area can be minimized resulting in reduced costs for

construction and maintenance than conventional steel box girder bridge type; and

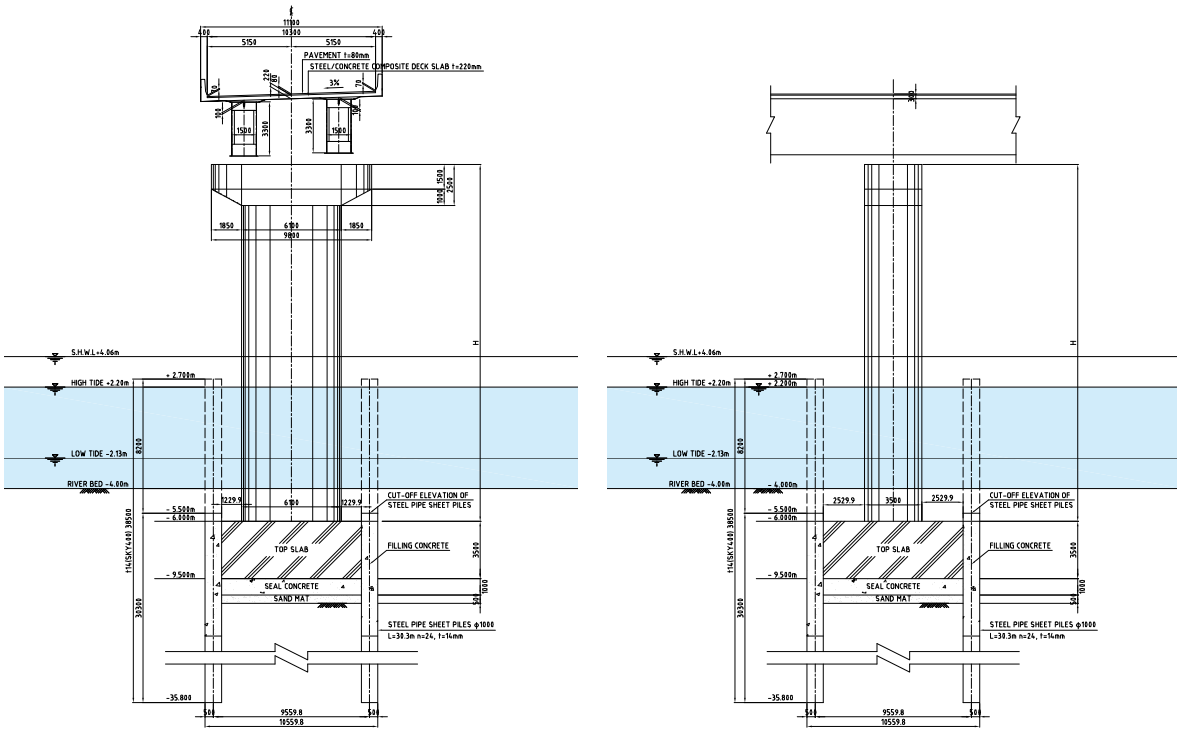
- The required time for construction is less because there are lesser components, and minimal need for formwork for the deck slab as well as scaffolding.

The substructure of long-span bridges, receive large reactionary forces from the superstructure, which normally require large-scale cofferdam work within the river for construction. Therefore, comparison of foundation types for long-span bridge was made with the two options, namely steel pipe sheet pile foundation option and the bored pile foundation option. As a result of a comparative analysis for the foundation structure type, steel pipe sheet pile foundation was selected as the most optimal option for the following reasons:

- The steel pipe sheet pile can also function as a cofferdam in addition to acting as the bridge foundation unlike for the bored pile option where the two have singular roles. Following from the above point, the steel pipe sheet pile option is more economical than the bored pile option where one has to allow for the cost for cofferdam work;
- The construction period is shorter than that of the bored pile approach.
- The size of steel pipe sheet pile is less than that of the bored piles and the impact on rivers such as scouring would be minimized.

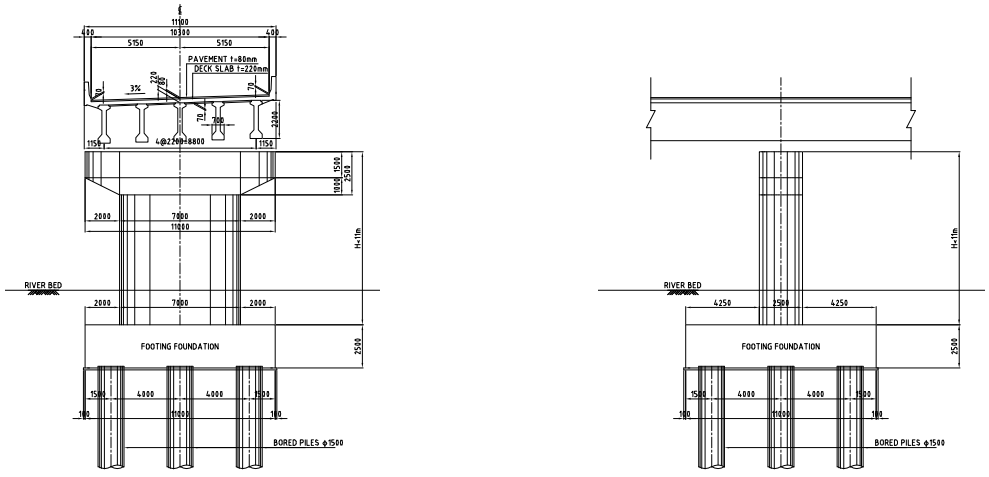
For a short span bridge, it is generally recognized that the PC-I girder type is optimal and an economical bridge type given most field conditions and many RHD's bridge projects in Bangladesh have applied this bridge type. The PC-I girder type bridge is consequently adopted for short-span bridge crossings without detailed comparison.

However, the bridge type for Bridge No.16, which is the longest of the short-span bridges having 1,260 m in total bridge length, was changed to a steel-I girder type in order to shorten the construction period despite their higher construction cost than the PC-I girder type.



Front View　　Side View

Steel Narrow Box Girder Bridge



Front View　　Side View

PC-I Girder Bridge

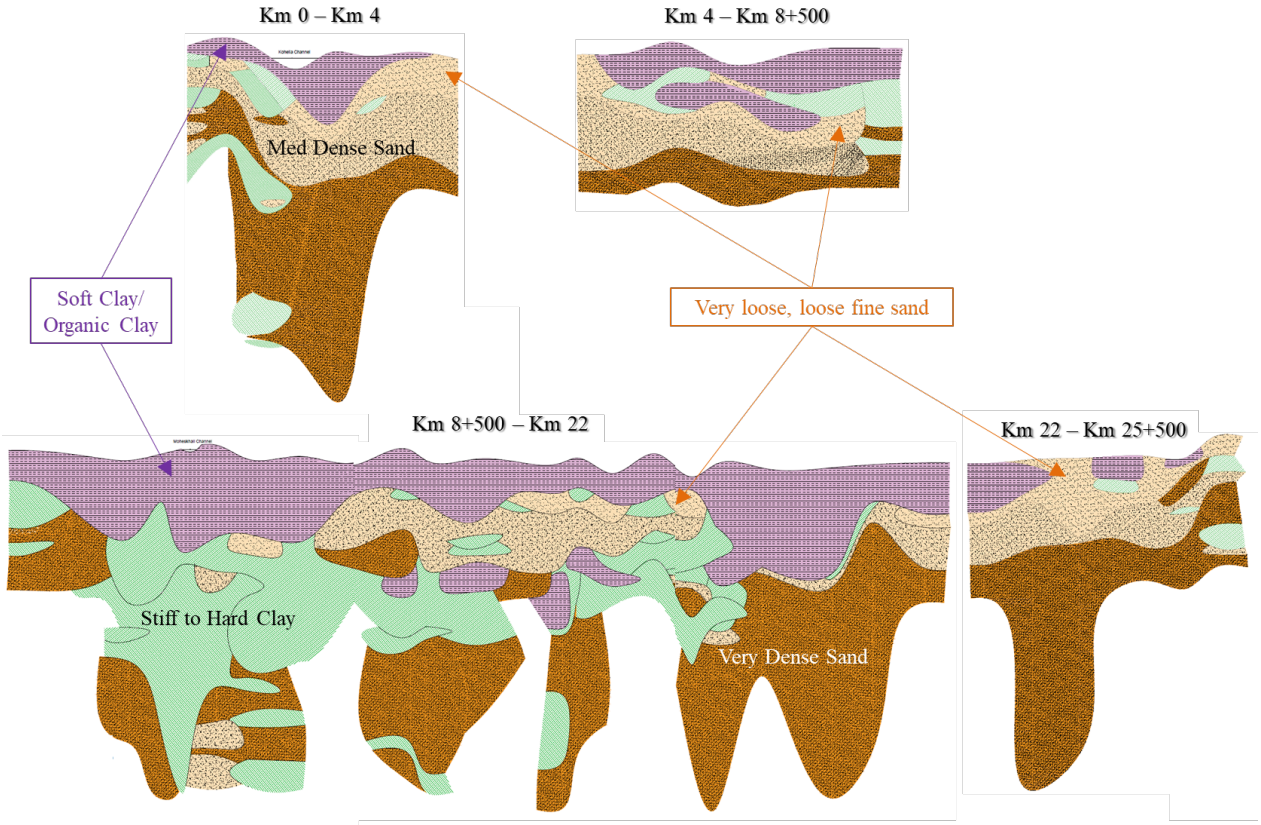
Source: JICA Survey Team

Structural Types of Bridges

(3) Soft Ground Analysis and Design

Site Conditions

The proposed alignment of the Matarbari Port Access Road overlies on weak compressible soils. The results of the boreholes and laboratory tests indicate that the presence of a soft soil layer along the alignment with thickness ranges from 1.0 m to 15.5 m. At some sections, the general ground profile comprises soft clay sandwiched between loose to dense sand stiff clay.



Source: JICA Survey Team

Soil Profile of the Matarbari Port Access Road

Soft Soil Improvement

The filling height for embankments along the Project alignment ranges from 6.5 m to 12 m. However, the soft layer beneath typically exhibits low shear strength which tends to the instability of an embankment during the construction phase. Considering such conditions and the limited construction time frame necessary complete before the opening of the Matarbari Port, the following three methods have been selected as measures for the soft soil improvement for the project road.

- Replacement
- Surcharge with/without Prefabricated Vertical Drains (PVD)
- Sand Compaction Pile

Summary of Soft Soil Improvement method

Section		Average Soft Soil Thickness (m)	Improvement Method	Installation Pattern	SCP		PVD
					Diameter (m)	Spacing (m)	Spacing (m)
From	To						
1. Embankment							
0+000	0+700	2.00	Replacement	-	-	-	-
2+200	3+200	4.50	Preloading Method	-	-	-	-
3+300	4+300	1.00	Replacement	-	-	-	-
5+000	5+900	9.50	Surcharge w/ PVD	square	-	-	1.65
6+500	8+500	11.50	Surcharge w/ PVD	square	-	-	1.65
8+500	9+500	10.50	Surcharge w/ PVD	square	-	-	1.65
12+300	13+700	12.50	Surcharge w/ PVD	square	-	-	1.65
17+000	18+000	6.50	Surcharge w/ PVD	square	-	-	1.65
19+000	20+000	14.50	Surcharge w/ PVD	square	-	-	1.65
20+000	21+000	15.50	Surcharge w/ PVD	square	-	-	1.65
21+000	23+000	7.50	Surcharge w/ PVD	square	-	-	1.65
23+000	25+412	-	Replacement	-	-	-	-
2. Approach Road for Bridges							
Bridge 1	Left side		Replacement	-	-	-	-
Kohelia Bridge	Right side	11.50	Sand Compaction Pile	square	0.7	1.1	-
Bridge 2	Right side	4.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 3		4.00	Surcharge	-	-	-	-
Bridge 4		11.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 5 Maheshkhali Bridge		11.00	Surcharge w/ PVD	square	-	-	1.65
Bridge 6		6.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 7		4.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 8	Left side	2.00	Replacement	-	-	-	-
	Right Side	Sandwiched	Sand Compaction Pile	square	0.7	1.1	-
Bridge 9		15.50	Sand Compaction Pile	square	0.7	1.1	-
Bridge 10/11/12 Left Side		5.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 12 Right side		7.50	Surcharge w/ PVD	square	-	-	1.65
Bridge 13		3.50	Surcharge	-	-	-	-
Bridge 14		-	No improvement needed	-	-	-	-
Bridge 15		-	No improvement needed	-	-	-	-
Bridge 16		Sandwiched	Sand Compaction Pile	square	0.7	1.1	-

Liquefaction possibility

Some sections in the Project Area indicate the presence of very loose sand with an average thickness of about 5m. Although there was less concern for assessing liquefaction potential at the Feasibility Study Stage, a comprehensive assessment ought to be undertaken at the Detailed Design Stage.

Lateral movement at bridge abutments

The underlying sub-soils near the abutments after being improved on as shown in エラー! 参照元が見つかりません。 to a minimum of 90% degree of consolidation is considered to result in no lateral movement effect to the bridge abutments.

(4) Hydraulic and Hydrological Study

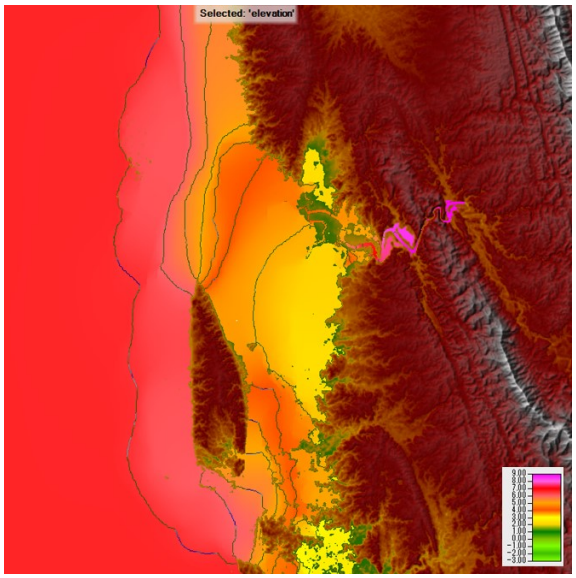
The destructive power of the storm surge is enormous and the calculation result shows that its influence extends to N1. Whereas, the external forces of the storm surge at the coastal area gradually decrease as the flow leads to the inland areas, to encounter the N1, the damage caused by flash-floods alone becomes greater. Therefore, protection works to the embankment and bridges against the run up of a storm surge and/or the flash floods is deemed necessary.

Further detailed hydrological and hydraulic studies should be conducted at the detailed design stage to reproduce the special / un-usual hydraulic phenomena and to take preventative measures. In addition, although the hydraulic analysis covers a large area, the full-scale of topographic, bathymetric and hydrological surveys were not conducted in this study. Hence, these detailed surveys should be conducted at detailed design stage also.

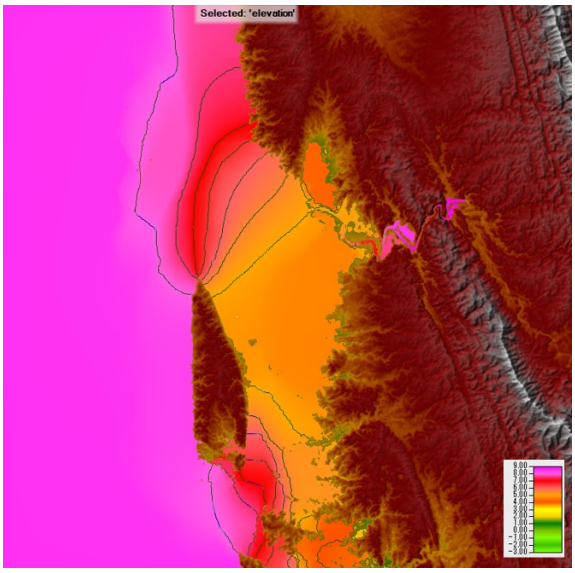
The results of 2-dimensional analyses are shown in the following figures.

Source: JICA Survey Team

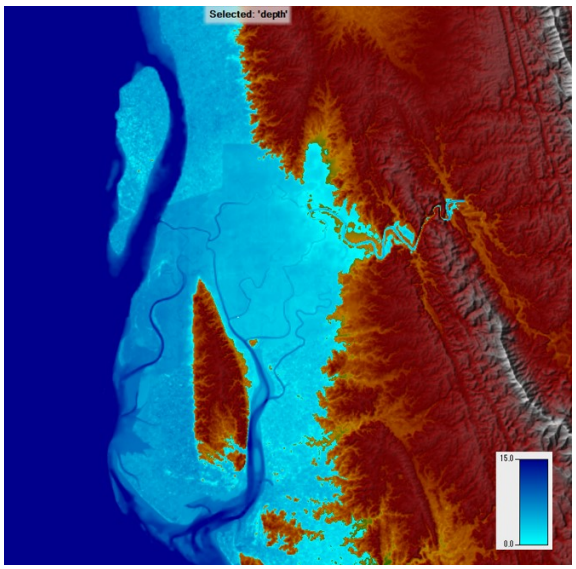
Hydraulic Profile on Proposed Road Alignment



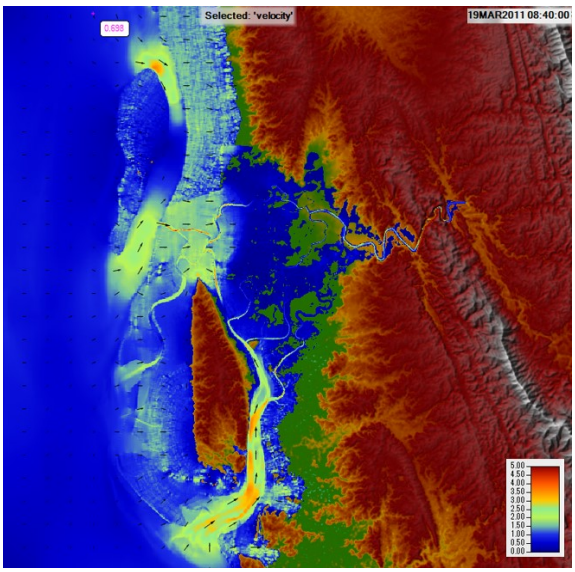
Maximum Water Surface Elevation Distribution
(50-year Storm Surge + 20-year Flood)



Maximum Water Surface Elevation Distribution
(100-year Storm Surge + 20-year Flood)



Distribution of Maximum Inundation Height
(100-year Storm Surge + 20-year Flood)



Flow Velocity / Velocity-Vector Distribution
(100-year Storm Surge + 20-year Flood)

Source: JICA Survey Team

2-Dimensional Flood Analysis Results

3.5 Construction Planning and Cost Estimates

Construction Schedule

Based on the analysis of construction work schedule per unit, the entire construction plan under the project was studied. The analyzed construction work schedule per unit is summarized as follows:

- Road: 13.0 months / km
- Bridge Substructure (Cast-in-place concrete piles): Abutment 2.5 month /place , Pier 4.5 months / place
- Bridge Substructure (Steel pipe sheet piles): 4.5 months / place
- Bridge Super structure (PC-I girders): 8.5 months / 1 span (40 m)
- Bridge Super structure (Steel box girders): 28.5 months / 4 spans (314 m)

Cost Estimates

For establishing the unit costs, the unit costs of "Construction of Kanchpur, Meghna and Gumti 2nd Bridges and Rehabilitation of Existing Bridges", RHD standard unit cost and WD Cox's Bazar standard unit cost were referred to. The following conditions should be factored:

- Price fluctuation is not considered.
- All of direct construction cost, temporary work cost, general administrative expenses, and site management cost are included in each unit cost.
- Consulting service fees are not included.
- VAT to be levied to the Contractor shall be borne by the Bangladesh government and shall not be covered by JICA's loan. However, payments from the Contractor to the Sub Contractors will be subject to taxation. Therefore, the estimated unit costs include such statutory taxes.
- Contingency is 5% of Construction cost.
- The following exchange rates shall apply:
  US$ 1 = Yen 106.11
  BDT 1 = Yen 1.28

The total construction cost was calculated based on the preliminary design and the analyzed unit cost. The table below summarizes the total construction cost (excluding VAT and contingency) and the unit costs for embankment sections and bridge sections estimated for 4-lane and 2-lane cases.

Comparison of the Estimated Construction Cost

	Total Construction Cost (excluding VAT & Contingency)		
	BDT billion	JPY billion	US$ million
4-lane Case			
2-lane Case			

Source: JICA Survey Team

Estimated Construction Cost per linear m (Embankment Sections)

	Unit Cost for Embankment Section per km		
	BDT million	JPY million	US$ million
4-lane Case			
2-lane Case			

Source: JICA Survey Team

Estimated Construction Cost per linear m (Bridge Sections)

	Unit Cost for Bridge Section per sq. m		
	BDT thousand	JPY thousand	US$
PC-I Girder Bridge			
Steel-I Girder Bridge			
Steel Box Girder Bridge			

Source: JICA Survey Team

The total construction costs for both cases result in a relatively high cost due to the following reasons.

Road Works

- Because of the frequent occurrence of floods and storm surges, the embankment is high and a considerable amount of materials for embankment construction is necessary;
- In order to construct the high embankment, soft ground improvement works and reinforced materials are necessary.

Bridge Works

- There are two rivers designated for class II canal by BIWTA having the minimum vertical

clearance of 12.20 m and the minimum horizontal clearance of 76.22 m;

- There is a high bridge section through the urban area;
- For the sub structure , the existing ground is soft and loose and it is difficult to work in the river during the wet season, so temporary works (temporary bridge, temporary cofferdam) are necessary;
- For the super structure , it is difficult to install girders by using truck cranes which is a relatively inexpensive method in order to adopt the "Launching Erection Method for Girder" (steel box girders) and "Girder Construction Method by Erection (temporary) Girder" (PC-I girders)

3.6 Implementation Plan

(1) Implementation Strategy (Phased Construction)

In a similar manner to the port component, the road aspect will also apply the phased construction approach. Whereas a 4-lane would be necessary at the final stage, a 2-lane road would be enough at the initial stage. However, it is recommended that the land acquisition for the road component is done entirely for the final 4-lane width at the initial stage considering the possibility of settlement along the project road in near future.

Interim Stage

- Land acquisition will cover the 4-lane width necessary in future;
- Embankment filling will cover the 2-lane width necessary at the initial stage but the remaining single side necessary at the final stage will also be filled to form with gentle slopes in order to protect the embankment against the frequent flooding as well as to prevent informal settlements;
- Pavement and bridge construction works will cover the single 2-lane only necessary at the initial stage. Therefore the size of the bridge substructures should be able to accommodate the width of the superstructures;
- Box culverts under the embankment will be constructed in view of the 2-lane width of embankment.

Final Stage

- By the time of commencement of the final stage, the settlement of embankment would be completed;
- Embankment filling for the remaining portion will be undertaken;
- Pavement and bridge construction works for the remaining 2-lanes will be undertaken;
- Box culverts under the embankment will be extended to allow for the 4-lane width of embankment.

(2) Scope of the Project

The scope of the project is summarized as follows:

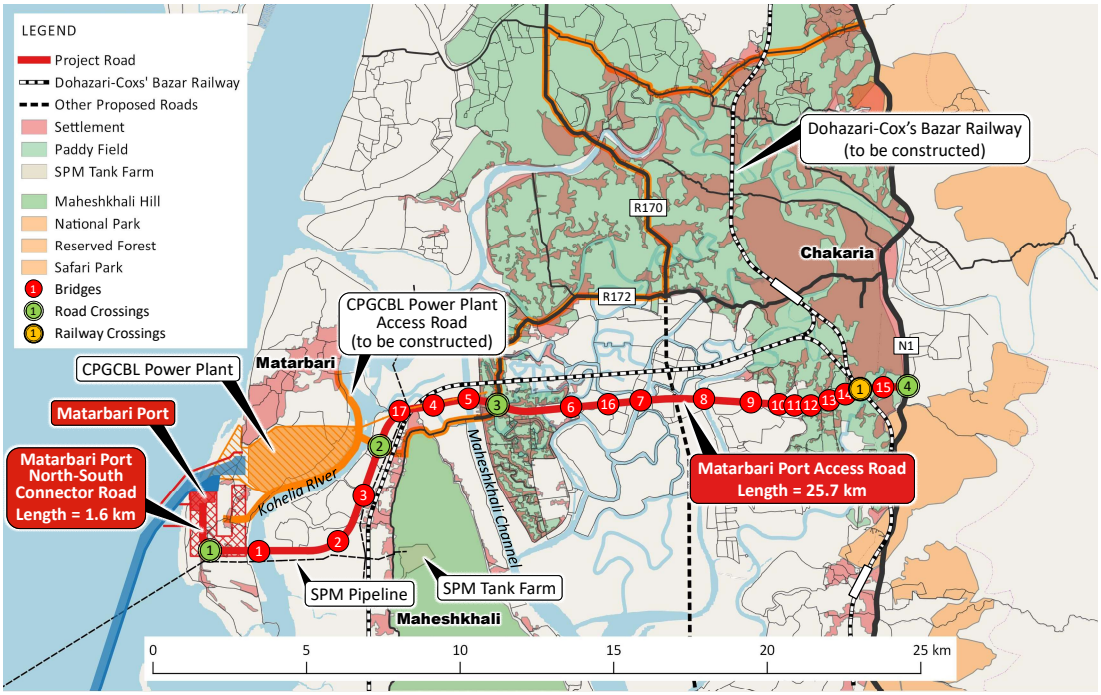
Matarbari Port Access Road

- Road length: 25.7 km
- Number of lanes: 2-lane (at initial stage, to be widened to 4-lane in future)
- Number of bridges: 17 (total 7,104 m)
- Number of intersections: 4 (3 at-grades, 1 grade separated)
- Installation of traffic signal: 1 (at the intersection with N1)
- Number of railway crossing: 1 (at-grade, Dohazari-Cox's Bazar Railway), Rail Spur Line to Matarbari is not considered at this stage
- Number of box culverts: 4 for roadway underpasses, 40 for pedestrian underpasses, 169 for channels
- Soft soil improvement: Replacement, surcharge with PVD, sand compaction pile
- Pavement type: Polymer modified asphalt concrete, semi-flexible pavement (only at intersections)

Matarbari Port North-South Connector Road

- Road length: 1.6 km
- Number of lanes: 4-lane

- Number of box culverts: 1 for roadway, 1 for pedestrian, 11 for channel
- Soft soil improvement: Replacement, preloading with PVD, sand compaction pile



Source: JICA Survey Team

Project Scope

List of Intersecting Roads/Railways

No.	Station	Road/Railway Name	Cross Angle	Intersection Type
1	0+000	Matarbari Port North-South Connector Road	90°	At-Grade
2	7+727	CPGCBL Power Plant Access Road	85°	At-Grade
3	11+780	R172	-	Grade Separation
4	23+935	Dohazari-Cox's Bazar Railway	64°	At-Grade
5	25+413	N1	90°	At-Grade

Source: JICA Survey Team

List of Bridges

No.	Station		Bridge Type	No of Spans	Span Arrangement (m)	Total Length (m)	River Name	Remarks
	From	To						
1	0+806	2+040	PC-I	11	11@40m=440m	1234	Kohelia River	BIWTA Class II
			Steel Narrow Box Girder	4	70m+2@87m+70m =314m			
			PC-I	12	12@40m=480m			
2	4+430	4+670	PC-I	6	6@40m	240	Nonaichnari Khal	*
3	6+080	6+215	PC-I	3	3@45m	135		*
4	9+890	10+115	PC-I	4	4@40m	160		*
5	10+680	12+154	PC-I	11	11@40=440m	1474	Maheshkhali Channel	BIWTA Class II
			Steel Narrow Box Girder	4	70m+2@87m+70m =314m			
			PC-I	18	18@40m=720m			
6	14+090	14+450	PC-I	9	9@40m	360	Bura Matamuhuri Khal	
7	16+490	16+760	PC-I	6	6@45m	270	ditto	
8	18+550	18+910	PC-I	9	9@40m	360	Matamuhuri	
9	20+460	20+580	PC-I	3	3@40m	120	Batamani Khal	*
10	21+340	21+430	PC-I	2	2@45m	90	ditto	*
11	21+530	21+690	PC-I	4	4@40m	160	ditto	*
12	21+785	21+920	PC-I	3	3@45m	135	ditto	*
13	22+680	22+840	PC-I	4	4@40m	160	Fasiakhali Chara	*
14	23+390	23+550	PC-I	4	4@40m	160	ditto	*
15	24+455	24+495	PC-I	1	40m	40		
16	14+640	15+900	Steel I Girder	23	50m+4@60m+50m x 3 +45m+3@50m+45m	1,260		Soft Ground
17	9+012	9+683	PC-I	3	3@45m=135m	671		LNG Pipeline
			Steel Narrow Box Girder	1	70m			
			PC-I	11	35m+5@45m+26m +4@45m=466m			

Note: * represents that bridge construction may not be necessary in view of drainage surveys. Further engineering study should be made during the detailed design stage in order to justify the necessity of bridges.
Source: JICA Survey Team

(3) Implementation Schedule

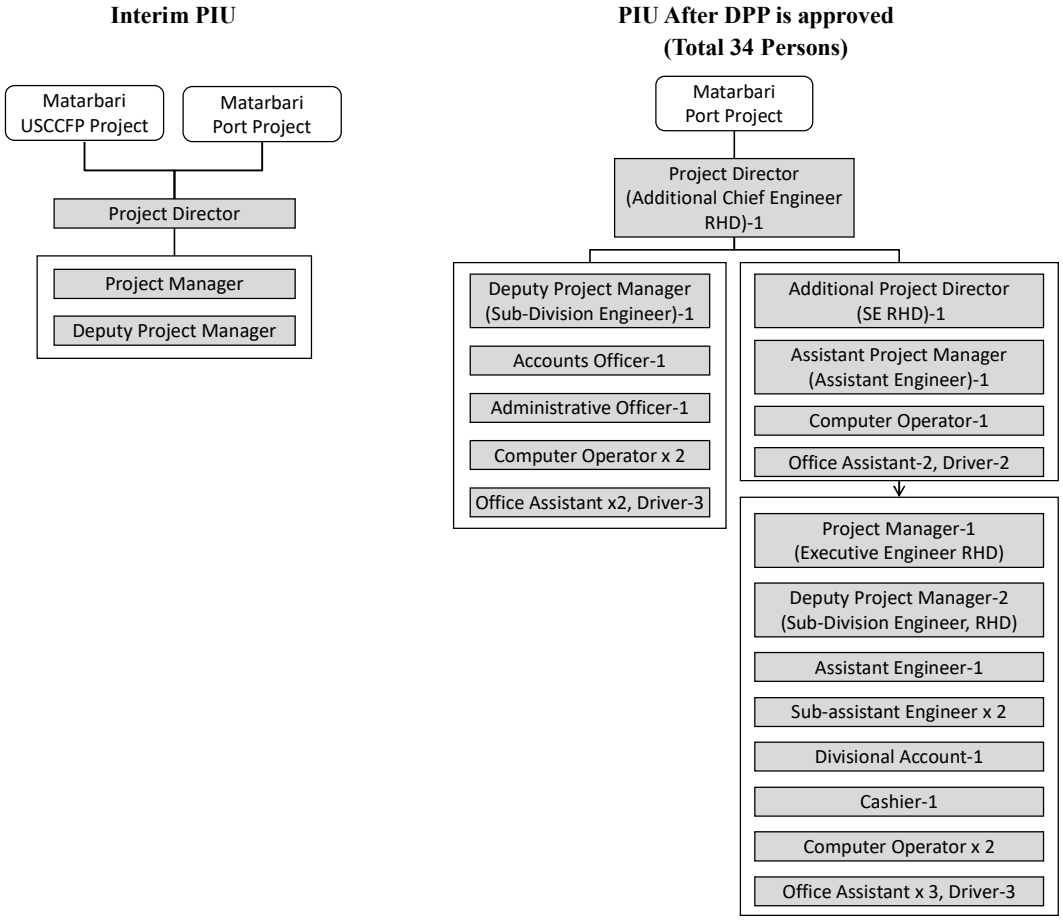
Implementation schedule of the road component of the project is to be as follows. The expected project completion is May 2024.

- Loan Agreement: July 2018
- Procurement of the Consultant: from Apr 2018 to Nov 2018 (6 months)
- Detailed Design: from Dec 2018 to Nov 2019 (12 months)
- Procurement of the Contractor: from Dec 2019 to Nov 2020 (12 months)
- Construction: from Dec 2020 to May 2024 (42 months)

At this moment, the road component is expected to be divided into three (3) contract packages. The procurement method will be International Competitive Bidding (ICB) with a single-stage two-envelope bidding approach including prequalification. The applicable standard bidding document will be the "Standard Bidding Document for Works".

(4) Implementation Structure

RHD will be the executing agency for the access road component of the project. After approval of the Development Project Proposal (DPP), a Project Implementation Unit (PIU) will be organized under RHD. Before approval of the DPP, an Interim PIU has been organized under the same umbrella of the CPGCBL's Power Plant Access Road Project. The required personnel to form the PIU is estimated to be 34 persons.



Source: RHD

Implementation Structure (RHD)

(5) Consultancy Services

The scope of the works of access road construction has not yet been finalized and it would be difficult to justify the necessary inputs for consultancy services for the project but the following are the tentative assumptions for the period of consultancy services.

- Detailed Design: 12 months, from Dec 2018 to Nov 2019
- Tender Assistance: 12 months, from Dec 2019 to Nov 2020
- Construction Supervision: 42 months, from Dec 2020 to May 2024
- Defect Liability Period: 12 months, from Jun 2024 to May 2025

Table 2.2 shows the required Man-Months of the consultancy services for detailed design, tender assistance, construction supervision and defect liability period. 561 man-months of International Experts, 1,153 man-months of Local Experts and 1,420 man-months of supporting staff will be engaged, over a 64

months' duration of consulting services. Total consulting input excluding supporting staff is 1,714 man-months.

(6) Operation and Maintenance Plan

Maintenance of Pavement

The key objectives of pavement maintenance and repairs are :

- To sustain pavement durability and the integrity of the pavement structure
- To sustain driver's comfort and maintain traffic safety
- To avoid environmental deterioration

Inspection and maintenance activities are often conducted while the road is open to public traffic. Therefore the following aspects should be considered while inspections and maintenance are conducted:

- Identify surface condition changes in the early stages of deterioration
- Damages which need emergency repairs shall be repaired temporarily
- Surface conditions shall be monitored to predict future surface changes
- Maintenance schedules shall have long term plans
- Make effective use of surface condition information and construction records
- Enforcement of automobile laws and traffic safety education

The major inspection items for pavements are rutting, cracking, skid resistance, faulting and local deformation. The major repair methods for asphalt pavements are overlays, patching or replacement of the pavement.

Maintenance of Bridges

The purpose of maintenance and repairs are classified in two categories:

- To retain load bearing capacity and to sustain bridge durability
- To prevent failure of the bridge structure and to maintain traffic safety

It is necessary to keep design data, in particular the detailed engineering specifications, design calculations and drawings of bridges and viaducts since these are essential reference materials for planning and engineering of the maintenance and repairs.

In order to maintain bridges in good condition, the deck surface, superstructure and substructure of bridges shall be inspected by routine, periodic and special inspections. When deficiencies are found, maintenance and repairs must be carried out. The major types of concrete deterioration are cracking, delamination, pop-outs, scaling, abrasion, spalling, efflorescence, honeycombs, or corner failure.

Institutional Capability of RHD for Roads and Bridges Maintenance

RHD has been using the Highway Development and Management Model (HDM-4) as an economic tool since FY 1999-2000. All roads have been analyzed to assess the overall long-term maintenance need of the RHD road network. Ongoing projects have been excluded from the HDM analysis to project the immediate maintenance requirement. However, few segments either completed or ongoing projects may appear in the HDM outputs because they were not reported by the field offices before the HDM analysis. The outputs from HDM-4 are based on the Road Maintenance and Management System (RMMS) database of RHD. Using the RMMS database, RHD has identified the total maintenance need of the RHD road network and has selected and prioritized the maintenance works based on NPV over financial cost ratio.

Since FY 2005-2006, RHD has introduced a new procedure of maintenance program called Road and Bridge Asset Management System (RAMS), which brings together all RHD's databases and analytical procedures. The final output of RAMS is the GIS-based map for each Division which combines all relevant information and shows decision makers where they can most effectively allocate funds for maintenance and rehabilitation. However, the biggest challenge for roads and bridges maintenance under RHD road network is budget shortage. Even though the maintenance system has been formulated, the physical maintenance activities have not been conducted properly.

Maintenance Plan for the Project Road

In order to maintain the project road in good condition, proper maintenance activities should be carried out during the operation and maintenance stage. The following table summarizes the estimated maintenance cost for the project road over 30 years.

Estimated Maintenance Cost for the Project Road (30 Years)

	Frequency	Unit Cost (Million BDT)	No. of Times	Cost (Million BDT)
Routine Maintenance				
Inspection	Every week	0.00625	1,440	10.5
Partial Resurfacing of Pavement	Every year	17	30	510.0
Sub-total				**520.5**
Periodic Maintenance				
Full Resurfacing of Pavement	Every 10 years	682	3	2,046.0
Bridge pavement resurfacing	Every 15 years	80	2	160.0
Replacement of Expansion Joint	Every 15 years	182	2	364.0
Replacement of Waterproofing Layer of Bridge	Every 30 years	265	1	265.0
Repainting of Steel bridge coating	Every 30 years	270	1	270.0
Sub-total				**3,105.0**
Total Cost per 30 Years				**3,625.5**

4. Environmental and Social Consideration

4.1 Environmental Impact Assessment

4.1.1 Project Outline

The port portion of this project is in Dhalghata Union (the smallest unit of the municipality in Bangladesh), which is 1,980 hectares (19.8 km 2) in size. Dhalghata Union's wetland distribution is 849.51 hectares, about 43% of the union, and aquaculture is a very popular area. Salt / shrimp farms occupy about 80% of the total 107.3 hectares of the planned port area and dredging soil dumping area.

The access road of this project is about 25.7 km from Mohşhkhali Upazilla to Chakaria Upazilla. The access road passes through the southern ends of the six unions of these two Upazilas, namely Dhalghata Union and Kalarmarchara Union in Moheshkhali Upazila, Badarkhali Union, Saharbil Union, Chiringa Union and Fasiakhali Union in Chakaria Upazila. The survey area of the EIA is a 2.5 kilometer buffer zone from the ROW of the road, consisting of salt fields (5996.2 hectares, 39.1% of the total area), rice cultivation (11.6%), rural vegetation (10.5%). The total area of the business area is about 200.8 hectares, mainly covered with salt fields.

The Port Project site is located in the Dhalghata Union, and it is as big as 1,980 ha (19.8km2). The wetland distribution of the Dhalghata Union is 849.51 hectare, which is about 43 % of the Union. Aquaculture is quite popular for this area, and it covers 99% of the wetland. Out of the planned port area totaling 75.0 ha, 89.0 % accounts for salt pan/shrimp farm, and others are 10.8% for inter tidal area, and 0.2 % for river and pond.

The access road project is approximately 25.6 km from Moheshkhali Upazila to Chakaria Upazila. The access road shall travel through the 8 unions of these two Upazilas, namely, Dhalghata, Kalarmarchara, north edge of Saflapur, Badarkhali, South edge of Paschim Bara Bhola, Saharbil, Chiringa and Fasiakhali. The study area, 2.5 km buffer of the ROW of the road, is mostly surrounded by Salt Pan (5996.2 ha, which is 39.1% of the total area) followed by Aman and Boro of 11.6% and rural settlement with homestead vegetation of 10.5%. Total land of the project area is about 243.4 ha which is mainly covered by salt pan.

4.1.2 Protected land and Ecological Critical Area-ECA

Forest reserve and hilly areas are located around the project site. They are: Moheshkhali Forest Reserve and Hill Region, Fasiakhali Wildlife Reserve, Medhakacchapia National Park, Sonadia Ecological Critical Area (ECA). The table below is an overview of the protected areas and hilly areas, ECAs found around the planned ports and their access roads.

Forest reserves, wildlife reserves, and national parks are managed by the Forest Department (DoFo). On the other hand, ecological critical areas (ecologically important areas = ECA) and hilly areas are managed by the Environmental Agency (DoE).

At the area located in 12 km south of the expected Port, there exists Sonadia Ecologically Critical Area. Sonadia ECA was declared in 1999 by the Bangladesh Environment Conservation Act (1995) by DoE, and it is about 4,900 ha of land. The area contains habitat for spoon billed sandpipers, which are rare species with the status of CR (critically endangered) and by considering this habitat, the area has been identified as the critical natural habitat.

Forests and Hills surrounding the Planned Port and its Access Road

Name	Area (ha)	Administered Law	Administered Organization	Gazette/attachment on the areas
Moheshkhali Forest	4142.8	Forest Act (1927) Article 29~34	DoFo	No. 1222- For dated 31-01-1957
Fasiakhali Wildlife Reserve	1302.4	Bangladesh Wild Life (Preservation) Order, 1973/ Act 2012	DoFo	IUCN Category: IV Area: 1302.42 Ha Gazette Date: 11-4-2007
Medha Kacchapia National Park	395.9	Bangladesh Wild Life (Preservation) Order, 1973 / Act 2012	DoFo	IUCN Categorization: IV Area: 395.92 Ha Gazette Date: 04-4-2004
Sonadia ECA	4916 .0Ha	Environmental Conservation Act Article 5 "Ecological Critical Area"	DoE	Area: 4916 Ha Gazette Date: 19-4-1999
Moheshkhali Hill Area	N/A	Environmental Conservation Act Article 6B "Restriction on cutting hill"	DoE	No Gazette. Need to be checked by khatian of mouza

Source: JICA Survey Team

4.1.3 Comparisons of Alternatives

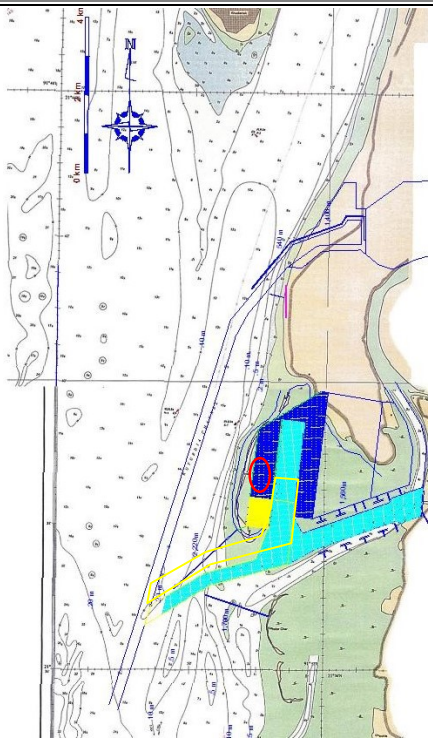
(1) Port

In the port portion of this survey, the four options were compared and examined. Table below shows feature comparison and map comparison of port development options. The project target year is 2026, looking at the overall picture including the different expansion schedule. In addition, the dredged soil of each option was marked with a red circle as the land dumping place. Regarding ocean dumping, a common place is determined for the 4 options shown in the figure below.

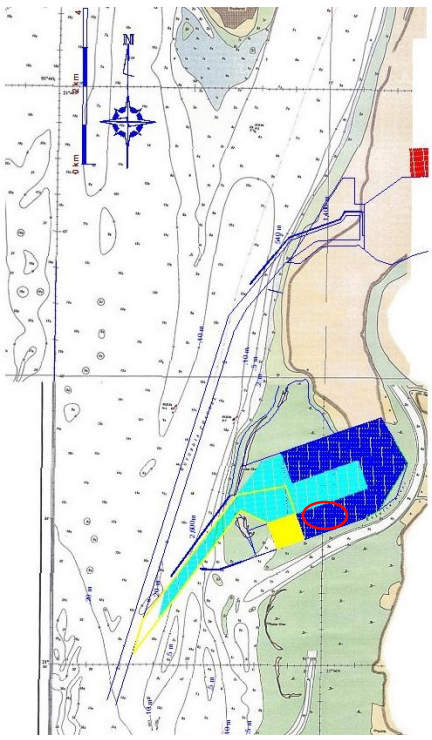
Outline of Four Options

Options	Option Description
without Project	No construction of port in this area, increased cargo will be handled at the expansion to Chittagong Port and increases to Payra Port.
Option1	Development of port by using the Kohelia river in the southern Dhalghata.
Option2	Separation from the Kohelia River in the southern Dhalghata and develops a port in the Dhalghata district.
Option3	CPGCBL dredge the route from the coal port to the Kohelia river to develop the new port.
Option4	CPGCBL dredge to the south from coal port to develop ports. (It does not connect to the Kohelia River.)

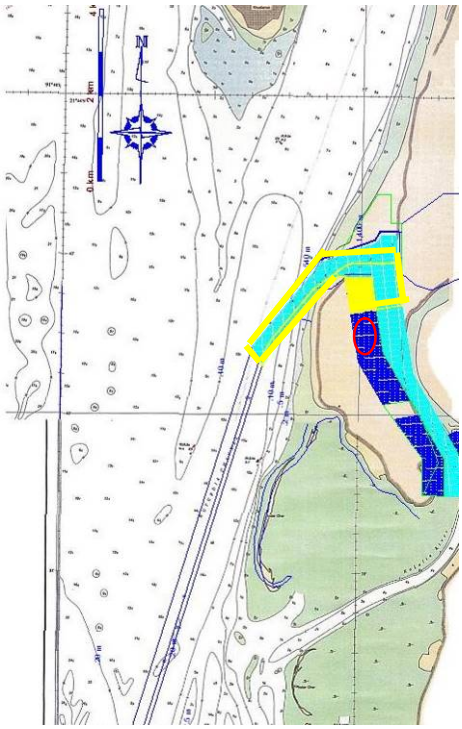
Source: JICA Survey Team



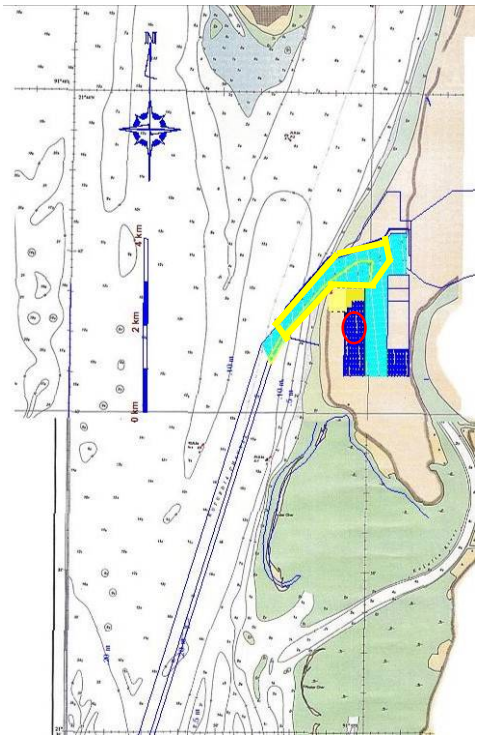
Option 1



Option 2



Option 3



Option 4

Legend: This Project; Future plan; Sea route and Shipping area; Dumping place on land

Source: JICA Survey Team

Plans of Four Options

Note: The timing of completion in the future expansion differs for each option.

Analysis of Options (Port)

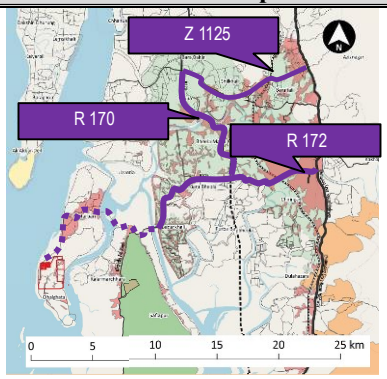
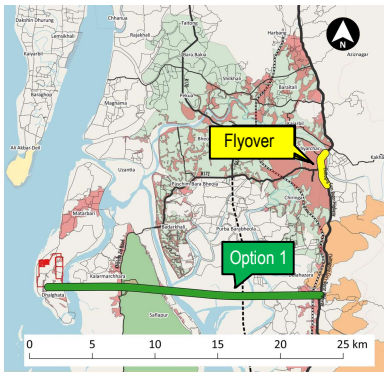
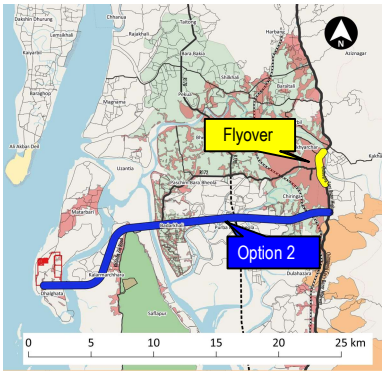
Option Plans	Overall evaluation	Comments
Without Project	B	There is a limit to expansion of Chittagong Port, and it is assumed that Payra Port cannot accept large container ships, so it cannot cope with increasing cargo volume.
Option No.1	D	Large initial investment. Destruction of mangrove forest. Relatively close to Sonadia Ecological critical area
Option No.2	D	Large scale initial investment
Option No.3	C	Bridges are necessary, transportation is not convenient.
Option No.4	A	Residents' relocation and impact on the natural environment are small, and it is possible to open with relatively small investment.

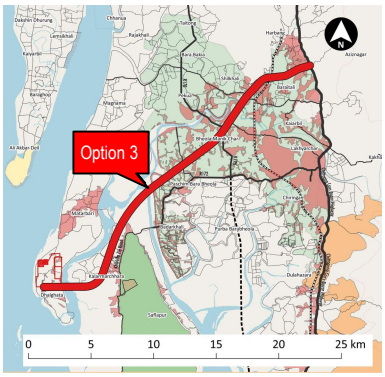
Source: JICA Survey Team

(Note) A: The highest evaluation, B: Good, C: Other options can be desirable, D: Shall be avoid

(2) Road

Overview of Alternatives

Alternatives	Location map	Features of the alternative plan
Without Project: To utilize the existing roads ("R172 - R170 - Z1125" or "R172")		・Concept: To utilize the existing roads "Regional Highway No. 172 (R172) - Regional Highway No. 170 (R170) - District Road No. 1125 (ZR1125)" or "R 172" ・Project features: No road nor land acquisition is required.
Option 1: Shortest route		・Concept: To connect to N1 by the shortest route ・Project features: Construction of a new road of approximately 22 km. Traversing Moheshkhali Hills, it connects the Port to N 1 in almost due west. In order to secure the accessibility to Chittagong direction, a flyover is required where N1 passes through the density area of Chakaria Paurashava. As most of the section passes through salt farms and shrimp farms, the section passing through residential area is rather short.
Option 2: Eastward route with avoiding Moheshkhali Hills		・Concept: To avoid Moheshkhali Hills while minimizing the section passing through private land and residential area ・Project features: Construction of a new road of approximately 25 km. Although it avoids Moheshkhali Hills, it passes through a village at the north foot of the Hills and a market after crossing the river. In order to secure the accessibility to Chittagong direction, construction of a flyover is required where N1 passes through the density area of Chakaria Paurashava. As most of the section passes through salt farms and shrimp farms, the section passing through residential area is rather short.

Alternative plan	Location map	Features of the alternative plan
Option 3: Route connecting to Chittagong direction with avoiding Moheshkhali Hills		・Concept: To avoid Moheshkhali Hills, extend to the northeast and connect to N1 in the direction of Chittagong ・Project features: Construction of a new road of approximately 30 km. It excels in the accessibility to the Chittagong and flyover of N1 in the section passing through Chakaria density area is not required by the Project. The route passes through three Upazilas, namely Moheshkhali, Pekua and Chakaria. Mainly salt farms and shrimp farms stretch in the section of Moheshkhali and Pekua, while paddy fields and residential areas stretch in Chakaria, meaning that long extended section passes through private land.

* Legend of the above location maps are as follows.

settlement　agricultural/ paddy field　hills　natural park, reserved forest
salt farm, shrimp farm

Source: JICA Survey Team

Analysis of Options (Road)

Option Plans	Overall evaluation	Comment
Without Project	**D-**	There is no passable road for large vehicles at Moheshkhali Upazila side, which makes smooth freight transportation impossible. As for utilization of local and district roads at Chakaria Upazila side as well, which means freight traffic such as trucks passing through community roads, it is not desirable from traffic safety as well as freight transportation planning points of view.
Option No.1	**D**	Although it is the shortest route and the negative impact on social environment seems to be minimum among the plans with project implementation, this plan is not desirable because it interferes with Moheshkhali Hills and forests and also because ethnic minorities are likely to subject to resettlement.
Option No.2	**B**	Since the road circumvents Moheshkhali Hills and forests, concern about natural environment is significantly mitigated. Although there are fewer private properties, it passes through the village on the northmost part of Moheshkhali Hills and there is concern about many relocated residents. Though relocation of additional 50 shops will be required, high project effect can be expected by securing smooth traffic to Chittagong
Option No.3	**C**	There are long extensions of the sections passing through private properties, therefore there is concern about a lot of land acquisition, resettlement and community severance. By taking much time for land acquisition, it is very likely that the road is not opened in time for the opening of the port, therefore this plan is undesirable.

Source: JICA Survey Team

(Note) A: The highest evaluation, B: Good, C: Other options can be desirable, D: Shall be avoided

4.1.4 Scoping and Environmental Impact Assessment

Scoping are carefully pursued in the EIA and the environmental and social consideration survey was conducted based on the scoping proposal. Scoping looks at 30 categories of 3 items: pollution control, natural environment, and social environment. Based on the environmental and social consideration survey results, environmental and social impact was analyzed. The following table shows the results of environmental impact assessment of ports and roads.

Scoping Matrix (port)

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	**Construction phase:** Production of dust is expected from land preparation and other construction work, but the impact will be temporary. **Operation phase:** Air pollution is predicted caused by exhaust gas generated from the vessels using the port. Dust is also predicted, produced from loading-unloading. Some cumulative impact will be seen.
	2	Water Quality	B-	A-	**Construction phase:** Turbid water is expected to be produced from the dredging activity. Also, concrete wastewater and oil-containing wastewater are expected to have an effect. **Operation phase:** Turbid water is expected to be produced from the maintenance dredging of the navigation channel. Ballast water should be properly managed and need the adequate treatment. Water pollution is also expected from the wastewater discharged from vessels using the port. Some cumulative impact will be seen.
	3	Waste	B-	A-	**Construction phase:** In order to make the water way, beach sand will be dredged. dredged materials will be ocean dumping and land dumping. General waste and hazardous waste will be generated by the construction work, but the impact will be temporary. **Operation phase:** Dredging will be periodically conducted because of maintenance of the water way. The disposal area of the dredged material is not determined yet, either onshore or offshore. Waste will be generated from the vessels using the port. Some cumulative impact will be seen.
	4	Soil Contamination	B-	B-	**Construction phase:** Occurrence of construction waste and waste materials is assumed. **Operation phase:** Pollutants are assumed to be generated from ships entering and leaving ports.
	5	Noise and Vibration	B-	B-	**Construction phase:** Impact of noise and vibration from the construction work is predicted but will be temporary. **Operation phase:** Impact of noise and vibration from the loading-unloading is predicted.
	6	Subsidence	C	C	**Construction and Operation phases:** The impact is unknown.
	7	Odor	D	D	**Construction and Operation phases:** No usage of substances that may be a potential source of foul odors is anticipated.
	8	Sediment	B-	B-	**Construction Phase**: The dredged sediment ocean dumping place may be affected. The influence on the benthos organisms

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
					in the area where the dredging route is conducted is predicted. **Operation phase:** Because of maintenance dredging, influence is assumed.
Natural Environment	9	Protected Areas	D	D	**Construction and Operation phases:** The protected areas are not existent in the Project area.
	10	Ecosystem	B-	B-	**Construction Phase**: The sandy beach of the intertidal zone of that part disappears for the construction of the port facility. Impacts on the surrounding ecosystems (birds, sea turtles, dolphins) by construction activities are assumed. **Operation phase:** Birds, sea turtles, dolphins and the like are expected to be inhabited. It is assumed that the influence of the ship of a large ship on the shoreline of the drill wave is assumed. Cumulative effects on the ecosystem due to surrounding development are also conceivable.
	11	Hydrology	B-	B-	**Construction and Operation phases:** The construction of the port facility may alter the hydrology surrounding area. Some cumulative impact will be seen.
	12	Topography and Geology	B-	B-	**Construction and Operation phases:** The construction of the port facility may alter the geography and geology of the area around the proposed site and cause the natural seashore to disappear. Some cumulative impact will be seen.
Social Environment	13	Resettlement and Land Acquisition	A-	D	**Pre-Construction:** Approximately 28ha of private land including residential area need to be acquired. Approximately 50 HHs will be resettled. **Construction:** No impact is expected, as relocation will be completed before construction begins. **Operation:** No impact is expected, as relocation will be completed before construction begins.
	14	Poor Classes	B- /B+	B-/ B+	**Pre-Construction:** There are poor households among those to be resettled and/or lose their livelihood means. **Construction:** They will have job opportunities at the construction site. **Operation:** Resettled people may experience the deterioration of their household economies and loss of livelihood following relocation if appropriate measures are not taken. Positive impact will be expected due to improvement of local economy.
	15	Ethnic Minorities and Indigenous Peoples	C	C	**Pre-Construction:** There can be ethnic minority and indigenous people found in or around the project site. **Construction:** Livelihood of ethnic minority can be affected by employment in construction work if ethnic minority and indigenous people live in or around the project site. **Operation:** Livelihood of ethnic minority can be affected by employment in port operation if ethnic minority and indigenous people live in or around the project site.
	16	Local Economy such as Employment and Livelihood, etc.	B-/ B+	B-/ B+	**Pre-Construction:** Employers/ employees of salt farms, shrimp farms, fishermen, farmers and some ferry boat workers may lose their means of livelihood or their jobs. Fishing activities around the site will also be affected due to a rise of water temperature and restriction of fishing. Cumulative

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
					impact from the adjacent project will be expected. **Construction:** Local people will be employed for construction work. The sandy beach will disappear due to the dredging activities for the port's construction and maintenance, resulting in the loss of fishing ground. Cumulative impact from the adjacent project will be expected. **Operation:** There is the possibility of loss of means of livelihood in salt farming and shrimp farming. Cumulative impact from the adjacent project will be expected. The construction of port will benefit the lives of local people through improvement of marine transport.
	17	Land Use and the Utilization of Local Resources	A-	A-	**Pre-Construction/ Construction:** The implementation of this project will change the traditional land use pattern and utilization of local resources. **Operation:** Influx of port workers may change the traditional land use pattern and utilization of local resources.
	18	Water Usage and Water Rights	A-	B-	**Pre-construction:** No activities are expected to give any impact on water usage. **Construction phase:** Local economy may be affected by the turbid water discharged from the construction site. Outflows of street dust and oil while it rains, may also cause certain effects. **Operation phase:** Local economy may be affected by the discharged water into the sea.
	19	Existing Social Infrastructure and Services	B-	B-	**Pre-construction:** Some social infrastructure may subject to relocation. Access to social infrastructure and social service may be affected due to resettlement of project affected persons. **Construction:** Construction work may disturb access to existing social infrastructure and social services. **Operation:** Increased marine traffic may disturb the existing marine traffic (traffic of fishing boats).
	20	Local Communities and Decision-making Institutions	B-	D	**Pre-construction:** Partial **r**esettlement of existing local communities may affect the concerned local communities and decision-making institutions. **Construction:** No impact is expected as relocation will be completed before construction begins. **Operation:** No impact is expected as relocation will be completed before construction begins.
	21	Unequal Distribution of Benefits and Damages	B-	B-/ C	**Pre-Construction:** There may be feelings of resentment, because people living around the project site will benefit through the improvement of social infrastructure and services. People to be resettled and those who lose their means of livelihoods will receive certain damages. **Construction:** Local resident may not receive benefits if external workers are employed at construction site. **Operation:** Local resident may not receive benefits if external workers are employed at port facility.
	22	Local Conflicts of Interest	B-	B-	**Pre-Construction:** Local conflicts of interest may occur between residents, and between local administration bodies and local political leaders.

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
					Construction: Conflicts between local residence and external workers may occur because of changes in local customs if the external workers cannot understand local customs. **Operation:** Conflicts between local residence and external port workers may occur because of changes in local customs if the external port workers cannot understand local customs.
	23	Cultural Heritage	C	C	**Pre-Construction/ Construction:** There can be historical, cultural and archaeological properties and heritage sites existing at the site, which will be confirmed through survey. **Operation:** There can be historical, cultural and archaeological properties and heritage sites existing near the site, which will be confirmed through survey.
	24	Landscape	B-	D	**Pre-construction:** No activities are expected to give any impact on landscape. **Construction:** Landscape will be affected during construction. **Operation:** No significant impact will be expected as there is no scenic spot near the site.
	25	Gender	B-	B+/ B-	**Pre-construction:** Unequal distribution of compensation can be occurred within households. **Construction:** Unequal employment opportunity can be provided at construction site. **Operation:** Improvement of local economy will give positive impact. Unequal employment opportunity can be provided at port facility
	26	Children's Rights	B-	B+/ B-	**Pre-construction phase:** There are children among households to be resettled and/or lose their livelihood means. Children from households losing their land or jobs may suffer from adverse impact on their household economy, such as dropping-out of school. **Construction phase:** Children's ability to go to school may further deteriorate if access way to their school is physically blocked by the construction site. Child labour can be provoked at the construction site because of the huge demand for unskilled workers. **Operation phase:** Improvement of local economy will give positive impact. Child labour can be provoked at the port facility.
	27	Infectious Disease such as HIV/AIDS	B-	B-	**Pre-construction:** No impact is expected as no influx of migrant labor is expected at this phase. **Construction:** A temporary influx of migrant labor during the construction period may increase the risk of infectious diseases. **Operation:** Influx of migrant port worker may increase the risk of infectious diseases.
	28	Work Environment (Including Work Safety)	B-	B-	**Pre-construction:** No activities are expected to give any impact on work environment. **Construction phase:** Accidents may be caused by construction work. **Operation phase:** Accidents may be caused by the entry and departure of vessels and loading-unloading of cargo.

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
Others	29	Accidents	B-	B-	**Pre-construction:** No activities are expected to cause accidents. **Construction phase:** Accidents may be caused by construction work. **Operation phase:** Accidents may be caused by increased marine traffic.
	30	Cross-boundary Impact and Climate Change	C	C	**Construction phase:** CO_2 will be produced from construction work, but the impact on climate change will be checked. **Operation phase:** CO_2 will be produced by entry and departure of vessels, but the impact on climate change will be checked.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Possibility, degree or extent of impact is unknown. (Further examination is needed.)
D: No impact is expected.

Source: JICA Study Team

Scoping Matrix (Access Road)

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	**Construction phase:** Production of dust is expected from land preparation and other construction work, but the impact will be temporary. The Emission of atmospheric pollutants (SOx, NOx, etc.) by heavy machinery and trucks is considered, but the influence range due to discharge is limited to the vicinity of the construction site. **Operation phase:** Air pollution is predicted caused by exhaust gas generated from the vessels using the port.
	2	Water Quality	B-	B-	**Construction phase:** Turbid water is expected to be produced from the dredging activity. Also, concrete wastewater and oil-containing wastewater are expected to have an effect, **Operation phase:** It is assumed that the exposed soil flows into the river with surface water.
	3	Waste	B-	D	**Construction phase:** General waste and hazardous waste will be generated by the construction work. **Operation phase:** No solid waste will be generated.
	4	Soil Contamination	B-	B-	**Construction phase:** There is a possibility of soil contamination due to leakage of fuel oil and lubricant from construction vehicles and construction machinery. **Operation phase:** Salt pans and paddy fields soil may be affected by traffic.
	5	Noise and Vibration	B-	B-	**Construction phase:** Although the effects of noise and vibration are assumed due to the operation of heavy machinery and trucks, the influence range is limited to the vicinity of the construction site. **Operation phase:** Impact of noise and vibration from the

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
					vehicles is predicted.
	6	Subsidence	C	C	**Construction Phase:** The impact will occur if the soft ground is existing. **Operation phases:** Same as above.
	7	Odor	D	D	**Construction and Operation phases:** No usage of substances that may be a potential source of foul odors is anticipated and the impact is temporary.
	8	Sediment	B-	D	**Construction phase:** Some negative influences due to disturbing river mud at the time of bridge construction can be considered. **Operation phase:** No effect or minor. no discharge or disposal will be necessary.
Natural Environment	9	Protected Areas	D	D	**Construction and Operation phases:** The protected areas are not existent in the Project area.
	10	Ecosystem	B-	B-	**Construction Phase:** There are mangrove forests by afforestation or natural forest along the river. If there is construction in the vicinity of the surrounding reserve, there are effects on animals and plants. **Operation phase:** When passing through neighboring protected areas, there are effects on animals and plants.
	11	Hydrology	C	B-	**Construction phase:** The influence is seen depending on the type of bridge construction on the river. **Operation phases:** Depending on the type of bridge, there are negative impacts. Due to the embankment of the road, it is expected that changes of the flood-affected area will occur at the time of monsoon, so countermeasures such as drainage are required.
	12	Topography and Geology	B-	B-	**Construction phase:** The embankment and cutting may influence the topography and geology, but significant impacts are not assumed as the embankment is used as most of the project planning area is flat. **Operation phases: The** erosion of the slope is assumed, but the influence is minimized by revetment construction.
Social Environment	13	Resettlement and Land Acquisition	A-	D	**Pre-Construction phase:** Approximately 55ha of private land including residential area need to be acquired. Approximately 150 HHs will be resettled. **Construction:** No impact is expected, as relocation will be completed before construction begins. **Operation:** No impact is expected, as relocation will be completed before construction begins.
	14	Poor Classes	B-/ B+	B-/ B+	**Pre-Construction phase:** There are poor households among those to be resettled and/or lose their livelihood means. **Construction phase:** They will have job opportunities at the construction site. **Operation phase:** Resettled people may experience the deterioration of their household economies and loss of livelihood following relocation if appropriate measures are not taken. Positive impact will be expected due to improvement of local economy.
	15	Ethnic	C	C	**Pre-Construction:** There can be no ethnic and indigenous

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
		Minorities and Indigenous Peoples			people found in or around the project site. **Construction:** Livelihood of ethnic minority can be affected by employment in construction work if ethnic minority and indigenous people live in or around the project site. **Operation:** Livelihood of ethnic minority can be affected by change of regional economy after road operation if ethnic minority and indigenous people live in or around the project site.
	16	Local Economy such as Employment and Livelihood, etc.	B-/B+	B-/B+	**Pre-Construction phase:** Employers/ employees of salt farms, shrimp farms, fishermen and farmers may lose their means of livelihood **Construction phase:** Local people will be employed for construction work. Access to market may be restricted. **Operation phase:** There is the possibility of reductions of means of livelihood in salt farming, shrimp farming and rice farming activities. The construction of road and bridges will benefit the lives of local people such as improvement of access to social services and opportunity of employment.
	17	Land Use and the Utilization of Local Resources	B-	D	**Pre-Construction/ Construction/ Operation phase:** There is the possibility of a change of traditional land use patterns and utilization of local resources **Operation:** No impact is expected, as activities requiring change of land use and utilization of local resources will be completed by the end of construction.
	18	Water Usage and Water Rights	B-	B-	**Pre-Construction/ Construction phase:** Salt farm/ paddy field may be affected by the turbid water discharged from the construction site. Outflows of street dust and oil while it rains, may also cause certain effects. **Operation phase:** Salt farm/ paddy field may be affected by the discharged water from the road.
	19	Existing Social Infrastructure and Services	B-	B+/B-	**Pre-construction:** Some social infrastructure may subject to relocation. Access to social infrastructure and social service may be affected due to resettlement of project affected persons. **Construction:** Construction work may disturb access to existing social infrastructure and social services. **Operation:** Access to social infrastructure and services will be improved. Increased traffic volume may disturb the access.
	20	Local Communities and Decision-making Institutions	B-	B-	**Pre-construction:** Partial **r**esettlement of existing local communities may affect the concerned local communities and decision-making institutions. **Construction:** Community can be divided because passage is blocked by construction work. **Operation:** Community can be divided because passage is blocked by the access road.
	21	Unequal Distribution of Benefits and Damages	B-	B-	**Pre-Construction Phase:** There may be feelings of resentment, because people living around the project site will benefit through the improvement of social infrastructure and services. People to be resettled and those who lose their means of livelihoods will receive certain damages. **Construction phase:** Part of residents will have disadvantage

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
					because access is limited by construction work. **Operation:** People living around the road will benefit through the improvement of social infrastructure and services, but people living far from the road will not benefit much
	22	Local Conflicts of Interest	B-	D	**Pre-Construction:** Local conflicts of interest may occur between residents, and between local administration bodies and local political leaders. **Construction:** Conflicts between local residence and external workers may occur because of changes in local customs if the external workers cannot understand local customs. **Operation:** No activity will be conducted to cause local conflict of interest.
	23	Cultural Heritage	C	C	**Pre-Construction/ Construction:** There can be historical, cultural and archaeological properties and heritage sites existing at the site, which will be confirmed through survey. **Operation:** There can be historical, cultural and archaeological properties and heritage sites existing near the site, which will be confirmed through survey.
	24	Landscape	B-	D	**Pre-construction:** No activities are expected to give any impact on landscape. **Construction:** Landscape will be affected during construction. **Operation:** No significant impact will be expected as there is no scenic spot near the site.
	25	Gender	B-	B+	**Pre-construction:** Unequal distribution of compensation can be occurred within households. **Construction:** Unequal employment opportunity can be provided at construction site. **Operation:** Improvement of local economy will give positive impact.
	26	Children's Rights	B-	B+	**Pre-construction phase:** There are children among those to be resettled and/or lose their livelihood means. Children from households losing their land or jobs may suffer from adverse impact on their household economy, such as dropping-out of school. **Construction phase:** Children's ability to go to school may further deteriorate if access way to their school is physically blocked by the construction site. Child labour can be provoked at the construction site because of the huge demand for unskilled workers. **Operation phase:** Children will have better access to social services throughout the year. Education opportunity can be improved.
	27	Infectious Disease such as HIV/AIDS	B-	B-	**Pre-construction:** No impact is expected as no influx of migrant labor is expected at this phase. **Construction phase:** A temporary influx of migrant labor during the construction period may increase the risk of infectious diseases. **Operation:** Improved mobility of local residents and influx of external residents may increase the risk of infectious diseases

Item	No.	Impact	Rating		Results
			Pre- / construction Phase	Operation Phase	
	28	Work Environment (Including Work Safety)	B-	D	**Pre-construction:** No activities are expected to give any impact on work environment. **Construction phase:** Accidents may be caused by construction work. **Operation phase:** No work will be expected to affect work environment.
Others	29	Accidents	B-	B-	**Pre-construction:** No activities are expected to cause accidents. **Construction phase:** Accidents may be caused by construction work. **Operation phase:** Accidents may be caused by increased traffic. Flyover may hinder firefighting.
	30	Cross-boundary Impact and Climate Change	C	C	**Construction phase:** CO_2 will be produced from construction work, but the impact on climate change will be checked. **Operation phase:** CO_2 will be produced by entry and departure of vessels, but the impact on climate change will be checked.

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Possibility, degree or extent of impact is unknown. (Further examination is needed.)
D: No impact is expected.
Source: JICA Study Team

4.1.5 Environmental Management Plan and Environmental Monitoring Plan

Using the results of environmental impact assessment, environmental management and monitoring plan are created. These portion discuss and suggest on future management and monitoring of the planned area. Regarding management plans and monitoring plans for the planned areas, they were made for three stages: before construction, during construction, during operation, respectively. In port project, effects of changes in water quality by breakwaters and dredging and increased waste by port activities were focused on discussions and the countermeasures against these are created. As for the access road, they are created with the special attentions on the impacts on the neighboring protected area, the mitigation measures against the soil runoff during the construction period, and consideration for the lost mangrove forests.

4.2 Land Acquisition and Resettlement

4.2.1 Requirement for Land Acquisition and Resettlement

As for the port component, 20 ha for container terminal, 12 ha for multipurpose terminal, 54 ha for the navigation channel, turning basin and the container yard, and 33 ha for the dumping site, thus 108 ha in total will be required. The standard Right of Way of the access road is 90 m in the embankment section and 25.6 m in the bridge section, and approximately 201 ha will be required.

4.2.2 Legal Framework for Land Acquisition and Resettlement

The policy framework and entitlements for the Project are based on national law, Acquisition and Requisition of Immoveable Property Act, 2017 (ARIPA 2017) and JICA's Policy on Involuntary Resettlement (JICA Guidelines). If any gaps between ARIPA 2017 and JICA Guidelines are found, project

policy would be made properly in accordance with JICA Guideline.

4.2.3 Scale and Scope of Land Acquisition and Resettlement

Project Affected Households (PAHs) and Project Affected Persons (PAPs) have been identified through door-to-door visits using mouza maps and hearings to landowners. For port, 207 households were identified whose houses/stores and/or land will be affected while 44 households were identified whose livelihood is affected though without title of the affected land. For access road, 614 households were identified whose houses/stores and/or land will be affected while 515 households were identified whose livelihood is affected though without title of the affected land. The summary of the survey is as shown in below tables. Cut-off date for the Project Affected Persons ineligible for compensation in Bangladesh law was declared at the commencement of census, namely 11th February, 2018 for port component and 1st April, 2018 for access road component. Cut-off date for the Project Affected Persons eligible for compensation in Bangladesh law will be declared before Joint Verification Survey at a detailed design stage.

In survey for inventory of losses (IOL), information on the area of affected land and structure and the quantity of affected crops and trees has been collected from PAPs by using questionnaires. In livelihood survey, respondents were interviewed by using structured questionnaire. Household composition, education level, occupation, income, and utilization of public amenities were confirmed. Questions related to livelihood restoration were included in the interview, where preference for skills training was asked.

Summary of the Survey (Port)

Category	Formal		Informal		Total	
	PAHs	PAPs	PAHs	PAPs	PAHs	PAPs
1. Houses	26	140	31	151	57	291
2. Shops	0	0	5	27	5	27
2.1. Both Houses and Shops Affected	0	0	4	21	4	21
2.2 Shop only	0	0	1	6	1	6
3. Sub-total of Structures	26	140	32	157	58	297
4. Loss of Salt Farm	159	856	0	0	159	856
5. Loss of Residential Land	26	140	31	151	57	291
5.1. Both salt farm and residential	10	60	0	0	10	60
5.2. Residential land only	16	80	0	0	16	80
6. Sub-total of Land	175	936	0	0	175	936
7. Sub-total of Structure/ Land	175	936	32	157	207	1,093
8. Sharecropper	-	-	-	-	10	39
9. Employee	-	-	-	-	34	157
10. Sub-total of Non-title holder	-	-	-	-	44	196
11. Total PAHs/PAPs	-	-	-	-	251	1,289

Source: JICA Survey Team

Summary of the Survey (Access Road)

Category	Formal		Informal		Total	
	PAHs	PAPs	PAHs	PAPs	PAHs	PAPs
1. Houses	97	484	33	175	130	659
2. Shops	5	23	2	10	7	33
2.1. Both Houses and Shops Affected	1	6	1	6	2	12
2.2 Shop only	4	17	1	4	5	21
3. Sub-total of Structures	101	501	34	179	135	680
4. Loss of Agriculture/ Salt Farm	487	2,661	0	0	487	2,661
5. Loss of Residential Land	97	484	0	0	97	484
5.1. Both salt farm and residential	8	38	0	0	8	38
5.2. Residential land only	89	446	0	0	89	446
6. Sub-total of Land	576	3,107	0	0	576	3,107
7. Sub-total of Structure/ Land	580	3,124	34	179	614	3,303
8. Sharecropper					258	
9. Agri-labour					12	
10. Labour in salt and shrimp farm					51	
11. Labour in salt farm					48	
12. Labour in shrimp farm					13	
13. Employee					119	
14. Sub-total of Non-title holder					515	
15. Total PAHs/PAPs					1,129	

Source: JICA Survey Team

4.2.4 Compensation and Assistance Policy

The main issue of compensation process entails that PAHs will be rehabilitated at the rate of full replacement cost, at least to pre-project socio economic condition.

The respondent's main choice of Income Restoration Program in port component is technical knowhow (48.8%), technical assistance (8.2%) and capital support (18.4%), interest free capital (17.4%). The respondent's main choice in road component is technical knowhow (30.0%) , technical assistance (9.0%) and capital support (32.4%), interest free capital (9.0%). As income restoration programs; the following was proposed;

- Agriculture
- Poultry Rearing
- Furniture Technician
- Tailoring/ Industrial sewing
- Pisciculture/Fish Cultivation
- Business Trade
-

The Entitlement Matrix lists 12 types of losses and category of entitled persons and corresponding proposed entitlements to cover all possible losses to achieve at least the same level of livelihood of the affected households.

4.2.5 Grievance Redress Mechanism

The grievance redress committee (GRC) would be established prior to the implementation of land acquisition and resettlement activities. There would be four-step to handle grievances from PAPs: first step is the union level; second is the upazila level; third is the district level; and fourth is the court level and that the GRC will be required to resolve grievances within 45 days and maximum15 days at each level with the exception of the fourth level. Other than disputes relating to ownership rights under the

court of law, the GRC will review grievances involving all resettlement benefits, relocation, and other assistance.

4.2.6 Institutional Arrangements

CPA/RHD are the Executing Agency (EA) responsible for implementing the LARAP. CPA/RHD shall establish a Project Implementation Unit (PIU) for the Project, headed by a Project Director (PD) that will be responsible for the overall execution of the project including land acquisition, relocation, resettlement and other related matters. The PMU will prepare a land acquisition (LA) plan for the land required to be acquired with the assistance from consultants and shall submit to the DC, Cox's Bazar.

The Executive Engineer concerned under the direct supervision of the Project Director, will undertake day-to-day activities with the appointed Implementation Agency (IA). The Executive Engineer concerned will be the convener of the Joint Verification Team (JVT) and Property Valuation Advisory Team (PVAT). Role of INGO will be support of acquisition process for requiring body, proposed to work for 2 years period. They will be selected by the Executing Agency from NGOs in social development field with the experience of land acquisition, resettlement and livelihood restoration assistance before the Joint Verification Survey is started.

4.2.7 Implementation Schedule

The overall schedule of implementation is based on the principle that resettlement benefits are paid to PAHs before they are displaced and civil engineering works takes off. Tentative day for resettlement work will be started after serving of Section 4 notice from Deputy Commissioner Office and will be finished within 1 year period and implementation NGO will work with the EA for expediting the acquisition process. Total implementation work is proposed for 3 years period. LARAP will be implemented as soon as the payments by DC is made, DC's payment is expected to be completed by June 2020.

4.2.8 Resettlement Budget and its Source

The resettlement budget takes account of compensation of affected Land, structures, trees, resettlement assistance, institutional cost, hiring of RAP implantation agency, contingency, HIV/STD awareness activities, capacity building, external monitoring and evaluation consultants, documentation and internal monitoring, institutional cost. At this initial stage it is not practicable to accurately estimate land acquisition and costs of resettlement benefits for the project. However, a provisional estimate of LARAP implementation costs for the project is provided based on Census and Socio Economic Survey(SES) of Project Affected Persons and Market Survey of land, trees and structure. The cost will be verified by Property Value Advisory Team (PVAT).

4.2.9 Monitoring and Evaluation

Monitoring & Evaluation is an important task for measuring the periodic progress of activities under resettlement program. This helps to identify the constraints and bottlenecks in the progress as well as to determine remedial measures. Implementation of the LARAP will be monitored regularly. The Project Implementation Unit (PIU) will establish a quarterly monitoring system involving staff of the implementing agency/ NGO staff. The PIU will prepare progress reports on all aspects of land acquisition and resettlement activities.

4.2.10 Public Consultations

There is no provision on the resident consultation in the LARAP-related laws in Bangladesh. In this Project, in accordance with the JICA guidelines, stakeholder consultations were held twice, namely at the times of scoping and preparation of draft LARAP, where consensus on the project was confirmed.

5. Economic and Financial Analysis for Port and Road Investment

5.1 Financial Analysis of Port Investment

Financial Situation of CPA

Revenues from port services were USD 281 million in fiscal year 2016/17, operating expenses amounted to USD 128 million, of which personnel cost accounted for USD 38 million, contractor charges for USD 20 million, electricity and fuel for USD 17 million, repair and maintenance for USD 19 million, and depreciation cost accounted for USD 28 million. Net operating revenue amounted to USD 118 million and net surplus after tax has kept a level of USD 60-70 million in the past three years. In general, CPA's financial performance is deemed to be very satisfactory.

Financial Analysis of Port Investment

The year of 2018 is set as the base year, and the project life is assumed to be 40 years, from 2019 to 2058, including the construction period from 2019 to 2024. Interest rate of long-term loan for the construction work is assumed to be 1%, for engineering services 0.01%, redemption period 30 years with 10 year grace period, and interest during the construction period is not financed by ODA.

FIRR of the Project

Basic case of the financial analysis was made on assumptions that maintenance dredging volume is 5.0 million m3 per year, and maintenance dredging cost is USD 5/m3 as the lowest case. Supposing that Phase 2 of the Matarbari port development is not confirmed, the basic case is comprised of Phase 1 projects only.

Maintenance dredging cost will be shared between CPA and CPGCBL. Taking into consideration the fact that CPGCBL would bear all costs of maintenance dredging if a commercial port were not developed, and the fact that tonnage dues from entering ships cannot cover the cost of maintenance dredging, two projects shall share the cost of maintenance dredging based on the volume of capital dredging. It is also assumed that port tariff will be raised to the level of Bangkok in consideration of large initial investment in breakwaters and channel dredging, which are non-profit making facilities and necessary facilities for both of Phase 1 and Phase2.

FIRR of the port project is estimated as follows:

Case	Base Case	Cost +10% Rev. +0%	Cost +0% Rev. -10%	Cost +10% Rev. -10%
Maintenance dredging of 5 mil m3, and the cost is shared based on the volume of capital dredging	2.89%	1.20%	1.01%	-0.98%

In cases that the volume of maintenance dredging is 3 million m3 and its cost is shared by CPA and CPGCBL based on the volume of capital dredging, FIRR is calculated at 3.7%. In additional case 1, it is assumed that private terminals for CTT, LNG and LPG will be developed, and tonnage dues and river dues (wharfage) will be collected from vessels to be accommodated and cargoes to be handled. In additional case 2, it is assumed that Phase 2 development will be realized and CPA will receive tonnage dues and river dues as the owner of the channel and basin. In the additional cases, revenue of CPA will increase due to more ship calls than Phase 1, so that it will not be necessary to raise tariff, but private terminals shall share the cost of capital dredging and maintenance dredging. If maintenance dredging cost will borne only by CPA, it will be necessary to raise tonnage dues.

5.2 Cost Benefit Analysis

Economic Benefit of Port Investment

As Matarbari port is planned to accommodate 8,000 TEU vessels, which can reduce maritime transportation cost by the economy of scale, savings in maritime transportation cost is counted as a benefit of "With Case". Port congestion surcharges on containers will be removed and ship waiting cost for general and bulk cargo vessels will be reduced if Matarbari port is developed, these savings are counted as benefits of "With Case".

Economic Benefit of Road Investment

If access road is not developed, all containers would have to be transported by barge to the hinterland, mainly to Chittagong and Dhaka. While bulk cargo can be transferred to barges at the outer anchorage, this is not possible for container cargo as the handling productivity would be too low. Therefore, a large number barges would have to berth to handle container cargo; however, the number of berths in Phase 1 is insufficient to accommodate many barges. Instead, barges would have to berth along a mother ship where containers could be directly discharged or loaded. Costs of barge transport (including direct discharge on a barge) and truck transport are assumed as a benefit of the access road.

In case that the access road is developed, trucks, passenger cars, and other vehicles can save travel time and running cost, which are counted as benefits of the access road.

EIRR of the Project

Based on the economic cost and benefits of the project, EIRR of the project is calculated as follows:

Case	Base Case	Cost +10% Benefit +0%	Cost +0% Benefit -10%	Cost +10% Benefit -10%
EIRR	11.3%	10.3%	10.2%	9.3%

The port project provides significant cost-saving benefits by reducing port congestion and maritime transportation cost as larger vessels will be able to call the port.

The access road project provides large cost-saving benefits for domestic transportation from the port to hinterland and vice versa. If the access road is not developed, the port project is not viable due to the fact that handling by barge requires transshipment of containers at the port, which is very costly because of the double handling of containers and the low handling productivity from ship to barge and vice versa.

In the base case, EIRR of the project is estimated at 11.3% and sensitivity calculation shows that EIRR is 10.3% in case that costs increase by 10%, 10.2% in case that benefits decrease by 10%, and 9.3% in case both costs increase 10% and benefits decrease of 10%. This range of EIRR implies that the port project is worth implementing from the viewpoint of the national economy.

5.3 Cost Benefit Analysis

Objectives of the development of Matarbari Port are to increase the handling capacity of maritime cargo to meet the future demand of Bangladesh, and to receive large-size oceangoing vessels, and thereby further promote maritime cargo transportation and logistics. Taking these into consideration, cargo throughput at the port is deemed as a basic indicator to evaluate the performance and outcome of the Matarbari port project.

In addition to the abovementioned cargo throughput, number of ship calls and the size of calling vessels are considered as ancillary indicators. It is estimated that number of container ship calls is about 75 and general/bulk carrier calls is about 25 in the second year of operation.

Another ancillary indicator is the maximum size of calling vessels. While the Matarbari port is designed to accommodate container vessels with a loading capacity of 8,000 TEU (100,000 DWT), max size of container ship is assumed to be 4,400 TEU (60,000 DWT) type in the second year of operation.

The opening of Matarbari Port will ease ship congestion at Chittagong Port, however, this indicator will be evaluated qualitatively as the development of new terminals at Chittagong Port will also lead to less congestion.

6. Conclusion and Recommendation

6.1 Port Development Project

6.1.1 Cyclic Review on Cargo Demand and Port Planning

In addition to Matabari port development; other new port developments are being discussed and examined in Bangladesh, e.g., Chittagong Bay Container Terminal and a deep sea terminal in Payra Port. Cargo demand of Matarbari port could change depending on the surrounding conditions. It is necessary to monitor economic trends and developments at other ports in order update the cargo demand and revise the

port plan as necessary.

6.1.2 Coordination with related development plan in Moheshkhali

Moheshkhali Integrated Development Initiative (MIDI) was launched in February 2018 for the coordination of development and investment plans in the Moheshkhali area. Each ministry has been instructed not to pursue projects independently; instead, projects are to be developed comprehensively under the initiative of the Prime-Minister's Office in order to better promote national interests.

6.1.3 Close collaboration of Ultra Super Critical Coal Fired Power Generation Project

Project coordination committee consisting of representatives of CPGCBL and CPA has been established at the initiative of relevant ministries. Effective coordination is vital for expediting both projects.

In 2022, vessels carrying required materials for the construction of power plant will call the port and coal imports will commence once the construction works are completed. For this reason, equipment (navigation aids, VTMS, tugs and pilot boat) and required services such as CIQ should be prepared in a timely manner.

6.1.4 Siltation and Maintenance Dredging in Approach Channel and Basin

The siltation simulation should be updated using the additional latest site data to sufficiently confirm the annual volume of maintenance dredging before the appraisal of the construction loan. It is also necessary to discuss and coordinate between CPGCBL and CPA on the maintenance cost allocation.

6.1.5 Port Management and Promotion

Terminal concession contracts with the private sector are regulated by the PPP act in Bangladesh under the control of the PPP authority in the Prime-minister's Office. One option would be for the private sector to invest in and operate the new terminals in Matarbari, but this is not recommended at the initial stage since there are various uncertain factors at present, e.g., the volume of maintenance dredging is not clear, and CIQ and other port related private services are not sufficient. CPA should manage facilities with support from Japan based on a tool port manner in cooperation with private companies in Bangladesh.

CPA together with relevant government agencies and private companies should enhance port promotion activities to attract cargoes and shipping lines to Matarbari Port.

6.1.6 Utilization of Advanced Technologies of Japan and Technical Guidance

Technical transfer to CPA staff will be necessary to use and maintain those advanced devices made in Japan for efficient management of the port.

6.1.7 Navigation Safety

Three tugs of 4,000 HP class, one pilot and one security boat with hydraulic survey sonar are necessary for port entry and departure. Maneuvering simulation will be necessary to determine the specifications of those boats.

6.1.8 Project Risks and Adaptation Measures

Project risks and adaptation measure are assessed and summarized in the JICA Risk Management Framework Format.

6.2 Access Road Development Project

The following are conclusions pertaining to the access road component:

- The total length of roads under the project will be 27.3 km, comprising of 25.7 km-long access road and 1.6 km-long north-south connector road, and the accumulated length of bridges is approximately

7.1 km.

- The access road crosses two (2) Class II inland waterways as categorized by BIWTA, which requires a navigation clearance of 12.2 m in the vertical direction and 67.66 m in the horizontal direction. Steel narrow box girder type of bridge was selected as the optimum bridge type for such river crossings.
- Based on the results of geotechnical investigation and analysis on embankment stability and consolidation settlement, consolidation drained method with PVD was evaluated as the optimum solution for soft soil treatment. However, existence of sandwiched layers consisting of stiff clay, loose to dense sand were confirmed and PVD would not be applicable for such conditions. Sand compaction pile method would be applicable where PVD would not be feasible however the costs are prohibitive. Therefore, viaducts are viewed as more reasonable than embankment construction for such sections.
- The effect of climate change on water level such as rising sea and flooding levels ought to be anticipated. This study assumed that such increments in water levels can be accommodated within the 1 m of freeboard for embankment and bridge design instead of undertaking a detailed study of such a scenario.
- The traffic on the project road would be dominated by heavy vehicles. Therefore, polymer modified asphalt should be applied to this road. Also, a semi-flexible pavement design, which has higher durability against rutting, was proposed for the pavements at intersections.
- As a result of cost estimation, 35% of the construction cost is for embankment works and the estimated volume of embankment material is about 5 million m^3. Bangladesh has a poor environment for procurement of construction materials and this project would not be exempt from such a challenge. Dredging would be the most provable material source for the embankment materials and the cost for such material is considered in the unit rate of the embankment construction.
- Economic viability represented by EIRR is 12% under basic conditions and it would be less than 12% in case the project cost is increased by 10% or the benefit of the project is decreased by 10%. However, the access road is indispensable for Matarbari Port because the existing roads are not suitable for freight transport and transportation by inland waterways would not be reasonable.

Based on the conclusions, the following matters should be carefully studied during the implementation stage.

- Topographic surveys are necessary during the detailed design stage. The project site is dominated with soft ground and topographic survey work would be challenging. Therefore, the work schedule for topographic surveys should be carefully planned at the initial stage of the detailed design.
- More detailed geotechnical investigations would be necessary for identifying the optimum soft ground treatment measure and optimization of road structure either embankment or bridge should be evaluated in order to minimize the construction cost.
- Procurement and transportation plans for construction materials such as embankment material should be re-examined in detail and such conditions should be incorporated into the bidding documents depending on their necessity.
- Semi-flexible pavements have never been applied in Bangladesh therefore their applicability should be studied.

6.3 Environmental and Social Considerations

6.3.1 Environmental Considerations (Port)

(1) Consideration for rare species

In areas surrounding the project site, habitats of sea turtles are confirmed in the southern part of Dhalghata. However, the area is not defined as an important habitat for them as there are surveys that the frequency of the turtles' nesting is very rare compared to the frequency in Sonadia Island. Sonadia island is 15 km away from the project site and the influence of various constructions and operations is considered to be minor, but it is a critical natural habitat for rare species and it needs the special consideration. Since Sonadia site and surrounding project site, where various valuable species exist are thus located, it is proposed to implement awareness programs for construction workers and neighboring residents in order to deepen their understanding of rare species.

(2)Environmental consideration for coastal area ecosystem

The surrounding area of Matarbari Port is formed of sand dunes. There are no large-scale developments in the surrounding area until now, and it is considered to be a region where there are many animals and plants other than small-scale residential facilities. Construction of ports and dredging accompanying routes and berths will result in changes in waves and currents around the area, especially in the long term, it occurs erosion and sedimentation of the surrounding coast. Dredging and dumping dredged soil will also increase water pollution.

In consideration of the above points, the study team showed coastline change prediction from the change of waves and flow conditions and examined the pollution diffusion by numerical prediction calculation model of pollution diffusion. Based on these models, the impact on the Sonadia region, the critical natural habitat area, is expected to be minor. However, experts' interests in the Sonadia region are very high and there is concern about making hasty decisions. Therefore, it is recommended to monitor the change of the natural environment and the accompanying change of the marine ecosystem sufficiently.

(3) Joint expert meeting on ecosystem

As shown in (2), from the prediction of coastline change prediction, pollution diffusion prediction and predicted values of various pollutants, the result that the change to the natural environment of the area is considered to be minor. Meanwhile, concerning the ecosystem around the project site, several rare species have been confirmed, and there have been also high interests of experts both inside and outside of Bangladesh.

Therefore, in addition to these calculation results, it is extremely important to monitor the actual situation and take flexible measures with the opinions of these experts. It is proposed to set up opportunities for joint meetings of various experts on the impact on ecosystems by this project.

(4) Waste management for the port activities

The country aims to enforce the IMO Convention Act 2018 as the domestic law that controls pollution of Port, the IMO's Marpol Convention and the Ballast Water Management Convention as early as possible. Also, as for the land waste management from the port activities, the country has joined the UN Basel Convention to limit the inflow of harmful substances, being controlled by environmental protection regulations of DoE.

However, regarding land waste generated by port activities, it is also predicted that due to the quantity and variety, individual measures and penalties by each law alone could be insufficient. In reality,

inadequate plan at Chittagong Port has shown various problems such as insufficient method of disposal of hazardous wastes and incomplete recycling are raised. The Survey Team propose CPA, the executing agency, to prepare comprehensive and sustainable waste management plan and control the port waste management by the plan, based on the lessons learned at Chittagong Port, concerning collecting, transporting, processing and recycling wastes found in the port.

6.3.2 Environmental Consideration (Access Road)

(1) Consideration for loss of mangrove forest

Mangrove forests have rich ecosystems such as providing habitats of living things, feeding sites, spawning grounds. In the access road project of Matarbari Port, 1.23 ha of mangrove forest exists under the bridge to be installed in the Kohelia River. Considering the density of mangrove forests in coastal areas of the area, it is necessary to cut down about 5,500 mangroves. Reforestation program for mangrove forests lost in the project needs to be done in appropriate location and quantity in consultation with the Forest Department (DoFo).

(2) Consideration for forest reserves, wildlife reserves, and hilly areas

Planned roads are planned carefully avoiding longitudinal traverses of various protected areas.
However, there are areas such as the Moheshkhali Forest Reserve and Hilly areas, Fasiakhali Wildlife reserves in the neighborhood. The protected area is managed by the Forestry Act (1927) under the DoFo and the Environmental conservation Law amendment (2010) under Department of Environment (DoE). Based on these laws, it is recommended for the executing agency that it should consult with the DoFo and DoE to sufficiently implement mitigation measures and monitoring in the forest reserve / wildlife reserves / hilly areas around the planned roads.

6.3.3 Social Considerations

(1) Cut-off Date

In accordance with the JICA guidelines, for the Project Affected Persons not eligible for compensation under Bangladesh law, the cut-off date would be the start date of the census survey, which was February 11, 2018 for port component, and April 1, 2018 for access road component. On the other hand, the Cut-off Date for the Project Affected Persons eligible for compensation under Bangladesh law will be declared before the Joint Verification Survey at the detailed design stage. Therefore, it is necessary to make continuous coordination in order to prevent discrepancies in recognition among relevant agencies.

(2) Monitoring and Feedback of Livelihood Restoration Program

From the lesson learnt from the Adjacent Project, monitoring on livelihood restoration program shall be implemented as follows through INGO in this Project. Livelihood restoration program will be reviewed and updated in consultation with the concerned PAPs if necessary.

- Implementation status of vocational training: quarterly after the beginning of vocational training.
- Job finding: 3 months after completion of vocational training program.
- Situation of employment and livelihood recovery: Once a year from above mentioned.

INGO will conduct assistance for job finding after vocational training if necessary.

(3) Compensation and Assistance for Fisherman

The information of all fishermen around Hasher Char was collected through this Survey for the monitoring purpose. INGO shall conduct interview on fish catch volume and income from fishery during construction and 5 years after operation. If the decrease in the volume of fish catches is not confirmed or the living standard equivalent to the previous can be maintained by moving their fishing ground, compensation/assistance will not be required. However, in case that the volume in the current fishing ground decreased, the relation between the Project and the decrease shall be surveyed. In case that the obvious relation is confirmed and fishermen cannot move their fishing ground to the appropriate place, or when the volume is reduced even after moving fishing ground, they will be subject to cash compensation. In case that obvious relationship is not confirmed between the Project and the decrease of fish catch volume, livelihood restoration assistance shall be provided. For the survey on the relationship, advices from local experts shall be asked.

(4) Salt Farm and Shrimp Cultivation

Regarding salt farm and shrimp cultivation, even if salt farm and shrimp farm became lost by the project, the same livelihood means can be maintained because there is plenty of similar land around the affected farms. Therefore, INGOs shall identify similar land that can be utilized for salt farm and shrimp cultivation as a substitute site.

(5) Calculation of Compensation Cost

All costs for land acquisition/resettlement and rehabilitation will be borne by the Bangladesh government. Since it is difficult to estimate land acquisition cost and resettlement costs separately for this project in this survey, which is at the initial stage of planning, expenses were estimated based on the land area, the number of resettlement households from the socio-economic survey (SES) to the Project Affected Persons (PAP), and the replacement cost of land, trees and structures. Therefore, at the detailed design stage, it will be necessary to calculate a highly accurate cost by the Property Valuation Advisory Team (PVAT).
Also, significant land price increases have been reported in the target area. Regarding the difference which is not covered by Bangladesh national laws for the reacquisition price confirmed by the Property Valuation Advisory Team (PVAT) at the DD stage, additional payment will be made at top-up value.

(6) Payment of compensation

From the lesson learnt from the Adjacent Project, INGO shall inform PAPs of documents to be submitted and support the document preparation in this Project. It is necessary to thoroughly enforce support to all PAPs under the supervision of the executing agency.

(7) Monitoring

CPA does not have any section specialized in social environment. For pre-construction and during construction, monitoring will be conducted through Implementing NGOs under PIU, and through an external consultant. During operation, establishment of a section in charge of monitoring needs to be considered within CPA, and monitoring will be conducted through consultants, or NGOs employed by CPA.

1. Introduction

1.1 Purpose of Survey

In Bangladesh, export and import cargoes have increased by 10% in the last 5 years. However, as almost all cargoes (98%) are handled at Chittagong, the capacity of the terminal facility has already been exceeded. Accordingly, expansion of the port is required to meet the demand as vessels are commonly forced to wait for berthing. As this situation is detrimental to the economic growth of the country, the Government of Bangladesh has been preparing the seventh five-year development plan (from 2016 to 2020) which calls for new port infrastructure for the port of Chittagong including a coal terminal in the Matarbari area (water depth – 15.3 m) to be developed by a Yen Loan. The Government of Japan and the Government of Bangladesh have strengthened their bilateral relationship through the Bay of Bengal Industrial Growth Belt Initiative (BIG-B).
In future, a special economic zone will be developed in this area including a logistics park, power plants, LNG terminal etc.
In the course of the survey, the Prime Minister's Office determined the future concept on the Matarbari port development, leading to the commencement of the "Preparatory Survey on Matarbari Port Development Project in the People's Republic of Bangladesh" (hereinafter referred to as "the Survey") for investigating the further detailed plan of Matarbari port development.
This project has been implemented based on the result of "Data Collection Survey on the Matarbari Port Development in the People's Republic of Bangladesh" conducted from December 2016.
The purpose of this survey is to examine the scope of the proposed project including procurement method, project cost, construction cost, the implementation body, the management system and required environmental and social consideration to determine whether the project can be carried out under yen loan assistance. .

1.2 Outline of Survey

The project will be implemented based on the results of "Data Collection Survey on the Matarbari Port Development" and cover the following items.

【Survey of the Existing Conditions】

① Confirmation of Back Ground and Necessity of the Project
② Analysis on the international maritime network and coastal shipping, and providing data to the outline design
③ Study of Navigational Channel and Basin Sedimentation
④ Survey of Shoreline Change
⑤ Assessment of Offshore Dumping of Dredged Material
⑥ Survey for Existing Access Road, Bridges and Surrounding area
⑦

【Outline Design and Effectiveness of the Project】

⑧ Natural Conditions Survey
⑨ Socio-Economic Survey on the Communities Concerned (Baseline Survey)

⑩ Traffic Survey of and Future Traffic Demand Forecast
⑪ Outline Plan of the Project
⑫ Dredging plan of navigational channel and basin area
⑬ Proposal for Future Development of Matarbari Port in connection with Industrial and Economic Development of the Hinterland
⑭ Conceptual Design of Port Facility (including Equipment) and Access Road and Bridges
⑮ Preliminary Project Cost Estimation
⑯ Construction Planning
⑰ Preliminary construction schedule
⑱ Project Implementation System
⑲ Study on Operation, Maintenance and Management of the Matarbari Port as well as Private Initiative Introduction Plan
⑳ Environment and Social Considerations
㉑ Response to climate change and mitigation measures
㉑ Economic/Financial Analysis and Performance Indicators
㉒ Points to be noted for Project Implementation
㉓ Invitation workshop in Japan
㉔ Creation of promotional video
㉕ Recommendation
㉖ Draft Final Report
㉗ Final Report

1.3 Target Area

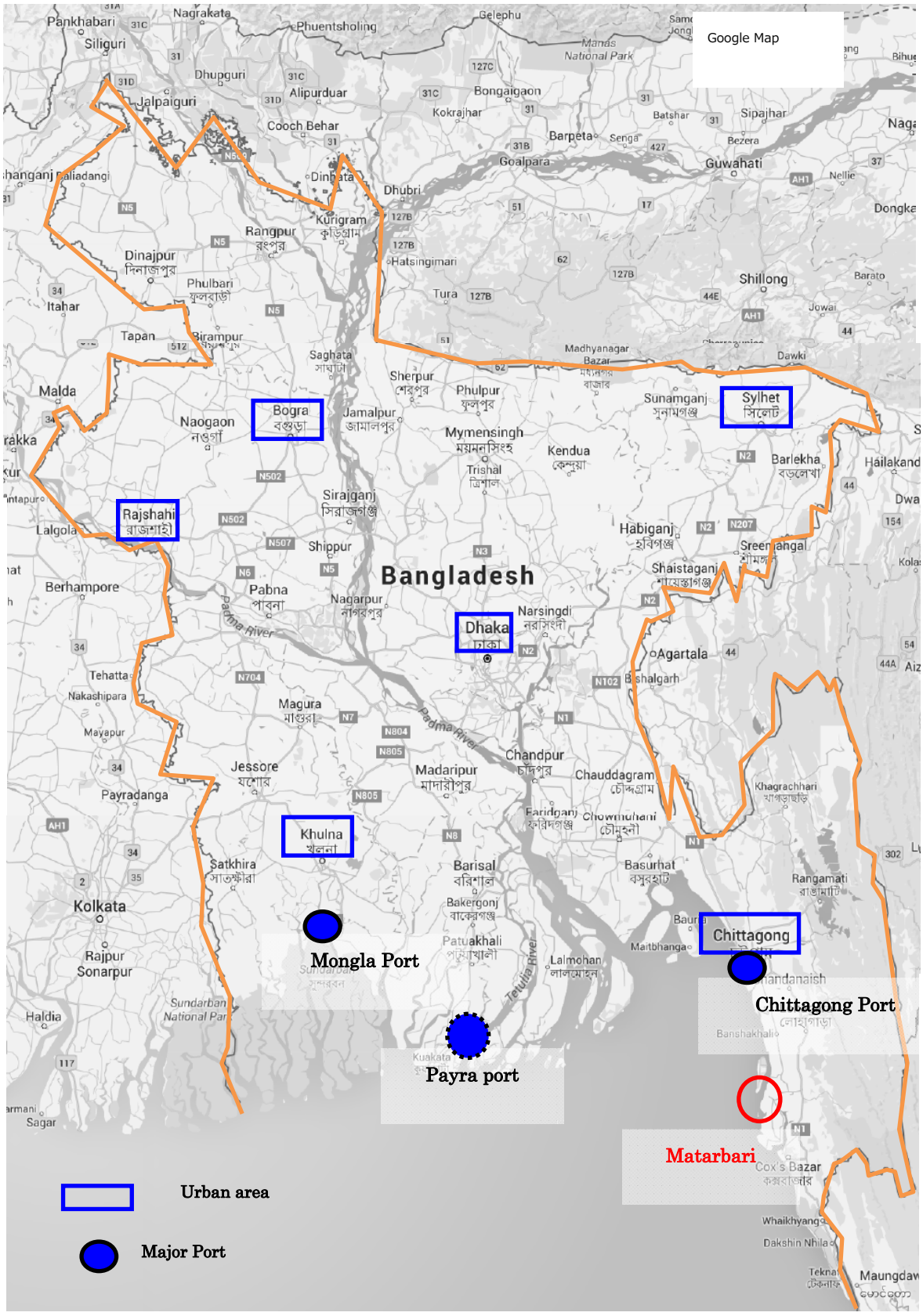


Figure 1.3-1 Target Area

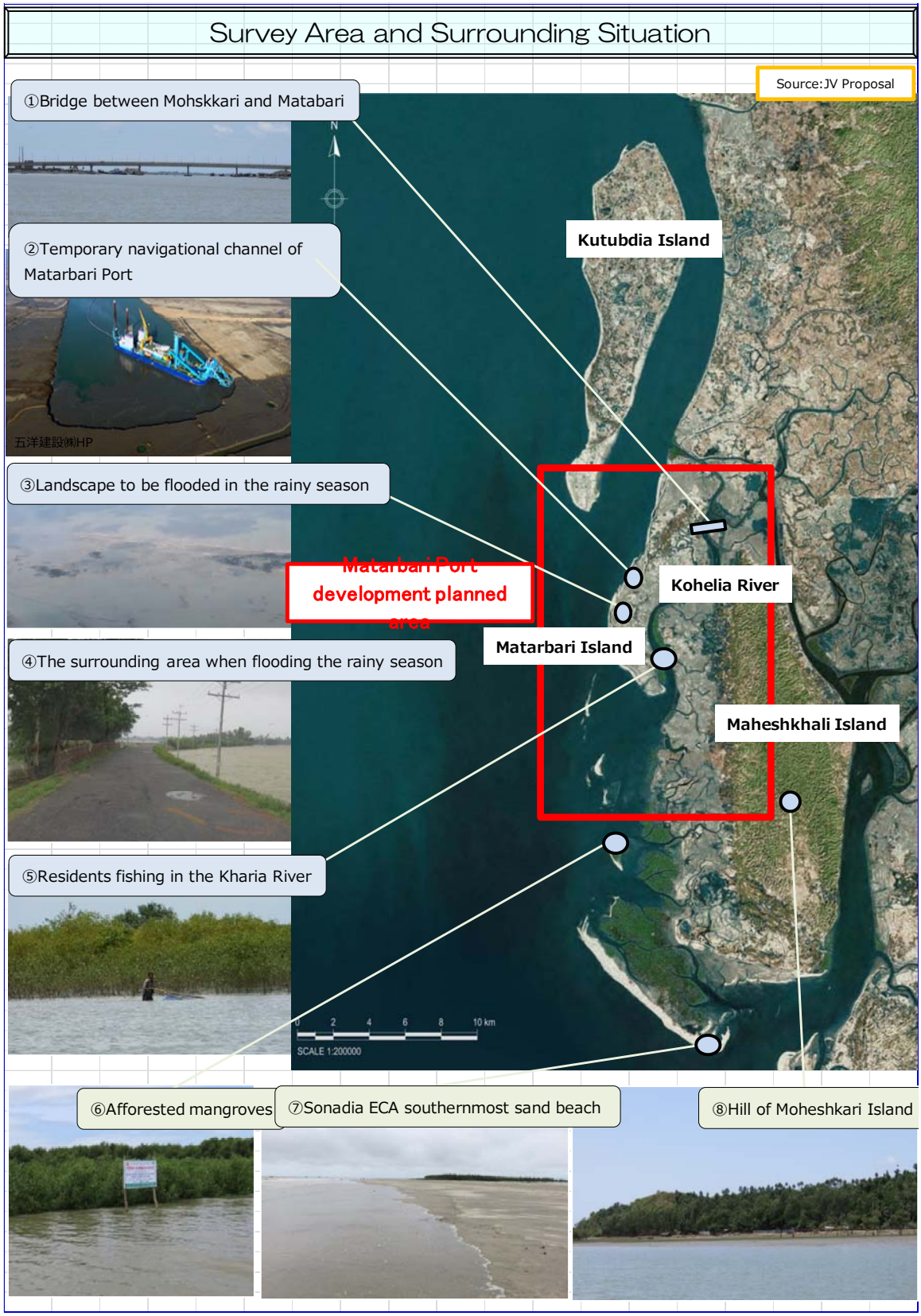


Figure 1.3-2 Survey Area and Surrounding Situation

1.4 Survey Schedule

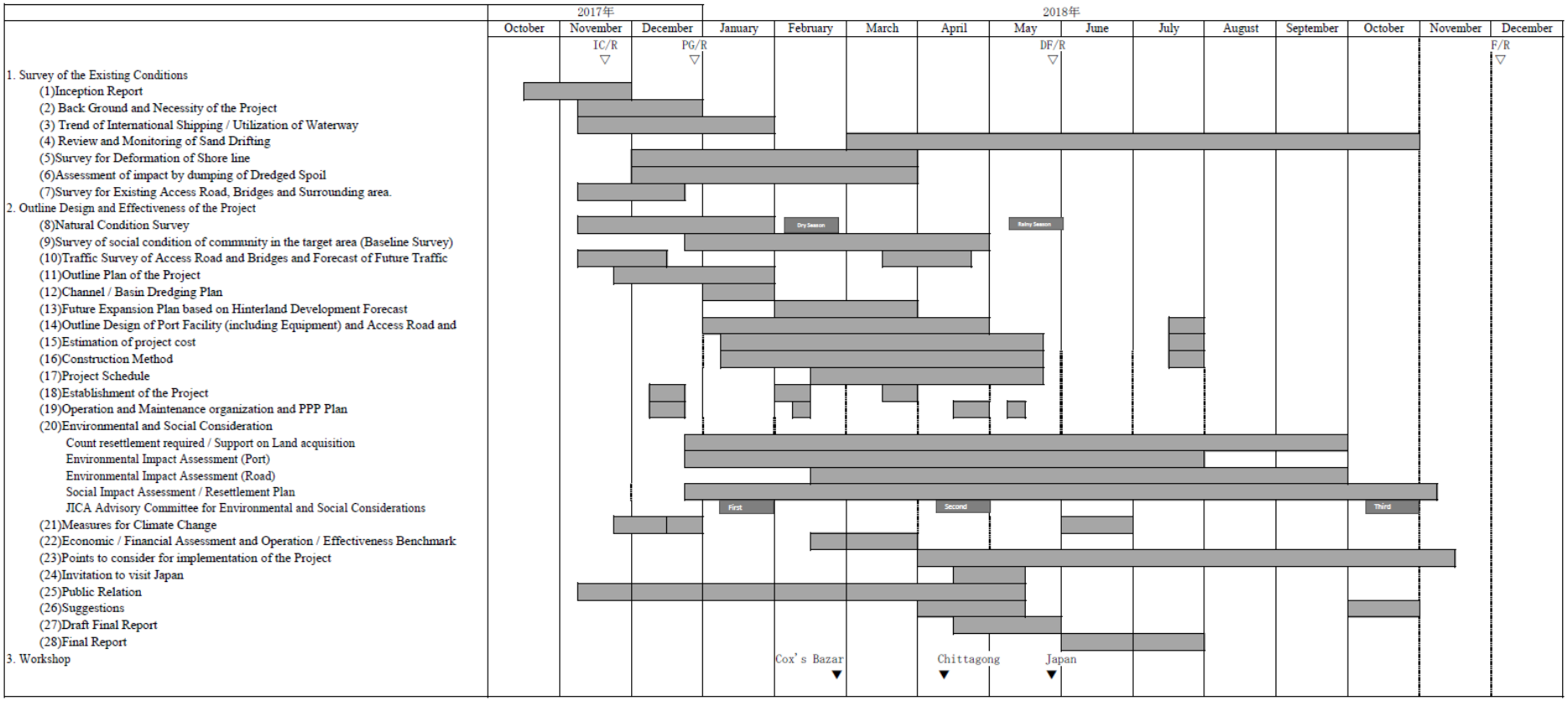


Figure 1.4-1 Actual Survey Schedule

1.5 Major Meetings and Activities

Actual and planned major activities for the Matarbari Port Development since the Data Collection survey are shown as follows.

Year	Month	Major Activity
2017	Nov	Submission of Inception Report
	Dec	Appraisal for Engineering Service
2018	Jan	Submission of Progress Report
	Feb	Workshop in Cox's Bazar
	Apr	Workshop in Chittagong
	May	Visit to Ports in Japan (Tokyo, Niigata) Workshop with Japanese companies
	May	Submission of Draft Final Report (Preparatory Survey)
	Jul	1st Fact Finding
	Jul	Submission of Final Report(Preparatory Survey)
	Sep	2nd Fact Finding
	Nov	Appraisal

Hearing Survey regarding Environmental and Social Consideration were held as follows.

Table 1.5-1 List of Hearing Survey regarding Environmental and Social Consideration

Date	Place	Stakeholder
28th November 2017	Dhaka	Divisional Forest Officer of DoF
30th November 2017	Cox's Bazar	Divisional Forest Officer of DoF
30th November 2017	Cox's Bazar	Joint Secretary of CPA
3rd December 2017	Chakaria	Upazila Nirbahi Officer of Chakaria Upazila Office
3rd December 2017	Pekua	Assistant Commissioner (Land) of Pekua Upazila Office
4th December 2017	Moheshkhali	Upazila Nirbahi Officer, Assistant Commissioner (Land) of Moheshkhali Upazila Office
18th December 2017	Chittagong	Divisional Forest Officer of DoF
20th December 2017	Chittagong	Divisional Forest Officer of DoF
21st January 2018	Chittagong	Member (Harbour and Marine) of CPA
21st January 2018	Chittagong	Divisional Forest Officer of DoFo
21st January 2018	Chittagong	Divisional Forest Officer of DoF
22nd January 2018	Cox's Bazar	DC of Cox's Bazar District
23rd January 2018	Matarbari	Forester and Forest Guard of DoF
24th January 2018	Chakaria	Site Officer of NACOM
24th January 2018	Cox's Bazar	Senior Upazila Fisheries Officer of Dep. Fisheries Industry advisor of Univ. of British Columbia, Canada
28th January 2018	Dhaka	Superintending Engineer of Roads and Highways Dept.
5th March 2018	Dhaka	Program Officer of IUCN
6th March 2018	Dhaka	Professor, Department of Botany of Dhaka University
7th March 2018	Cox's Bazar	ADC (General) of Cox's Bazar District
8th March 2018	Moheshkhali	Upazila Nirbahi Officer of Moheshkhali Upazila Office
13th March 2018	Dhaka	Divisional Forest Officer of DoF