

Report on
Environmental Impact Assessment
of
Construction of Matarbari 600X2 MW Coal Fired
Power Plant and Associated Facilities



Volume 1/2

Submitted By

Coal Power Generation Company of Bangladesh Limited
(An Enterprise of the People's Republic of Bangladesh)

Conducted By

Tokyo electric Power Services Co. Ltd (TEPCO)
(Japan International Cooperation Agency Study Team)

June 2013

Index

	Page
Abbreviation	
Terms of Reference	1-6
Executive Summary	i-xxii
Chapter 1	
Introduction	
Background	1-1
Purpose of the Study	1-5
Need of the Project	1-6
Importance of the Project	1-7
Scope of the Study	1-7
EIA Team	1-8
Chapter 2	
Legal and Legislative Framework, Regulations and Policy Consideration	
Environmental Regulation	2-1
Protected Areas and Environmentally Controlled Areas	2-9
Chapter 3	
Project Data Sheet	
Project Proponent	3-1
Comparison of Energy Option for	3-5
Unit Capacity	3-6
Economic Effect brought by the Project	3-7
Selection of Suitable Site	3-7
Design Condition	3-9
Chapter 4	
Environmental Background: Analysis and Detailed Description	
Environmental Base Maps	4-1
Description of the Features	4-3
Land Use	4-3
Natural Physical Resources	4-4
Natural Biological Resources	4-51
Socio-Economic Status	4-78
Environmentally Sensitive Areas of special or Unique Scientific, Socio-economic or Cultural Value	4-81
Chapter 5	
Primary Fuel Sources and Transportation	
Amount of Coal Resources	5-1
Demand and Supply of Imported Coal	5-2
Global Coal Production	5-4
Thermal Coal Export Countries	5-5
Thermal Coal Import Countries	5-5
Possibility of Coal Supply to Matarbari	5-6
Coal Supply Plan	5-14
Transportation and Loading Port	5-17

		Page
Chapter 6	Environmental Impact Assessment	
	Results of Environmental Impact Assessment for the Power Plant	6-1
	Results of Environmental Impact Assessment for the Port Facility	6-9
Chapter 7	Environmental Management and Mitigation Plan	
	Power Plant and Port Facility	7-1
	Proposed Mitigation or Management Measures for Threatened Species	7-33
Chapter 8	Risk Management	
	Identification of Risk	8-1
	Analysis of Risk	8-1
Chapter 9	Environmental Monitoring Plan	
	Power Plant and Port Facility	9-1
Chapter 10	Work Plan	
	Project Implementation Schedule	10-1
Chapter 11	Financial and Economic Analysis	
	Project Cost	11-1
	Financial and Economic Evaluation	11-2
	Financial Simulation	11-8
	Financial Evaluation	11-12
	Economic Evaluation	11-22
Chapter 12	Public Consultation	
	Meeting Minutes	12-1
	List of Participants	12-16

Abbreviation

Abbreviation

AEZ	Agro-ecological Zone
BBS	Bangladesh Bureau of Statistics
BIWTA	Bangladesh Inland Water Transport Authority
BMCR	Boiler maximum continuous rating
BMD	Bangladesh Meteorological Department
BPDB	Bangladesh Power Development Board
BWDB	Bangladesh Water Development Board
CF	Capacity factor
CPGCBL	Coal Power Generation Company Bangladesh LTD
CT	Current Transformers
DAE	Department of Agricultural Extension
DCS	Distribution Control System
DOE	Department of Environment
ECA	Ecological Critical Area
ECC	Environmental Clearance Certificate
ECR	Environment Conservation Rules
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulphurization
FD	Forced draft
GCV	Gross Calorific Value
GOB	Government of Bangladesh
HEI	Heat Exchange Institute
HHV	Higher heating values
IFC	International Finance Corporation
IEE	Initial Environmental Examination
IESC	Important Environmental and Social Components
ID	Induced draft
JICA	Japan International Cooperation Agency
LA	Lighting Arrestors

MARPOL	International Convention for the Prevention of Pollution from Ships
Matarbari CFPP	Matarbari Coal- Fired Power Plant
MEAs	Multilateral Environmental Agreements
MHWS	Mean High Water Spring
NCS	National Conservation Strategy
NEMAP	National Environment Management Action Plan
NEP	National Environment Policy
PGCB	Power Grid Company of Bangladesh LTD
PT	Potential Transformers
PSMP	Power System Master Plan
RO	Reverse Osmosis
SCC	Site Clearance Certificate
SRDI	Soil Resource Development Institute
TOR	Terms of Reference
USC	Ultra-supercritical
WHO	World Health Organization

Terms of Reference

Government of the People's Republic of Bangladesh
Department of Environment
www.doe-bd.org
Head Office, E-16 Agargaon
Dhaka-1207

Memo No : DoE/Clearance/5222/2013/179

Date: 18/07/2013

Subject: Approval of Terms of Reference (ToR) for Environmental Impact Assessment (EIA) of the Proposed 2x600 MW Matarbari Coal Based Thermal Power Plant Construction Project at Matarbari, Moheshkhali, Cox's Bazar.

Ref: Your Application dated 17/06/2013.

With reference to your letter dated 17/06/2013 for the subject mentioned above, the Department of Environment hereby gives approval of TOR for Environmental Impact Assessment (EIA) for the proposed 2x600 MW Matarbari Coal Based Thermal Power Plant Project at Matarbari, Moheshkhali Upazila under Cox's Bazar District subject to fulfilling the following terms and conditions:

1. The project authority shall submit a comprehensive Environmental Impact Assessment (EIA) report considering the overall activity of the said Project in accordance with the TOR and time schedule indicated in the Initial Environmental Examination (IEE) Report.
2. The TOR of the EIA shall incorporate the following components/items :

I. Executive Summary

II. Introduction

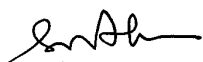
- II.1. Background
- II.2. Purpose of the Study
- II.3. Need of the Project
- II.4. Importance of the Project
- II.5. Scope of EIA Study
- II.6. EIA Team

III. Legal and Legislative Framework, Regulations and Policy Considerations

Legislative, regulation and policy consideration (covering the potential legal, administrative, planning and policy framework within which the EIA will be prepared)

IV. Project Data Sheet

- IV.1. Project Proponent
- IV.2. Project location and area
- IV.3. Nature and Size of the Project
- IV.4. Project Concept
- IV.5. Project Components
- IV.6. Project Activities
- IV.7. Project schedule
- IV.8. Resources and utilities demand
- IV.9. Sources of Primary Fuels (Quality and Country of Origin)
- IV.10. Transportation of primary Fuel



V. Process Description

- V.1. Project Site
- V.2. Project Layout
- V.3. Land Requirement
- V.4. Fuel Requirement
- V.5. Water Requirement
- V.6. Technology Selection and Process Description
- V.7. Description of Major Systems
- V.8. Material Balance
- V.9. Pollution Mitigation Measures (Units & Devices)

VI. Analysis of Suitability for Different Alternatives (this analysis shall be performed, among other approaches, in a GIS based Spatial Decision Support System (SDSS) presenting the suitability of different options for both the interventions)

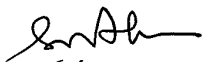
VII. Detail description of the land cover/land use (with all the existing resource classes along with area coverages shall be shown in the respective maps derived from updated image of proper spatial and spectral resolution. Basic information (name of satellite, date and time of acquisition with atmospheric condition, spatial resolution, color composite etc.) of the image data to be used for making landuse/landcover maps shall be mentioned)

VIII. Description of Environment

- VIII.1 Study Area (10 Km. radius), Period, Component and methodology (Seasonal Variation should be covered)
- VIII.2 Coal availability, including distance to “mine mouth”, the non-sterilisation coal reserves and the feasibility of distance between station and coal
- VIII.3 Water availability
- VIII.4 Sorbent availability
- VIII.5 Hydrogeology
- VIII.6 Meteorology
- VIII.7 Ambient Air Quality
- VIII.8 Ambient Noise Quality
- VIII.9 Surface & Ground Water Quality
- VIII.10 Aquatic Monitoring
- VIII.11 Soil Quality
- VIII.12 Ecology
 - VIII.12.1 Forests
 - VIII.12.2 Flora
 - VIII.12.3 Fauna
- VIII.13 Demography Profile and Occupational Pattern
- VIII.14 Land use and Cropping Pattern
- VIII.15 Socio-economic Scenario
- VIII.16 Distance to urban and rural communities (proximity to sensitive receptors)
- VIII.17 Transmission capacity/options for linking to grid
- VIII.18 Distance to existing infrastructure such as roads, ports, rail, etc.
- VIII.19 Current and surrounding land use and associated communities

IX. Environmental Impacts

- IX.1 Identification of Impact
- IX.2 Sustainability of Quality of Coal and Continuity of Supply



IX.3 Pre-Construction and Development Stage Impact

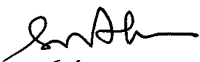
- IX.3.1 Impact on the sites from where material would be collected
- IX.3.2 Impact on Landform
- IX.3.3 Impact on Natural Resources
- IX.3.4 Impact on Eco-systems
- IX.3.5 Impact on Ambient Air
- IX.3.6 Impact on Ambient Noise
- IX.3.7 Impact on Water Bodies
- IX.3.8 Impact on Soil
- IX.3.9 Impact on Workers Health, Sanitation and Safety
- IX.3.10 Impact on Key Point Installations & Others
- IX.3.11 Solid Waste Disposal
- IX.3.12 Impact due to transportation of raw materials

IX.4 Construction Stage Impact

- IX.4.1 Impact on Landform
- IX.4.2 Impact on Natural Resources
- IX.4.3 Impact on Eco-systems
- IX.4.4 Impact on Ambient Air
- IX.4.5 Impact on Ambient Noise
- IX.4.6 Impact on Water Bodies
- IX.4.7 Impact on Soil
- IX.4.8 Impact on Workers Health, Sanitation and Safety
- IX.4.9 Impact on Key Point Installations & Others
- IX.4.10 Solid Waste Disposal
- IX.4.11 Social Impact due to industrial set up and harnessing of coal and other resources locally (if any)
- IX.4.12 Impact due to transportation of raw materials

IX.5 Operation Stage Impact

- IX.5.1 Impact on Natural Resource
- IX.5.2 Impact on Eco-systems
- IX.5.3 Impact due to collection of Resources from Local Sources within the Country (if any)
- IX.5.4 Impact on Ambient Air
- IX.5.5 Impact on Ambient Noise
- IX.5.6 Impact on Water Bodies (both surface & ground)
- IX.5.7 Solid Waste Disposal
- IX.5.8 Soil and Agriculture
- IX.5.9 Impact on Ground Water
- IX.5.10 Impact due to Ash Disposal
- IX.5.11 Ecology (Flora and Fauna)
- IX.5.12 Impact on Occupational Health
- IX.5.13 Impact on Public Health and Safety
- IX.5.14 Impact on Traffic Movement
- IX.5.15 Social Impact
- IX.5.16 Impact on Tourism
- IX.5.16 Impact due to transportation of primary fuels



X. Evaluation of Impacts

The impacts should be evaluated in terms of their local, regional and national importance. The impact should be assessed in terms of the magnitude, significance, frequency of the occurrence, duration and probability. The confidence level in the prediction must be stated. The judgment of significance of impacts can be based on one or more of the following, depending on the environmental factor being evaluated. These are :

- i. comparison with laws, regulation or accepted national or international standards
- ii. reference to pre-set criteria such as conservation or protected status of a site, feature or species
- iii. consistency with pre-set policy objectives
- iv. consultation and acceptability with the relevant decision makers, civil society, local community or the general public.

XI. Mitigation Of Impacts

Mitigation measures which may be of the following categories and coverages:

- i. changing project layout, transport routes, disposal routes or locations, timing or engineering design
- ii. introducing pollution controls, waste treatment, phased implementation and construction, engineering measures, monitoring, landscaping, social services or public education;
- iii. rehabilitation, compensation to restore, relocate or provision of concession for damage

XII. Environmental Management Plan

XII.1 EMP during Preparation Phase

XII.1.1 Land Development

XII.1.2 Location and Sources of Soil and Other Material for Development

XII.1.3 Transport of Soil and Other Material

XII.1.4 Method and Equipment for Collection of Soil and Other Material

XII.1.5 Closing of Sites of Sources of Soil and Other Material

XII.2 EMP during Construction Phase

XII.2.1 Site Preparation

XII.2.2 Infrastructure Services

XII.2.3 Construction Equipment

XII.2.4 Safety Measures

XII.3 EMP during Operation Phase

XII.3.1 Air Pollution Management

XII.3.1.1 transportaion and handling of raw materials

XII.3.1.2 Operation Stage

XII.3.2 Waste Water Management

XII.3.3 Noise Management

XII.3.4 Solid Waste Management

XII.3.4.1 Fly Ash Utilization

XII.3.4.2 Ash Utilization

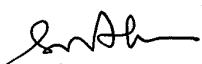
XII.3.5 House Keeping

XII.3.6 Safety and Occupational Health

XII.4 Greenbelt Development

XII.5 Rain Water Harvesting Plan

XII.6 Rehabilitation and Resettlement Plan



- XII.7 Thermal pollution management
- XII.8 Coal Washery
- XII.9 Coal Yard Mgt
- XII.10 CDM Intent
- XII.11 Budget for EMP
- XII.12 Contingency Plans

The project authority shall:

- a) Provide a conceptual contingency plan that considers environmental effects associated with operational upset conditions such as serious malfunctions or accidents;
- b) Describe the flexibility built into the plant design and layout to accommodate future modifications required by any change in emission standards, limits and guidelines.

XIII. Risk Assessment

- XIII.1 Consequence Analysis
- XIII.2 Emergency Response Plan
- XIII.3 Risk Mitigation Measures

XIV. Environment Monitoring Plan

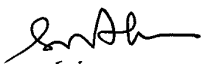
- XIV.1 Monitoring Plan
 - XIV.1.1 Stack Emission Monitoring
 - XIV.1.2 Ambient Air Monitoring
 - XIV.1.3 Meteorological Monitoring
 - XIV.1.4 Equipment and Ambient Noise
 - XIV.1.5 Surface Water & Waste Water Monitoring
 - XIV.1.5 Ground Water Monitoring
 - XIV.1.6 Solid & Hazardous Waste Monitoring
 - XIV.1.7 Flora and Fauna Monitoring
 - XIV.1.8 Workers Health and Safety Monitoring
 - XIV.1.9 Community Health Monitoring
 - XIV.1.10 Monitoring of DMP
 - XIV.1.11 Monitoring and CSR Activities
- XIV.2 Action During Abnormal Operating conditions
- XIV.3 Budgets for Monitoring
- XIV.4 Reporting

XV. Work Plan

XVI. Project Benefits with Benefit-Cost analysis that covers among others, Environmental and Social Cost

XVII. Public Consultation

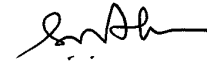
Public Consultation both in Local and National Level should be carried out. The public participation process is critical in ensuring public review and input into the EIA process. Some of the authorities to be engaged include: Department of Environment, Forest Department, Water Development Board, BIWTA, Chittagong Port Authority, RHD, PWD, DPHE, Bangladesh Parjatan Corporation, Department of Fisheries, LGED, other national/local departments where deemed necessary, Local Administrations (DC, UNO, UP Chairman & Members), Community Based Organisations, Non-Governmental Organisations, Business Unions, Farmers' Unions, etc.



The project authority must provide a detailed Public Participation Plan, which shall include, but not be limited to the following: A timetable for communication, detailing who will be consulted and why; as a minimum, one public meeting should be held during the Scoping phase and one public meeting during the impact assessment phase (although this number might be increased due to the width of the study area). The timing of these meetings would be decided upon in conjunction with relevant stakeholders; ensure that the public participation process complies with the relevant EIA regulations; compile minutes of the meetings and send to all participants and organize appropriate feedback mechanisms for public comment.

XVIII. Conclusion & Recommendation

3. Without obtaining approval of EIA report by the Department of Environment, the project authority shall not be able to start the physical activity of the project and also not be able to open L/C in favor of importable machineries.
4. Rehabilitation of human settlement or compensation for any sort of activity which will incur damage or loss of public or private property shall be addressed as per Government of Bangladesh rules and regulations.
5. The project authority shall submit the EIA along with a filled-in application for Environmental Clearance in prescribed form, the feasibility report, the no objection certificate (NOC) from forest department (if it is required in case of cutting any forested plant/trees-private or public), NOCs from other relevant agencies and other necessary documents to the Chittagong Divisional Office of DOE at Chittagong with a copy to the Head Office of DOE in Dhaka.
6. A soft copy of the image data as well as the maps to be generated from the image shall be submitted to DOE Head Office along with the EIA.



(Syed Nazmul Ahsan)

Deputy Director (Environmental Clearance)
and
Member Secretary
Environmental Clearance Committee
Phone # 02-8181778

Managing Director

Coal Power Generation Company Bangladesh Limited (CPGCBL)
Room # 918, Biddyt Bhaban (Level-9)
1, Abdul Goni Road, Dhaka-1000, Bangladesh.

Copy Forwarded to :

- 1) Secretary, Ministry of Environment and Forests, Bangladesh Secretariat, Dhaka.
- 2) Secretary, Power Division, Ministry of Power, Energy & Mineral Resources, Bangladesh Secretariat, Dhaka.
- 3) Chairman, Bangladesh Power Development Board, Biddyt Bhaban, 1, Abdul Goni Road, Dhaka.
- 4) Director, Department of Environment, Chittagong Divisional Office, Chittagong.
- 5) Assistant Director, Department of Environment, Cox's Bazar District Office, Cox's Bazar.
- 6) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

Executive Summary

Executive Summary

Introduction

Development of a country largely depends upon its proper electricity service, as it influences the other sectors like industry, education, agriculture and so on. Power sector is considered one of the most vital sectors in Bangladesh. But at present, the generation of electricity is inadequate and shortage of electricity supply is occurred frequently that hampers the quality of electricity services for the nation. With a view to meet the said peak electricity demand, Coal Power Generation Company of Bangladesh (CPGCBL) is planning to construct a new power plant under the project "Construction of Matarbari 600X2 MW Coal-Fired Power Station and Associated Facilities".

As a regulatory requirement set forth in the Environment Conservation Act 1995, a detailed environmental impact assessment (EIA) has been carried out for the proposed Coal Fired Power Station at Matarbari.

Government of Bangladesh has requested Government of Japan to conduct a Feasibility Study (F/S) regarding construction of a Coal Fired Power Station at Matarbari which will be the large scale power station in the south zone of Bangladesh.

The proposed power plant project is expected to be implemented with financial assistance from Japan International Cooperation Agency (JICA).

DESCRIPTION OF THE PROJECT

Overview

Basically, the project consists of a coal-fired thermal power plant with two units of 600 MW each and a circulating cooling water system, including proper intake and discharge tunnels, and a 275m high stack. The Power Plant will be designed in such a way so that the construction of future additional units is possible. A typical diagram of a coal based thermal power plant is shown in Figure 1.

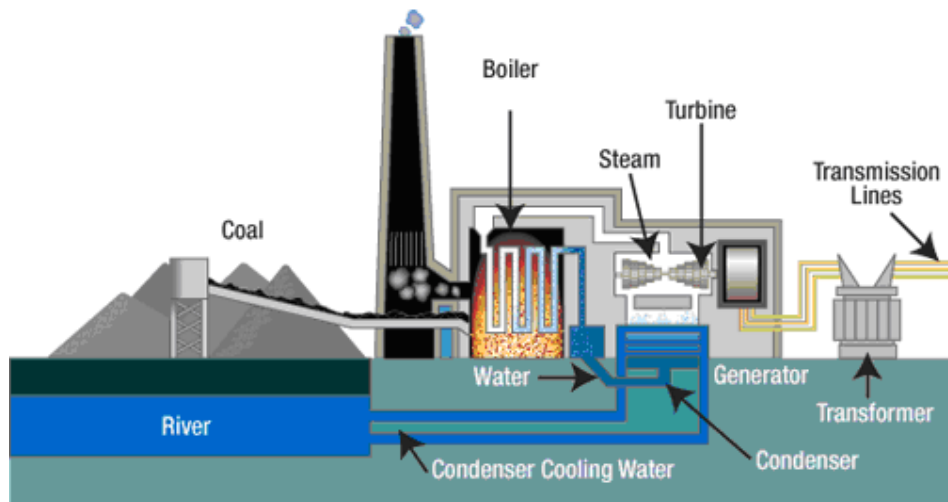


Figure 1: Typical diagram of a coal fired thermal power plant

The main project facilities are comprised of a power house and auxiliary facilities that include a switch yard, desalinization plant (Seas Water Reverse Osmosis), demineralization plant, circulating cooling water system, coal handling system (unloaders, stackers, reclaimers, conveyor belt and stockpiles), ash handling and disposal system, and a waste water treatment plant. Other project facilities that will be constructed by BPDB include an embankment along the sea shore. In addition, Flue Gas Desulphurization (FGD) and Electrostatic Precipitator (ESP) will be installed for flue gas treatment.

The proposed 600X2 MW (gross power output) ultra-supercritical (USC) bituminous pulverized coal plant will be constructed at a green field site. The turbine shaft configuration is a tandem compound design. The step up voltage level has been assumed as 400 KV as the capacity of the project will be 2 x 600 MW. The 400 KV double circuit line from Matarbari to Anowara will be built by Power Grid Company of Bangladesh LTD (PGCB), Bangladesh. The primary fuel of the plant will be sub-bituminous coal with a Gross Calorific Value (GCV) of 4700 Kcal/kg. The capacity factor (CF) for the plant is 80% without sparing of major train components. A summary of plant performance data for the USC plant is presented in Table 1 below.

Table 1: Basic plant information of the proposed coal based thermal power plant (estimated)

Component	Design Condition
Plant type	USC
Gross power output	1,200 MW (600X2 MW)
Primary fuel (type)	Sub-bituminous Coal having GCV of 4200-5200 kcal/kg and low Sulfur content (1.0 wt.% or less)
Coal flow (at 100% ECR)	12,800 ton/day
Annual coal requirement	3.73 mil. ton/year (considering 80% load factor)
Ash production	20%

Component	Design Condition
Temperature of flue gas at stack	75°C
Flue Gas Flow	2 x 4.47 x 10 ⁶ Nm ³ /hr
Flue Gas Treatment System	Low NO _x burner and over fire air, seawater FGD and electrostatic precipitator will be facilitated to reduce emissions and pollutions and to meet WHO standard for ambient on qualities
Maximum emission of SO _x	Less than 820 mg/Nm ³
Maximum emission of NO _x	Less than 460 mg/Nm ³
Particulate matter	50 mg/Nm ³ (from each unit)
Stack height	275 m
Water Intake	Necessity of water volume: 25(m ³ /sec/unit) × 2 units = 50(m ³ /sec)
Water discharge after treatment	Into sea

Layout

In the plant layout, adequate space shall be kept for lay-down and pre-assembling activities of open stores, contractor's offices and stores, etc. Construction offices and storage sheds area shall be located close to the main approach road to the plant. The administrative building is proposed to be located outside the plant boundary near the main approach road. The total land requirement area (455 hectares) is shown in the above table, which does not include the access road, township, greenbelt and other use areas. The following major components shall be included in the layout plan, but it is not an all-inclusive list:

A: Industrial (plant area)

1. Main power plant (boiler, turbine, generator, workshop store, etc.)
2. Electrostatic precipitator, FGD as required, and chimney
3. Greenbelt and open space
4. Open air sub-station and network control room
5. Water treatment, sewerage treatment plant and sewerage channel
6. Coal terminal including jetty and coal conveyer belt
7. Ash handling control room, ash silo, ash disposal area
8. Coal stock yard (open and covered)
9. Port and harbor facilities

B: Township

10. Residential buildings, school, mosque, playground, community hall, rest house, dormitory, health center, club, etc.
11. New alternative road construction instead of the existing community road, administrative building, auditorium and parking area including cafeteria, and social building

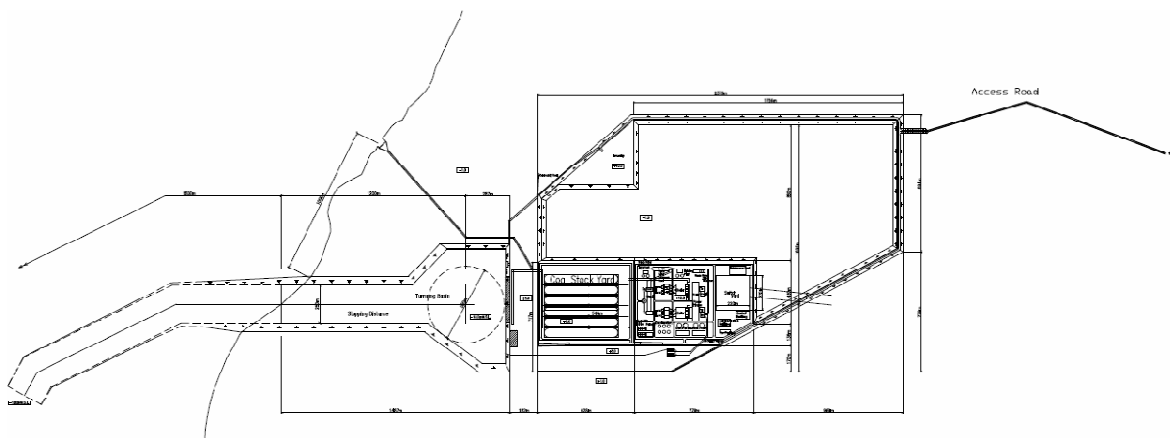


Figure 2: Plant layout plan

Administrative approval in connection with the acquisition of the required land will be obtained in the future. A land acquisition proposal (after necessary revision as per suggestions of the DC office) will also be submitted to the office of the DC, Cox's Bazar.

Project Activities

Pre-construction phase

- a) Selection of candidate sites
- b) Environmental and feasibility study
- c) Selection of site
- d) Land acquisition and site establishment

Construction phase

- a) Dredging work and berth work
- b) Civil construction and technological installation work
- c) Post erection check and pre commissioning test
- d) Monitoring of mitigation measures for environmental impact of the plant
- e) Commissioning test
- f) Reliability test run
- g) Commercial operation of the plant
- h) Overall project management
- i) Alternative road

The existing road along the shoreline will be cut off by the construction of the power plant.

A new alternative road, instead of the existing road, shall be constructed and the route/ location of the alternative new road is planned between the east side of the harbor and the west side of the coal stock yard. Also, during the construction period, a temporary alternative road, instead of the existing road, will be used.

Operation phase

- a) Commercial operation of the plant
- b) Monitoring of EMP
- c) Proper O&M for efficient running of the plant

Pollution Mitigation Measures

Air Pollution Control System

The boiler shall be designed for low NO_x formation by adopting low NO_x burners and over fire (two stage firing) system. High efficiency ESPs will be installed to limit the particulate emissions to 100mg/Nm³. An FGD system will also be installed to reduce SO₂ to at least 90%. To facilitate wider dispersion of remaining particulates and gaseous pollutants (SO₂ and NO_x), a chimney of 275 m height shall be used. To control emissions of fugitive dust within and around the coal handling plant and coal stockyard, a water spray system shall be installed. The chimney shall also be provided with facilities for online monitoring of stack emissions.

Noise Control

The major noise generating sources are the turbines, turbo-generators, compressors, pumps, fans and coal handling plant, etc., from where noise is continuously generated. Equipment will be designed to control the noise level to below 90 dB (A). Wherever it is not technically possible to meet the required noise levels at the work place, personnel protection and equipment, like ear plugs/ear muffs, shall be provided to the workers. The buffer area around the plant, including the boundary wall around the project, shall dampen noise levels so that the nearby community will not experience significant noise.

Intent of Water Reuse

The entire water consumption and management system has been designed with the provision of water use facilities. A circulating water system has been designed for the cooling system, boiler water, ash disposal and handling system.

Effluent Treatment

A wastewater treatment plant has been planned to collect, treat and dispose of plant effluents. Liquid effluents shall be collected and treated/ recycled.

Thermal Pollution Control

About 180,000 m³/hr cooling water will be discharged through the discharge tunnel, after the condenser, with a temperature increase of 6.6°C. The cooling water facilities will be designed so that the discharged water temperature will be not higher than 40°C which is the maximum temperature allowed in the wastewater quality standards of Bangladesh.

Waste Management

All kinds of solid waste to be generated at the power plant will be disposed on site maintaining

DOE's standards. Ash particles will be the major waste to be generated from the power plant and details of the ash management are described. Some waste will also be generated from the coal storage yard and belt conveyor facilities. To control flying coal dust, a water spraying system will be installed in the coal yard.

Water Intake Structure

Water supply from the intake point to the pump pit shall be provided with sufficient screening to filter out larger aquatic organisms like fish, etc. Drum screens shall be adopted in order to limit the entrainment of fish in the cooling water system.

Description of Existing Environment

Land Use

The land use of the project site is categorized in "Salt-Shrimp Area", according to the land use map of Maheshkhali Upazila, Cox's Bazar District.

Physical Environment

Climate

The climate in Bangladesh is divided into three seasons: summer from March to June with high temperatures and high humidity, the monsoon season from June to October with high winds, and winter from October to March with low temperatures and low precipitation.

The temperature in January is 19 - 21°C, and then gradually rises toward April to 28 - 29°C. The high temperature of 27 - 29°C continues from April to October, while it is a little lower from July to October compared to April to June. The temperature is in decline in November and December, and the average temperature in December is 21 - 23°C.

Northerly winds are dominant in January and February, and no significant high wind speed was observed in specific wind direction. Southerly winds become dominant from March, especially from April to September. In July and August, there is a tendency of slightly higher wind speed in southwesterly winds, otherwise no significant high wind speed was observed in any specific wind direction.

Topography

There are no structures in the project site. There are some fish and salt cultivation land and some temporary houses in the project site. And there are many water courses in the project site, made manually for the purpose of fish and salt cultivation. There are no features like electric poles, roads, etc, located anywhere in the boundary lines.

There is a long water course and the Kohelia River on the East side, the Bay of Bengal on the West side, a Homestead village of Nasir Mohammad Deil on the South side, and another Homestead on

the North side of the project site.

Geology

The maximum depth of the boreholes at the project site is 33.0m from the existing ground surface. Mainly seven soil layers were observed in the studied site, i.e., very soft to medium stiff clay, loose to very dense silty fine sand, stiff clay, medium dense to very dense silty fine sand, very stiff silt, hard clay, and very dense silty fine sand.

Tidal

From all the current profiles, it is evident that almost 90% of the direction falls either from 0 to 90 degrees (Northeast direction) or from 180 to 270 degrees (Southwest direction). This happens because it represents the tide. When there is a flood tide the water goes towards shore/land, then it follows a southwest direction (180 to 270 degrees), whereas when there is an ebb tide the water goes towards the sea then it follows a northeast direction (0 to 90 degrees).

Flood

There are generally four types of floods in Bangladesh. “Storm Surges” in which the project site is located, is a type of flood mostly occurred along the coastal areas of Bangladesh which has a coast line of about 800km along the northern part of the Bay of Bengal. This coastal area is shallow and the coastal line in the eastern portion is conical in shape. Therefore, Storm Surges are likely to occur due to flood tides of cyclones and southwestern monsoon winds.

Cyclone

During the years 1960 to 2010, Bangladesh was hit by 53 severe cyclones, 32 of which were accompanied by storm surges. The height of the surges is limited to a maximum of 10 meters in the bay.

Tsunami

Cox’s Bazaar coast near the project site would be inundated during a Tsunami.

Tsunami height is considerably lower than the storm surge height in the range of 7-9m. Therefore, Tsunami conditions have not been included in the design of the power plant ground level.

Air Quality

The main industries of Matarbari Island are agriculture and fishery, and it is not an industrial area. The air quality survey results indicated overall that the air quality in the rainy season is clean, with a slightly high concentration of dust (SPM) and a low concentration of SOx and NOx.

Water Quality

Sea Water

In rainy season, the water temperature was in the range of 28.5–30.5°C, with the tendency of higher temperatures near the surface layer and lowering towards the deeper layer. The salinity was in the range of 15.8 to 21.6, tending to be lower in the surface layer and becoming higher toward the deeper layer. SS (suspended solids) concentration is very high (640–910 mg/L) due to the strong effects of river water. COD is also very high (160–197 mg/L), while BOD is not at a high level (0.6–1.1 mg/L) (the water quality standard for surface water is 2 mg/L or less). Concentration of heavy metals, with the exception of a rather high concentration of Iron (Fe), was not high.

In dry season, the water temperature was in the range of 18.0 to 19.0°C, and temperature differences by water depths were not observed. The salinity was in the range of 34.3 to 37.3 with no big difference between water depths, the same as the water temperature. Suspended solids (“SS”) concentration is very high (46 – 329 mg/L) due to the strong effects of river water, especially at the bottom layer. COD is also very high (203 – 235 mg/L), while BOD is not at a high level (0.2–0.6 mg/L). Concentration of heavy metals, with the exception of a rather high concentration of Iron (Fe), was not high.

Surface Water

The results of the surface water quality survey indicate that the surveyed area has brackish water that is under the influence of sea water in the rainy season. SS (only in the rainy season) and COD showed high concentration levels similar to the sea water quality survey results. Environmental standards for surface water quality are determined by 6 criteria in Bangladesh, and the survey results satisfied even the highest criteria except DO.

Ground Water

The results of the ground water survey for both the rainy and dry seasons satisfied the drinking water standards of Bangladesh.

Noise

The noise measurement results indicated that the day time noise level was above the environmental standards for residential areas at one sampling point. Matabari Island is, as cited above, not an industrial area and therefore vehicles used for local transportation were the noise source. These vehicles are not used during the night.

Ecological Environment

Ecologically Valuable Habitats

Coral reef

According to the Chief Scientific Officer of the Bangladesh Fisheries Research Institute in Cox’s Bazar, there is no coral reef habitat around the project site, and the closest coral reef to the project

site is St. Martins Island located approximately 120km from the project site.

Seaweed

According to the Chief Scientific Officer of the Bangladesh Fisheries Research Institute in Cox's Bazar, seaweed does not grow around the project site because the transparency of the sea water is low.

Mangrove Forest

There are no mangrove forests around the proposed port facility site or along the coastline where the outlets for thermal effluents will be constructed. They are only scattered at the riverside of the Kohalia River, which flows between Matarbari and Maheshkhali Islands. There is a mangrove forest, which is large scale and artificially established, at the south side of Matarbari Island and its opposite bank is Maheshkhali Island.

Mud Flats

The coastline of Matarbari Island is a long sandy beach, and the sea side of the project site, where a port facility and outlets for thermal effluents will be constructed, is also part of the beach. The slope of the sandy beach is steep, and the area of its inter-tidal zone is relatively small. On the other hand, a sand bar and shallow sea area lie in the estuary of the Kohalia River located south of Matarbari Island due to sedimentation.

Marine Organisms

Phyto-plankton

In rainy season, fifteen species of phyto-plankton were observed, and Diatom was the largest in number of species. *Thalassiothrix* sp. was the species that emerged most frequently, followed by *Biddulphia* sp. The emergence of *Pleurosigma* sp., which is a freshwater species, indicates the strong influence of river water inflow in the sea front area of the power plant site. In dry season, eight species of phyto-plankton were observed, and Diatom was the largest in number of species. *Biddulphia* sp. and *Thalassiothrix* sp. were the species that emerged most frequently, followed by *Coscinodiscus* sp. and *Rhizosolenia* sp.

Zoo-plankton

In rainy season, eleven species of zoo-plankton were observed, and ARTHROPODA was the largest in number of species. Copepoda was the species that emerged most frequently, followed by *Sagitta* sp. In dry season, twelve species of zoo-plankton were observed, and ARTHROPODA was the largest in number of species. Copepoda was the species that emerged most frequently, followed by *Sagitta* sp.

Benthos (Sea bottom)

In rainy season, the population was scarce with only 3 individuals /m² in sampling point 1, and 16 to 18 individuals/m² in sampling point 2 to 4. On the other hand, 306 individuals/m² of *Bivalvia* and

30 individuals/m² of Gastropod were observed in sampling point 5. In dry season, a lot of Bivalvia was observed in sampling point 5 during the rainy season, but was not observed in the dry season.

Benthos (Mudflat)

In rainy season, the bottom sediment of each sampling points was sand and only a small population was observed. Twenty eight individuals per m² were observed in Dhalghata, which is 2/3 of Sonadia, in the sea front area of the power plant site. The dominant species were different in Sonadia and Dhalghata, and no dominant species was observed in Kutubdia. In dry season, 115 individuals/m² of Benthos was observed in Dhalghata in the sea front area of the power plant, which was more than the number of individuals observed in Kutubdia and Sonadia. Many kinds of Mollusk species such as Gastropoda and Bivalve were observed in Dhalghata, but only a few or even none of Mollusk was observed in Kutubdia and Sonadia.

Fish and Nekton

In rainy season, the highest number of species was observed at the sampling point in Sonadia, which had 22 species, followed by 21 species in Dhalghata and 20 species in Matarbari where the proposed power plant will be located and 14 species in Kutubdia. The only common species observed in all of the 4 sampling points was "*Loligo* sp." under DECAPODIFORMES.

The dominate species in the 2 sampling points near the power plant site were different from the dominate species in Sonadia and Kutubdia; the dominate species near the power plant site were "*Metapenaeus monoceros*" and "*Exopalaemon styliferus*" under DECAPODA, "*Stolephorus tri*" under Engraulidae, "*Glossogobius giuris*" and "*Odontamblyopus rubicundus*" under Gobiidae and "*Terapon jarbua*" under Terapontidae; whereas, in Sonadia and Kutubdia, "*Squilla* sp." under STOMATOPODA, "*Acetes* sp." under DECAPODA, "*Charybdis natator*" under BRACHYURA and "*Harpadon nehereus*" under Synodontidae were the dominate species.

In dry season, the highest number of species was observed at the sampling point in Matarbari, which had 29 species, followed by 26 species in Dhalghata, 25 species in Kutubdia, and 17 species in Sonadia. The only common species observed in all of the 4 sampling points was "*Acetes* sp." under DECAPODA and "*Cynoglossus cynoglossus*" under Cynoglossidae.

The dominate species near the power plant site were "*Metapenaeus monoceros*" under DECAPODA, "*Harpadon nehereus*" under Synodontidae, "*Coilia dussumier*" under Engraulidae, "*Johnius argentatus*" under Sciaenidae, and "*Otolithoides pama*" under Sciaenidae; whereas, in Sonadia and Kutubdia, "*Metapenaeus brevicornis*" and "*Metapenaeus lysianassa*" under DECAPODA were the dominate species.

Terrestrial Wildlife

Flora

Humans have impacted much of the land area of the Power Plant site, particularly by shifting shrimp farming and salt pans to the area over several generations. The project area now has species generally associated with secondary and pioneer communities, secondary scrubs, grasslands, poor vegetation cover, and little cash crop in its fringe areas. In all, 77 species in the rainy season and 71 species in the dry season were recorded at the power plant site, the majority of which are angiosperms. No threatened species, as designated by IUCN status declaration of 2012, were recorded. Three species (*Calamus guruba* Buch-Ham, *Trihosanthes cordata* Roxb, and *Lepisanthes rubiginosa*) which are considered as threatened species under local status by scientist groups in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

Fauna

Insects

A total of 23 species of 22 families under 10 orders in the rainy season and 22 species of 20 families under 9 orders in the dry season were recorded in the proposed project area. All of these species have Not Threatened (NO) status as per the IUCN status declaration of 2012.

Amphibians

A total of 4 species of 2 families under 1 order in the rainy season and 5 species of 2 families under 1 order in the dry season were recorded in the proposed project area, all of which are Not Threatened (NO) status by IUCN.

Reptiles

A total of 13 species of 7 families under 2 orders in the rainy season and 9 species of 5 families under 2 orders in the dry season were recorded in the study area. Among these reptiles, 1 Turtle species (*Eretmochelys imbricate*) was identified as being designated as Critically Endangered (CR) as per the IUCN Red list category.

Three Turtles species (*Geoclemys hamiltonii*, *Chelonia mydas*, and *Caretta caretta*) were identified as being designated as Endangered (EN) and another Turtle species (*Lepidochelys olivacea*) was identified as being designated as Vulnerable (VU) as per the IUCN Red list category. Five species (*Calotes versicolor*, *Mabuya mabuya*, *Gekko gecko*, *Panghura tentoria*, and *Naja naja*) which are considered as threatened species under local status by scientist groups in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

Birds

A total of 77 species of birds in the rainy season and 103 species of birds in the dry season were recorded in the proposed project area. No threatened species, as designated by the IUCN status

declaration of 2012, were recorded. Two species (*Arachnothera magna*, *Ketupa zeylonensis*) which are considered as threatened species under local status by scientist groups in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

Mammals

A total of 11 species of 8 families under 4 orders in the rainy season and 8 species of 6 families under 4 orders in the dry season were recorded in the proposed project area. All of these species have Not Threatened (NO) status as per the IUCN status declaration of 2012. (The results of the dry season will be added to the Final Report)

Socio-Economic Environment

Social Environment

A household survey targeting over 300 household heads as well as focus group discussions targeting women, children, salt workers and shrimp workers were conducted in December 2012 for comprehensive apprehension of the socio-economic profile of the project affected people. The project site is home to the local residents over generations. The maximum length of time found among them reached 300 years. The household size typically found at the site is 6 people, and over 70% of the interviewed household heads were illiterate or could only write their own names. 35% of the interviewed households received between 10,000 and 20,000 taka, and the average household monthly income was approximately 26,500 taka, 45.5% of the households spent between 10,000 and 20,000 taka per month, and the average household monthly expenditure was approximately 18,000 taka. Based on the incidence of poverty by the cost of basic needs (CBN) method defined by the Bangladesh Bureau of Statistics, 9% of them were categorized as poor households on income basis, and 13% on expenditure basis.

Most of the land in the power plant site is used for salt cultivation during the dry season (November to April), and shrimp cultivation during the rainy season (May to October).

There are mainly four kinds of people involved in salt and shrimp cultivations: cultivator, laborer, mazi, and businessman. Among the households interviewed at the project site in December 2012, cultivators were comprised of over 30% among them, are the owners of salt field of shrimp field (by owning or leasing the land). They invest money for cultivation. Laborers are those people who sell their labor under the instruction given by the cultivators. They prepare and make the salt bed, for instance. They receive wages from cultivators. Due to the fact that their households have not been financially privileged, they do not have sufficient opportunities for education. Many of them have to drop out of school while they were children even before they completed primary education. They have fewer job opportunities because of their low education and literacy levels. They also shared around 30% in the interview survey. Maziz, comprised of 10% among the interviewed households, coordinate between cultivators and laborers. They find laborers and allocate them at

salt/shrimp fields that belong to the owners or lessees who need laborers. Businessmen, around 10% as well, are those who are involved in purchasing salt (or shrimp) from the field and local market, and sell them at markets in Chittagong, Dhaka or Narayanganj. One of the salt factories located within the site has 70 to 80 workers throughout the year, 20 to 30 of whom live together in a terrace house. Laborers come from other districts for shrimp cultivation during the rainy season. All salt taken at the site is sent to Chittagong as there is no salt market in Cox's Bazar.

Fishery

Fisherman's village in Maheshkhali Upazila is located along the coast line and Kohalia River, and the number of fisherman's households is estimated to be 3000 to 4000. The average annual income by fishing activities is about 10,000 to 15,000 per household. There are four main fishing zones in the Bay of Bengal, and the nearest fishing zone from the proposed power plant site is South Patches, located at south of Sonadia Island. Therefore, it can be noted that the sea side of the proposed power plant site is not the main fishing ground.

Environmentally Sensitive Areas of Special or Unique Scientific, Socio-economic or Cultural Value

Under the Environmental Conservation Act (ECA), ecologically sensitive and precious areas are designated as ECAs (Ecologically Critical Areas) by Department of Environment in Bangladesh in cases where an ecosystem or biodiversity area is considered to be threatened to reach a critical state. On the other hand, protected areas such as national parks and protected forests are designated by Department of Forest under the Wildlife Order and Forest Act.

ECAs focus more on the importance and diversity of species and ecosystem and target any ecologically sensitive areas except for the protected areas designated by Department of Forest. Along with the ECAs declaration, each ECAs has notifications declared by Department of Environment in which specific activities to be restricted in that ECA are specified.

The closest ECA to the project site is Sonadia ECA located 15km from the project site. The area of Sonadia ECA is 49.2km².

Potential Environmental Impacts and Mitigation

Construction Phase

Air Quality

Watering the access road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken to reduce dust generation. Periodic maintenance and management of all the construction machinery and vehicles will be conducted to reduce exhaust gas discharged from construction machinery and vehicles.

Water Quality

A wastewater treatment facility for workers, such as a septic tank and an oil separator for oily run-off water, will be installed in the worker's camp and construction area. Oil and chemical materials will be stored in an appropriate storage site to prevent permeation into the ground. These measures will minimize the impact of contamination of sea water, river water and! underground water.

Wastes

Separating waste collection, recycling and reuse of waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to related regulations. Hazardous waste will be treated under the related regulations. To reduce the amount of solid waste discharged from the workers during the construction work, efforts will be taken to employ local workers wherever possible, so that the amount of household waste at the plant will be minimized. These measures will be taken to ensure that water pollution or sanitary problems resulting from waste will not arise.

Noise

Noise level generated by construction activities is 23.0 → 70.3dB(A) at the boundary of the power plant site and discharge facility and 36.4 → 55.4dB(A) at the nearest residence (1 point at north of the site and 2 points at south of the site.). The noise levels at all points in residential areas exceed the day-time noise level standard of Bangladesh, but satisfy IFC/WB guideline. Noise impact caused by construction activities will be mitigated by managing the construction schedule in order to level out the construction amount and scale as well as introducing up-to-date low-noise equipments. Monitoring on noise levels will also be necessary.

Protected Areas

Sonadia ECA has been designated pursuant to the Environmental Protection Law in Bangladesh, and it is located 15km south of the proposed project site. Environmental impact of air pollution, water turbidity, noise and other environmental impact during construction will be mitigated through appropriate countermeasures and the extent of any impact will be limited. Consequently, the impact to Sonadia ECA will be insignificant.

Ecosystem

The project site consists of land used for salt farms and other purposes, and not primeval forests or tropical rain forests. A sandy beach is located in front of the proposed project site; however there are no mangrove forests or tidal flats.

The area is the presumed habitat of birds, dolphins, and sea turtles on the IUCN Red list (endangered species, etc.), and construction work may have a possible impact on the rare species and ecosystem. Very few trees will be cut down due to the construction work, and the environmental impact of air pollution, water turbidity, noise and other environmental impact during construction will be minimized through appropriate countermeasures.

As for precious species of animals designated by IUCN, one Turtle species (*Eretmochelys*

imbricate) classified as CR (Critically Endangered), three Turtles species (*Geoclemys hamiltonii*, *Chelonia mydas*, *Caretta caretta*) classified as EN (Endangered) and one Turtle species (*Lepidochelys olivacea*) classified as VU (Vulnerable) were observed within the project site and the front beach. There were no other precious species of insects, amphibians, reptiles, mammals or birds designated by IUCN observed.

Spawning takes place at nighttime when human activity is low, however the light and noise of any nighttime construction may have adverse effects on these species. Consequently, night construction activity in the spawning season should be avoided as much as possible, and should be conducted under minimum light. Lighting colors that do not affect the spawning (e.g., red or yellow) should be selected. The careful monitoring of spawning status is necessary.

Land Acquisition

It is expected that the approximately 20 households currently living on the site without permission will have to vacate their homes due to the land acquisition for the construction of the power plant. Land owners will lose their land. Employers/ employees of salt farms, shrimp farms, and fishermen will lose their means of livelihood. Those people who run business, employers or employees at salt farms, shrimp farms and fishermen in the site will lose their livelihood means. Note that the site selection was reconsidered to the present site from the previous one (2 km south), where large settlements were found on private land, in order to avoid a large-scale resettlement.

267 households and 1,588 people will be affected by the construction of the power plant and the port facility. Besides, there are 76 households living or make a living around the project area and will be indirectly affected by the project. LARAP (Land Acquisition and Resettlement Action Plan) that includes not only a compensation plan but also a livelihood restoration program for affected people shall be established.

Deterioration of Local Economy such as Losses of Employment and Livelihood Means/

Land Use and Utilization of Local Resources

About 70% of the heads of 343 households that will be directly or indirectly affected are working in salt or shrimp farms. Although the number of salt and shrimp farms will decrease due to the construction of the power plant, employment opportunities will increase for various subcontract work of the construction. Local people will be given priority in employment. However, approximately 70% of heads of household are illiterate or can only write their signatures, so they can only be engaged in very simple tasks due to their lack of skills. Livelihood restoration measures will be established, including job training for those who want it.

Disturbance to Existing Social Infrastructure and Services

As material and equipment transportation will be mainly conducted by vessels, increased marine traffic may disturb existing marine traffic including fishing boats. Additionally, vehicles

transporting commuting workers may cause increased traffic and traffic jams around the project area.

In regard to vessels, water routes shall be determined after consultation with the related authorities. Marking buoys will be set around the construction area for marine safety. The schedule of vessels shall be announced to fishermen, etc. And in regard to vehicles, bus use will be promoted to reduce increasing the number of vehicles on the roads. The bus schedules shall be managed in consultation with related organizations and shall be communicated to people in the surrounding villages.

Social Institutions such as Social Infrastructure and Local Decision-making Institutions
The Deputy Commissioner's Office of Cox's Bazar District will officially take responsibility for initiatives to conduct local consultations concerning compensation. In consideration of changing emotions of local residents over the course of negotiations with office staff, LARAP preparations should be carried out in consultation with the local people.

A number of consultations with local residents have been conducted in preparing the draft LARAP in this feasibility study. Laws of Bangladesh stipulate the need to conduct public consultations in land acquisition processes. In the resettlement process, personnel responsible for responding to complaints or suggestions from local residents will work at the power plant office.

Children's Rights

Labor contracts between the construction industry and children shall be prohibited. Regular patrols to check for child workers shall be conducted.

Infectious Diseases such as HIV/AIDS

Local people should be recruited for simple work as much as possible so to minimize the risk of infectious diseases being transmitted from external workers. Pre-employment and periodic medical check-ups should be conducted for external workers (technical workers, etc).

Work Environment (Including Work Safety)

Construction companies should establish work safety plans and submit them to CPGCBL to obtain approval. Work safety plans should stipulate mitigation measures on soft aspects (safety training, etc.) and hard aspects (provide workers with appropriate protective equipment, etc.).

Cross-boundary Impact and Climate Change

CO₂ will be produced by the construction work. Periodic maintenance and management of all construction machinery and vehicles will be conducted.

Operation Phase

Air Quality

A flue gas desulphurization (FGD) system using marine water, an electrostatic precipitator (EP), and low-NO_x burning method (multi phase burning) will be adopted in this project, and exhaust

concentrations will be kept below the Bangladesh emission standards and the guideline values of the IFC/WB EHS guidelines. Predicted concentration of pollutants from exhaust gases, taking into account the background concentration, will satisfy the ambient air quality standards of Bangladesh as well as IFC/WB EHS guidelines and environmental standards of the EU etc. A cover will be installed on the conveyor for coal and ash transportation, and watering coal storage and the ash pond will be conducted to keep the surface wet.

Water Quality

Water used in the power plant will have intake at low speed (0.2m/s) from low-temperature seawater in the deep layer at the water inlet located in the port using the curtain wall method. Thermal effluent will be discharged at low speed (0.3m/s) from the water discharge outlet located 1km north of the port in order to prevent recirculation. The temperature of thermal effluent will be discharged within ΔT 8°C compared to the water temperature of the intake water and will be less than 40°C. Therefore the temperature of the thermal effluent is within the discharge water regulation (40°C).

According to the simulation result for diffusion model of thermal effluent, thermal effluent is diffused at a fast speed due to the fast current; therefore, the range of water temperature increase by more than 3°C is limited to the surrounding area of the discharge outlet. The range of water temperature increase by more than 2°C is up to 200m from the discharge outlet in case of NNE current and not reached to the coastal area of the island. On the other hand, in case of SSW current, the range of water temperature increase is up to 200m from the discharge outlet and not reached to the coastal area of the island.

Wastewater from each facility will collect in the central wastewater treatment system. The wastewater treatment system will consist of neutralization, coagulating sedimentation, and a filtration and oil separator. Wastewater will be managed and treated appropriately to comply with water quality of Bangladesh regulations and IFC/EHS Guideline values for thermal power plants. Treated wastewater will be mixed and diluted with a large volume of thermal effluents.

Leakage from the bottom of the ash pond will be prevented by using an impermeable layer, such as high density polyethylene (HDPE) sheet or silt layer. Wastewater will be managed and treated appropriately by neutralization and sedimentation to comply with water quality of Bangladesh regulations and IFC/WB EHS Guideline values for thermal power plants. The above measures will be taken to ensure that the impact on the water quality will be insignificant.

Wastes

Separating waste collection, recycling and reuse of waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to the related regulations. Hazardous waste will be treated under the related regulations. An ash disposal pond (183 ha) will be built at the project site. The nominal capacity of the ash disposal pond is calculated based on the total volume

of the ash to be accumulated for the duration of 25 years operation with 80% load factor. The total capacity is estimated to be 20,250,000 ton. The above measures will be taken to ensure that water pollution or sanitary problems resulting from waste do not arise.

Noise

Noise level generated by power plant operation is 10.6 → 43.3dB (A) at the boundary of the power plant site and discharge facility and 30.2 → 41.2 dB (A) at the nearest residence (1 point at north of the site and 2 points at south of the site). The noise levels at all the points in residential areas satisfy the day-time noise level standard of Bangladesh. The noise level at 1 point in the residential areas exceeds the night-time noise level standard of Bangladesh; however, the range of the noise levels exceeding the night-time standard is only limited to the surrounding area of the power plant, and the noise level at the whole village satisfies the night-time standard. IFC/WB guideline is satisfied at all the points. Maintenance of equipment will be conducted and low noise type equipment and adequate enclosures will be installed.

Ecosystem

The project site consists of land used for salt farms and other purposes, with no primeval forests or tropical rain forests. A sandy beach is located in front of the proposed project site, but there are no mangrove forests or tidal flats.

The area is the presumed habitat of birds and sea turtles of the IUCN Red list (endangered species, etc.), and construction work may impact the rare species and ecosystem. Environmental impact of air pollution, water turbidity, and noise, etc., during the operation phase will be mitigated through appropriate countermeasures, as described above, and results of simulations also indicate that environmental standards will be met. The water intake and discharge of cooling water used in the power plant will be carried out at a flow rate much lower than the current in the surrounding ocean, and the water flow in the surrounding sea will not be affected.

In addition, smaller fish in the sea area have sufficient swimming ability in comparison to the flow rate of water intake, and it is considered they will not be affected as a consequence. The diffusion area of thermal effluents with increased temperature of 2 °C or higher is limited to a certain surface layer and fish can easily bypass this area.

It is highly likely that the spawning of four IUCN precious species of sea turtles takes place on the sea coast, and a detailed survey should be conducted. Light and noise of nighttime construction may have adverse effects on the sea turtles. Consequently, night construction activity in the spawning season should be avoided as much as possible, and should be conducted under minimum light. Lighting color that does not affect spawning (e.g., red or yellow) will be selected. Low-noise equipment shall also be installed. The careful monitoring of spawning status is necessary.

Deterioration of Local Economy such as Losses of Employment and Livelihood Means/ Land Use and Utilization of Local Resources

Local people should be employed to work at the power plant and related facilities to the maximum extent possible according to their skills. Livelihood restoration means shall be conducted including job training for those who want it. Services (e.g., laundry, catering services, etc.) and products offered by the local community should be used by the power plant as much as possible.

Disturbance to the Existing Social Infrastructure and Service

Traffic volume and traffic jams will increase in the surrounding roads during the operation phase. Mitigation measures to decrease traffic volume shall be conducted, such as the promotion of bus use. The management of schedules of project vehicles will be conducted in cooperation with related organizations, and the schedules will be announced to local people living in surrounding villages. Additionally, an access road, community road and road around the power plant boundary shall be built. These roads will be built with sufficient height so that they can be used even in the rainy season, in order to enable public access to markets and social services.

In addition, a school and medical facility constructed within the power plant site shall be open to all local people for the improvement of their lives.

Children's Rights

There is a possibility that children may be forced to work and not attend school. Labor contracts between the subcontractors and children shall be prohibited. Regular patrols to check for child workers shall be conducted.

Work Environment (Including Work Safety)

Work accidents involving workers may occur at the power plant site. CPGCBL shall establish a work safety plan. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc.) and on hard aspects (provide workers with appropriate protective equipment, etc.).

Cross-boundary Impact and Climate Change

CO₂ will be produced by the operation of the power plant. Ultra supercritical (USC) technology will be adopted at the power plant, producing less CO₂ of approximately 566 thousand tons/year compared to a sub-critical coal-fired power plant.

Environmental Management and Monitoring

The main objective of the environmental management plan and environmental monitoring plan is to ensure implementation of the mitigation measures planned to reduce the environmental impact by the implementation of the power plant project, and to verify and record the environmental impact.

Construction Phase

At the construction phase, CPGCBL shall carefully consider all construction activities with the supervision consultant, and encourage the contractor to fully understand the necessary mitigation measures and to implement them. In this regard, an environmental management unit shall be organized prior to construction activity and an expert environmental management administrator shall be employed. The unit will discuss and prepare mitigation measures with the supervision consultant and the contractor prior to the construction activity.

During the construction activity, in which a large inflow of workers and vehicles is predicted, the CPGCBL shall encourage the understanding of the surrounding community about the contents and schedule of the construction activity and mitigation measures, and shall obtain local people's opinions and change the mitigation measures as appropriate.

In order to confirm the implementation of the environmental management and to consider further mitigation measures, the contractor should submit regular reports to the supervision consultant and environmental management unit on the implementation status of the management plan.

The environmental management administrator shall regularly hold explanation sessions with the local people and submit reports to the Department of Environment, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

Operation Phase

The power plant is responsible for organizing an unit in charge of environmental management to develop and implement the environmental management plan as mitigation measures. An expert environmental management administrator shall be employed so that the environmental management plan is appropriately implemented. The environmental management administrator shall encourage the understanding of the environmental management plan to the project staff prior to plant operation, and continue regular education of the staff during the operation phase.

The environmental management unit shall also function as a grievance organization to understand and address any grievances from local people during the operation phase, and conduct appropriate mitigation measures.

The basic policy of the environmental management plan is to liaise with local community, and sufficient explanation of the positive mitigation measures to local people is very important.

The administrator shall report the contents and implementation status of the environmental management plan and the environmental monitoring plan described below to the director of the plant, with the director taking final responsibility. The environmental management administrator shall regularly provide explanations to the local people and submit reports to the Department of Environment, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

Public Consultation

In accordance with JICA Guidelines for Environmental and Social Consideration, the first stakeholder meeting for the power plant was held at the scoping stage of the Feasibility Study of the Coal-fired Power Plant Development Project (600X2 MW) at Matarbari, Cox's Bazar. The project owners, the Coal Power Generation Company Bangladesh LTD. (CPGCBL) for the power plant hosted the meetings assisted by the JICA Study Team. At the meeting, a power-point presentation was given to the local participants in their local language (Bengali), with a full explanation of the project and environmental impacts in addition to the mitigation measures to be taken, to allow the audience to fully understand the project and contribute valuable comments.

Conclusion and Recommendation

Conclusions

The study suggests that most of the adverse impacts on the physic-chemical environment are of low to moderate in nature and therefore, could be offset or minimized if the mitigation measures are adequately implemented. From the social environmental point of view, people welcomed the proposed power plant project at Matarbari. However, they recommended installing a plant of good quality, which will be able to keep anticipated air, water and noise pollution to a minimum level.

Some adverse impact during the operation phase of the plant will come from pollutants, emission from the power plant. However, modeling study suggests that the predicted concentration of pollutants from exhaust gases, taking into account the background concentration, will satisfy the ambient air quality standards of Bangladesh as well as IFC/WB EHS guidelines and environmental standards of the EU etc.

Cooling Water used in the power plant will have intake in the deep layer at the water inlet located in the port using the curtain wall method. Thermal effluent will be discharged at outlet located 1km north of the port in order to prevent recirculation. The temperature of thermal effluent will be discharged within ΔT 8°C compared to the water temperature of the intake water and will be less than 40°C as the discharge water regulation.

According to the simulation result for diffusion model of thermal effluent, thermal effluent is diffused at a fast speed due to the fast current; therefore, the range of water temperature increase by more than 3°C is limited to the surrounding area of the discharge outlet. The range of water temperature increase by more than 2°C is up to 200m from the discharge outlet and not reached to the coastal area of the island.

Waste water from each facility will be managed and treated appropriately to comply with water quality of Bangladesh regulations and IFC/EHS Guideline values for thermal power plants. Treated wastewater will be mixed and diluted with a large volume of thermal effluents. Noise level has been identified as significant potential impact of the proposed power plant during both the

construction and operation phases. The noise generated from construction activities during the construction phase might become a source of annoyance at the residential Area to the project site. However, the noise level is expected to come down to tolerable levels within residential area. The area is the presumed habitat of birds and sea turtles of the IUCN Red list (endangered species, etc.), and construction work may impact the rare species and ecosystem. Environmental impact of air pollution, water turbidity, and noise, etc., during the operation phase will be mitigated through appropriate countermeasures. The diffusion area of thermal effluents with increased temperature of 2 °C or higher is limited to a certain surface layer and fish can easily bypass this area.

It is highly likely that the spawning of four IUCN precious species of sea turtles takes place on the sea coast, and a detailed survey should be conducted. Light and noise of nighttime construction may have adverse effects on the sea turtles. The careful monitoring of spawning status is necessary.

The approximately 20 households currently living on the site will have to vacate their homes due to the land acquisition for the construction of the power plant. Land owners will lose their land. Employers/ employees of salt farms, shrimp farms, and fishermen will lose their means of livelihood. LARAP (Land Acquisition and Resettlement Action Plan) that includes not only a compensation plan but also a livelihood restoration program for affected people shall be established. During public consultations carried out as a part of the EIA study, people welcomed the proposed power plant project at Matarbari. However, they recommended installing a plant of good quality, which will be able to provide uninterrupted power and will be able to keep anticipated air and noise pollution to a minimum level.

Recommendations

The environmental assessment carried out for the proposed coal fired power plant at Matarbari, suggests low to moderate scale of adverse impacts, which can be reduced to acceptable level through recommended mitigation measures as mentioned in the EMP. It is therefore recommended that the proposed power plant may be installed, provided the suggested mitigation measures are adequately implemented. It is also recommended that the environmental monitoring plan be effectively implemented in order to identify any changes in the predicted impacts and take appropriate measures including LARAP to off-set any unexpected adverse effects.

Apart from risks associated with emissions, noise generation, solid waste, hazardous waste and wastewater disposal as a result of construction and operation activities, the coal fired power plant put human beings and the environment inside and outside of the plant to a certain degree of risk of accident and sometime loss of life. A risk analysis for the proposed power plant has been developed listing various actions to be performed in a very short period of time in a pre-determined sequence if it is to deal effectively and efficiently with any emergency, major accident or natural disaster.

Chapter 1

Introduction

Chapter 1

Introduction

Table of Contents

1.1	Background	1
1.2	Purpose of the Study	5
1.3	Need of the Project	6
1.4	Importance of the Project	7
1.5	Scope of the Study	7
1.6	EIA Team	9

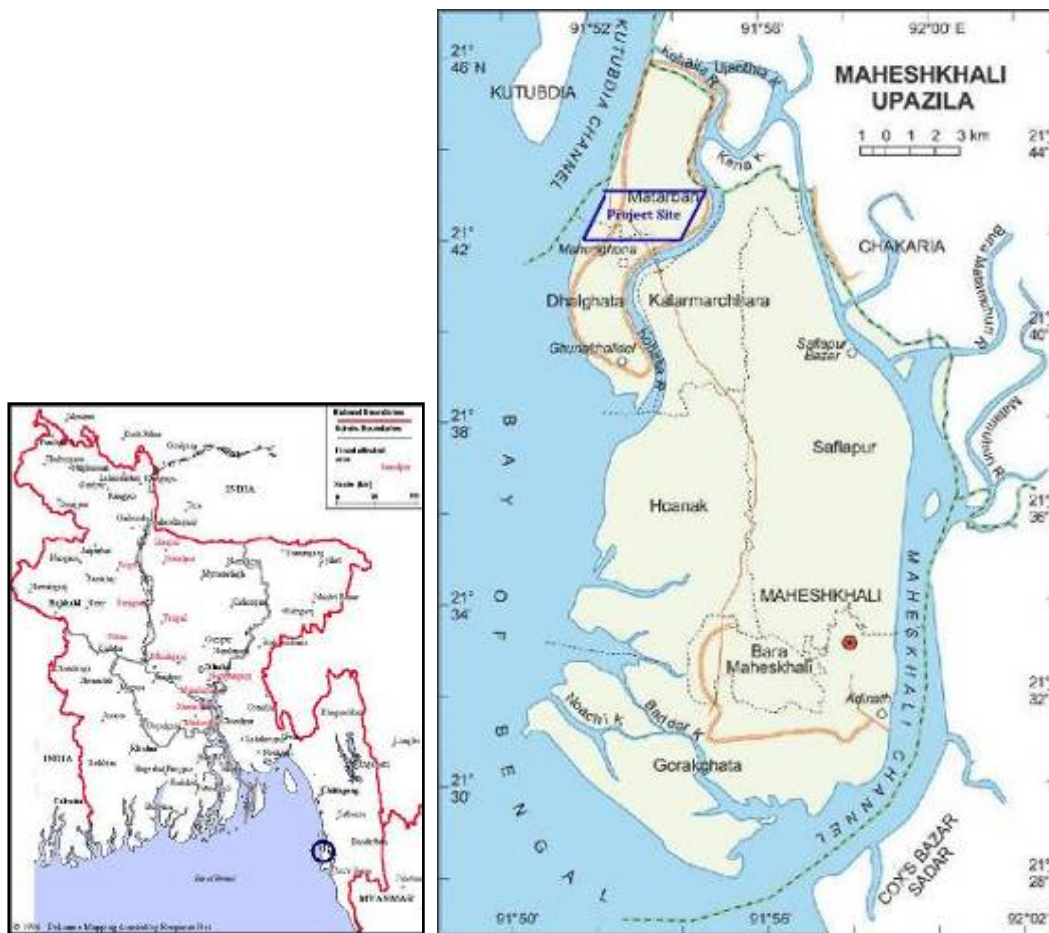
1.1 Background of the Study

Electricity is the key to all development activities. Sustainable power supply is a major precondition for the socio-economic development of Bangladesh. Access to electricity is now being recognized as a fundamental right. Notwithstanding the medium growth rate of GDP of Bangladesh, the per capita electricity generation, only 254 kW (BPDB; Bangladesh Power Development Board, 2012), is very meager. At present, 50% of the total population has access to electricity but reliable and quality power generation and supply is still a far away. The Government assigns top priority to the development of power sector realizing its importance in economy, industrial and social development of the country. To this end, the government has set the goal of providing electricity to all citizens by 2020. The present installed generation capacity is 8,315 MW including 3,771 MW from private sector and electricity demand growth 10% per annum. Government forecasts that the maximum electricity demand would be 13,000MW in 2017 and 34,000 MW in 2030. To meet up this, the Government of Bangladesh (GOB) has formulated a Power System Master Plan (2010). Taking consideration of high dependency on natural gas (67%) of power generation comes from natural gas based units), Power System Master Plan (PSMP 2010) recommends diversification of fuel used for electricity generation because present primary energy i.e natural gas supply will decrease after 2017 and opt coal as a prime energy for electricity generation. The Master plan, targets composition of power supply as of 2030 set at 50% for domestic and imported coal, 25% for domestic and imported (in the form of LNG) natural gas and 25% for other sources such oil, nuclear power and renewable energy. The coal based generation is the least cost option in consideration to present economy.

In this situation, Japan International Cooperation Agency (JICA) implemented PSMP 2010 The study covered strategy to expand coal-fired power generation focusing on utilizing imported coal and developing domestic coal. Based on the results of the PSMP 2010, GOB has requested the Japanese government to conduct a study to inquire into possibility of receiving support from Japan for imported coal power development. JICA implemented “Data collection survey on coal power master plan follow-up survey”. After the follow-up survey, JICA has implemented “The preparatory survey on the Chittagong area coal-fired power plant development project”. Then BPDB plans for establish Coal Power Generation Company Bangladesh LTD (CPGCBL) and installation of Matarbari Coal-Fired Power Plant (Matarbari CFPP; 2 x 600 MW) at Matarbari island under Maheshkhali Upazila, Cox’s Bazar District (Figure 1.1-1).

The proposed power plant area is situated within Matarbari and Dhalghata Union under Maheshkhali Upazila (Figure 1.1-1). The proposed power plant will cover an area of about 455 hectare.

As stipulated in the Environment Conservation Acts, 1995, no project shall be established without obtaining Environmental Clearance from the Department of Environment (DOE) and the detail procedure and steps have been described in the Environment Conservation Rules, 1997. The proposed project falls under the Red category of industrial classification made under the Environment Conservation Rules (ECR), 1997 which requires Site Clearance Certificate (SCC) and Environmental Clearance Certificate (ECC) from DOE. As such, for obtaining these aforementioned clearance certificates from DOE, JICA Study Team on behalf of CPGCBL has conducted Initial Environmental Examination (IEE) and Environmental Impact Assessment (EIA) study for the proposed coal-fired thermal power plant. Table 1.1-1 shows the distance of the important locations from the project site. Figure 1.1-2 shows the aerial distance of important locations from the project site.



Note: The center of location is 21° 42' 15" N, 91° 53' 16" E

(Source: <http://www.in2bangla.com/upazilaMap.php?id=293>)

Figure 1.1-1 Location map of the proposed power plant site in Matarbari

Table 1.1-1 Aerial distance of different point of interest from the site

Location	Distance (km) (center to center)
Chittagong city	67
Cox's Bazar city	33
Cox's Bazar airport	31
Sonadia Island	24
Sonadia ECA	15 (center to boundary of ECA)
The crossing of National road No. 1 and the district road No. 177 (Chakaria)	20



Figure 1.1-2 Aerial Distances of important locations from the proposed power plant site

1.2 Purpose of the study

The project falls under the red category defined by DOE which requires EIA to obtain SCC and ECC from DOE as per Environmental Conservation Rules, 1997.

This study will identify and evaluate the potential environmental and socio-economic impacts due to construction of the coal-fired power plant providing detail Environmental Management Plan (EMP) to mitigate the project oriented negative impacts. It is expected that the study will facilitate the planning and design of the proposed power plant in the way of mitigating the potential negative impacts and enhancing the project benefits.

Given the vision of obtaining site clearance certificate the specific objectives of the study are:

- Selection of alternative sites
- Identification of national and international legal environmental requirements
- Identification of potential environmental and socio-economic impacts
- Identification of occupational risk and hazard
- Identification of mitigation and abatement measures
- Delineation of Environmental Management Plan (EMP)

According to EIA guidelines for Industries of DOE, Bangladesh, Power Plant, Transmission line and gas pipeline, distribution, construction /re-construction/ extension fall under the Red category (Category-D). Red category projects require EIA.

This project falling under the red category is therefore required to undertake EIA which is a precondition for giving go-ahead clearance by the DOE.

Hence, JICA study Team on behalf of CPGCBL carried out EIA to fulfill the requirement of the DOE. The main objectives of the EIA study were:

- Describing the existing environment of the area;
- Assessment of the potential environmental impacts, including residual impact of the proposed project;
- Identifying mitigation measures to minimize the impact;
- Preparing an Environmental Monitoring Program etc.

1.3 Need of the project

At present a total number of 79 Power Plants having total capacity of 7613 MW generate 4,000 MW to 5500 MW on an average. Against this generation, the daily average demand at the generation end varies about 5,100 - 6,000 MW. In accordance to an unofficial calculation, the average shortfall is about 2,000 MW per day. The demand of power is rising with the economic development of the country. MoPEMR, has forecast power demand growth in line with the desired economic growth of the country under PSMP, 2010. As per the forecast, with government policy scenario the power demand will reach 17,000 MW in 2017 and 34,000MW by 2030. The PSMP also forecasts the demand as per different GDP growth rate. Figure 1.3-1 shows power demand forecasts of PSMP, 2010 up to 2030.

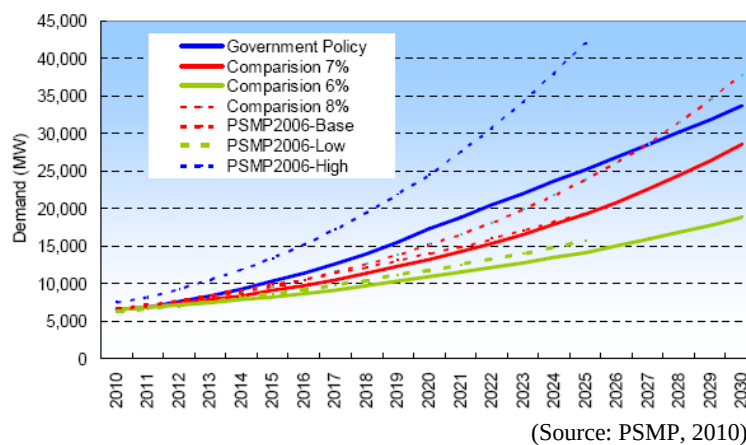


Figure 1.3-1 Power demand forecast for different scenarios

The present electricity crisis is hindering the national economic development by discouraging the foreign investment, disturbing the national industrial production and dropping the quality of living standard (Mozumdaer and Marathe, 2007). A research on electricity consumption and GDP growth reveals that Bangladesh loses industrial production worth \$1 billion per year that reduces 0.5% of the GDP due to power outage. To mitigate the prevailing crisis of electricity demand as well as to achieve the desirable overall development of the country, the BPDB/GOB has adopted a power generation increase plan up to 2016 in line with the PSMP (2010). The summary of the plan is shown in the Table 1.3-1.

Table 1.3-1 Summary of the power generation increase plan

(Unit: MW)

Type	2012	2013	2014	2015	2016	Total
Public	632	1467	1660	1410	750	5919
Private	1354	1372	1637	772	1600	6735
Power Import	---	500	---	---	---	500
Total	1986	3339	3297	2182	2350	13154

(Source: BPDB)

Taking consideration of national gas reserves which is the primary energy of power generation of the country at present (67% of total power generation from gas based units), the PSMP recommends diversification of fuel for electricity generation and opts coal based power generation as least cost option to reduce the dependency on natural gas. In this line, Government has taken initiatives to install Matarbari CFPP (2 x 600 MW) at Matarbari island.

1.4 Importance of the project

The proposed power plant will add 1,200MW electricity to the national grid that will improve the present electricity generation significantly and as well as trigger the national economic development. Not only that, industrial development will be initiated after implementation. Additionally, it will create employment opportunity to the local people and improve transportation system in the project area, which will ultimately play an important role in poverty reduction and develop social safety net condition. Moreover, this coal based power plant will thereby play an important role in fuel diversification in electricity generation and reduce pressure on natural gas reserve.

1.5 Scope of Study

The scope of works includes mainly execution of EIA and detail scope of works is as follows:

1.5.1 Environmental and Social Impact Assessment

The scope of services under the ESIA study is as follows:

- a) Carry out environmental and social impact assessment identifying Matarbari CFPP (2 x 600 MW) that will satisfy the applicable environmental requirements, including the laws and bylaws of Bangladesh and JICA guideline.
- b) Carry out hydrological investigation; in order to design the appropriate port facility.
- c) Elaborate project description and design and the activities at pre-construction, construction and post-construction phases.
- d) Establish environmental and social baseline condition in respect of water resources, land resources, agriculture, fisheries, ecology and socio-economic condition.
- e) Carry out meteorological, noise level and air quality investigations for the proposed power plants and the necessary additional transmission lines.
- f) Select environmental and social components likely to be impact by the proposed coal-fired power plants.
- g) Identify suitable control measures to minimize CO₂, Dust, SO_x, and NO_x emissions from the power plants.
- h) Identify exhaust stack requirements (275 meters as per DOE rules) applicable to the plant so that concentration of SO₂ and particulate matter in the surrounding area is uniform and minimum.
- i) Thermal plume modelling will be completed considering the proposed power plant including nearby industrial installations (if any).

- j) Ability for the developers of the power generation projects to satisfy all national regulatory requirements and international obligations related to health and human safety and the environment in the construction, operation, and maintenance of imported coal projects of the anticipated size at the identified sites.
- k) Ability to dispose efficiently and in a manner that complies with all national regulatory requirements and international obligations related to the ash generation by the power generation facilities (and the development of a recommended plan for doing so).
- l) Social/infrastructure facilities to be required.
- m) Assess and evaluate the ability of each of the projects (and any expansion projects at the site) to comply with all health and safety and environmental laws of Bangladesh and the requirements of the JICA guideline. Identify any restriction that should reasonably be imposed on the developers of the power generation projects to ensure that expansion projects can be designed, constructed and operated in compliance with all such laws, regulations and requirements and also international obligations.
- n) Evaluate the impact on environment in line with Bangladesh and/or JICA guideline requirement for the coal power plant to ensure that the power generation facilities and transmission facilities can be designed, constructed and operated in compliance with all applicable environmental requirements.
- o) Preparation of EMP, which shall include mitigation measures, enhancement and contingency measures and compensation.
- p) As per TOR approved by the DOE, produce an EIA report which shall form the basis of obtaining environmental clearance from the DOE for implementation of the coal-fired thermal power generation facilities.
- q) Study of prevention measures for dust particles from coal to the air.
- r) Study of siltation problem and migration of soil/sand in the proposed area.
- s) Study of the township development of the area.
- t) Study of salinity of the area.

1.5.2 Topographical and Engineering Survey

- a) Carry out Benchmark pillar from nearest established Benchmark Pillar
- b) Establishment of 5 numbers of Benchmark and 10 numbers of Reference Pillars (2 reference pillars for each BM)
- c) Total station survey on 455 hector area
- d) Producing maps of topographical information and features
- e) Detail contour survey by taking spot levels at 20 Meter intervals constructing Bench mark, reference pillars and grid pillars of approved specifications at 100 meter grid points of the area surveyed.

1.5.3 Geotechnical Investigations

- a) Execution of minimum 6 numbers of exploratory borings depth up to 40 meters, recording of sub-soil stratification and position of ground water table.
- b) Execution of standard penetration test (SPT) at an interval of 1.5 m depth with collection of disturbed soil samples up to the final depth of exploration of each boring.
- c) Carry out laboratory test of required engineering properties of sub soil.

1.6 The EIA Team

JICA Study Team has formed a multidisciplinary team of EIA experts of having experience of conducting Environmental Impact Assessment of large scale industrial and infrastructural development projects. The name of the professionals' involved in the study is as below:

Japanese expert list and its role of work are as follows:

● Team Leader/ Power Plant System Planning A	Shigeru SAITO
● Deputy Team Leader/ Power Plant System Planning B	Yoichiro KUBOTA
● Power Plant Construction Planning	Shinji OUCHI
● Implementation Plan and Estimation	Sachio KOSAKA
● Civil	Mitsuaki SHIMADA
● Mechanical	Hideki ASAYAMA
● Electrical and I&C	Yoshihide KANAI
● Port Planning	Mitsunobu ABE
● Port Engineering	Ryo KONDO
● Power System Analysis	Atsushi YUIHARA
● Transmission	Satoshi KOBAYASHI
● Substation	Tomio ICHIKAWA
● Fuel Supply Planning	Hajime ENDO
● Fuel Transportation Planning	Genshiro KANO
● Operation & Maintenance Management A	Kiyoshi KATAOKA
● Operation & Maintenance Management B	Mayo YONEYAMA
● Human Resource Administration	Keiichi FUJITANI
● Economy and Financial Analysis	Yasuhisa KURODA
● Organization Structure	Noboru SEKI
● Project Operation	Atsumasa SAKAI
● Environmental A	Tadashi NAKAMURA
● Environmental B	Shigeki WADA
● Environmental Impact Evaluation	Norihiko FUKAZAWA
● Fauna & Flora	Kenzo UTSUGI
● Environmental & Social Consideration	Tadashi MIYAGI
● Social Consideration	Junko FUJIWARA
<Access Road Unit>	
● Access Route Selection/Road /Foundation	Kiyoshi WATANABE
● Road Planning	Toshiyuki KOBAYASHI
● Road Construction Plan/Cost Estimate	Takeo MOGAMI

- Natural Condition (Foundation/Geology/Hydrology) Yoshiyuki AKAGAWA
- Bridge/Structure Design Makoto IIDA
- Environmental & Social (Land Acquisition and Resettlement Action Plan) Osamu NAKAZAWA
- Environmental & Social 8Social Survey and Ecosystem Jiro OTSUBO
- Environmental & Social (EIA) Kazuhiro YOSHIDA
- Economic Analysis Hiroaki YAMAGISHI

Bangladeshi expert list and its role of work are as follows:

Sl. No.	Name of Professionals	Position Assigned
1.	Syed Bahar Uddin	Electrical Engineer & Local Team Leader
2.	Rama Nath Roy	Environmental Specialist
3.	Dr. Khairul Bashar	Geological Expert
4.	AKM Anisur Rahman	Mechanical Engineer
5.	Mohammad Muslem Uddin	Fisheries Specialist
6.	Dr. Nazmun Nahar	Water Resources Engineer
7.	Mohammad Omar Faruque	Flora Specialist
8.	Mohammad Abdul Wahed Chowdhury	Wildlife Specialist
9.	Mizanur Rahman Khan	Socio-Economist
10.	Md. Mahbubul Islam	Geologist
11.	Md. Mohsin Patwary	Morphologist
12.	S.M. Andalib	Environmental Law Specialist

Chapter 2

**Legal and Legislative Framework,
Regulations and Policy Consideration**

Chapter 2

Legal and Legislative Framework, Regulations and Policy Consideration

Table of Contents

2.1	Environmental Regulation	1
2.2	Protected Areas and Environmentally Controlled Areas.....	9

2.1 Environmental Regulation

Details of the environmental standards applicable in Bangladesh are described in the Environmental Conservation Rules (ECR). Regulated areas cover all industries, and regulated items are air quality, water quality (surface water, drinking water), noise (boundary, source), emissions from motor vehicles or ships, odor, sewage discharge, waste from industrial units and industrial effluents or emissions. Items and standards, which are related to the construction and operation of coal-fired power plants, are listed below. Tables and annotations of environmental regulations are described as textual descriptions of ECR.

ECR is currently in the process of amendment. There is a possibility that the environmental regulations of the following items will be amended, but the current regulations are applicable until the amendment process is completed.

In addition to ECR, this project will also comply with IFC (International Finance Corporation) EHS (Environmental, Health and Safety) Guideline “General”, “Thermal power” and “Transmission and Distribution”.

(1) Air quality

Table 1.1-1 shows the air quality standards in Bangladesh. Air quality standards adhere to WHO guidelines, also mentioned in the table below.

Table 2.1-1 Standards for air quality in Bangladesh ¹

No.	Parameter	Concentration (mg/m ³)		Exposure Time
		ECR	IFC Guideline (General: 2007)*	
a)	Carbon Mono-oxide	10	-	8 hours
		40	-	1 hour
b)	Lead (Pb)	0.5	-	Year
c)	Nitrogen Oxide	0.1	0.04	Year
		-	0.2	1 hour
		-	0.2	1 hour
d)	Suspended Particulate Matter (SPM)	0.2	-	8 hours
e)	Particulate Matter 10µm (PM ₁₀)	0.05	0.02	Year
		0.15	0.05	24 hours
f)	Particulate Matter 2.5µm (PM _{2.5})	0.015	0.01	Year
		0.065	0.025	24 hours
g)	Ozone	0.235	-	1 hour
		0.157	0.160	8 hours
h)	Sulfur Dioxide	0.08	-	Year
		0.365	0.125	24 hours

Notes: * Air quality standard of IFC Guideline is quoted from WHO Guideline.

(Source: Bangladesh Gazette July 19, 2005, IFC Environmental Health and Safety Guidelines 2007)

¹ Not exceed one time per year

Table 2.1-2 shows gas emission standards for industrial facilities in Bangladesh, and Table 2.1-3 shows gas emission standards for industrial boilers in Bangladesh.

Table 2.1-2 Gas emission standards for industrial facilities

No.	Parameter	Unit	Standard Limit
1	Particulates		
	a) Electric Power plants of 200 Megawatts and above	mg/Nm ³	150
	b) Electric Power plants less than 200 Megawatts	mg/Nm ³	350
2	Chlorine	mg/Nm ³	150
3	Hydrochloric Acid gas & mist	mg/Nm ³	350
4	Total Fluoride (F)	mg/Nm ³	25
5	Sulfuric Acid mist	mg/Nm ³	50
6	Lead particles	mg/Nm ³	10
7	Mercury particles	mg/Nm ³	0.2
8	Sulfur Dioxide		
	a) Sulfuric Acid manufacture (DCDA process)	kg/ton	4
	b) Sulfuric Acid manufacture (SCSA process)		
	Minimum Stack height for Sulfuric Acid emissions	kg/ton	10
	Lowest height of stack for dispersion of sulfuric acid		
	a) Coal Fired Electric Power plants		
	i) 500 Megawatts & above	m ²	275
	ii) 200-500 Megawatts	m	220
	iii) Below 200 Megawatts	m	14 (Q) ^{0.3}
	b) Boilers		
	i) For Steam up to 15 tons/hour	m	11
	ii) For steam above 15 tons/hour	m	14 (Q) ^{0.3}
9	Nitrogen Oxides		
	a) Nitric Acid manufacture	kg/ton	3
	b) Gas Fired Electric Power plants		
	i) 500 Megawatts & above	ppm	50
	ii) 200-500 Megawatts	ppm	40
	iii) Less than 200 Megawatts	ppm	30
	c) Metal Treatment Furnace	ppm	200
10	Soot & Dust Particles		
	a) Air Ventilated Furnaces	mg/Nm ³	500
	b) Brick-fields	mg/Nm ³	1000
	c) Cooking Furnaces	mg/Nm ³	500
	d) Limestone Furnaces	mg/Nm ³	250

(Source: The Environmental Conservation Rules, 1997)

Table 2.1-3 Gas emission standard for industrial boiler

No.	Parameters	Standard for presence in a unit of mg/Nm ³
1	Soot and particulates (fuel based)	
	a) Coal	500
	b) Gas	100

² Lowest height of stack is defined

³ Q=SO₂ emission in kg/hour

No.	Parameters	Standard for presence in a unit of mg/Nm ³
	c) Oil	30
2	Oxides of Nitrogen (fuel based)	
	a) Coal	60
	b) Gas	15
	c) Oil	30

(Source: The Environmental Conservation Rules, 1997)

A coal-fired power plant utilizes coal (main fuel) and oil (auxiliary fuel for startup). Since the planned output of the power plant is 600MW, the emission standard limit of particulates is 150mg/Nm³. For Sulfur Dioxide, if a stack of 275m height is installed, there are no standard limits of emissions densities and amount limits. The emission standard limit of Oxides of Nitrogen shown in Table-3 is 600 mg/Nm³ in the case of coal-firing and 300 mg/Nm³ in the case of oil firing.

It is common to set emission standards to SO₂ based on global standards. Table 2.1-4 shows a comparison of the flue gas emission standards of Bangladesh to the World Bank (IFC). A new coal-fired power plant should consider these world standards.

Table 2.1-4 Comparison of flue gas emission standards between Bangladesh and IFC

Parameters	Bangladesh Standard	IFC Guidelines (Thermal Power: 2008)
SO ₂	- ⁴	850mg/m ³ ⁵
NO _x	600 mg/m ³	510 mg/m ³
Particulate Matter (PM)	500mg/m ³	50mg/m ³
Dry Gas , Excess O ₂ Content	-	6%

(Source: The Environmental Conservation Rules 1997, IFC Environmental Health and Safety Guidelines 2008)

(2) Water quality

Table 2.1-5 shows ambient water quality standards (inland surface water), Table 2.1-6 shows environmental water quality standards (drinking water), and Table 2.1-7 shows waste water standard parameters in Bangladesh. For drinking water standards and waste water standards, WHO standards are also stated in the tables below for comparison. World Bank (IFC) guidelines stipulate monitoring necessary heavy metals according to the characteristics of each thermal power plant.

⁴ Lowest height of stack is defined

⁵ As the high limit in non-degraded airsheds

Table 2.1-5 Ambient water quality standards (inland surface water)⁶

No.	Best Practice Based Classification	pH	BOD mg/l	Dissolved Oxygen (DO), mg/l	Total Coliform Bacteria quantity/ml
a)	Potable water source supply after	6.5-8.5	2 or less	6 or above	50 or less
b)	Water used for recreation	6.5-8.5	3 or less	5 or above	200 or less
c)	Potable water source supply after	6.5-8.5	3 or less	6 or above	5000 or less
d)	Water used for pisci-culture	6.5-8.5	6 or less	5 or above	5000 or less
e)	Industrial use water including chilling & other processes	6.5-8.5	10 or less	5 or above	
f)	Water used for irrigation	6.5-8.5	10 or less	5 or above	1000 or less

(Source: The Environmental Conservation Rules, 1997)

Table 2.1-6 Environmental water quality standards (drinking water)

No.	Parameter	Unit	Standard Limit	WHO Guidelines
1	Aluminum	mg/l	0.2	0.2
2	Ammonia (NH ₃)	mg/l	0.5	-
3	Arsenic	mg/l	0.05	0.01
4	Barium	mg/l	0.01	0.7
5	Benzene	mg/l	0.01	0.01
6	BOD ₅ 20°C	mg/l	0.2	-
7	Boron	mg/l	1.0	0.5
8	Cadmium	mg/l	0.005	0.003
9	Calcium	mg/l	75	-
10	Chloride	mg/l	150-600	-
11	Chlorinated Alkanes			-
	Carbon Tetrachloride	mg/l	0.01	-
	1.1 Dichloroethylene	mg/l	0.001	-
	1.2 Dichloroethylene	mg/l	0.03	-
	Tetrachloroethylene	mg/l	0.03	-
	Trichloroethylene	mg/l	0.09	-
12	Chlorinated Phenols			-
	Pentachlorophenol	mg/l	0.03	-
	2.4.6 Trichlorophenol	mg/l	0.03	-
13	Chlorine (residual)	mg/l	0.2	-
14	Chloroform	mg/l	0.09	0.3
15	Chromium (hexavalent)	mg/l	0.05	-
16	Chromium (total)	mg/l	0.05	0.05
17	COD	mg/l	4	-
18	Coliform (fecal)	n/100 ml	0	-
19	Coliform (total)	n/100 ml	0	-
20	Color	Huyghens unit	15	-
21	Copper	mg/l	1	-
22	Cyanide	mg/l	0.1	-
23	Detergents	mg/l	0.2	-
24	DO	mg/l	6	-
25	Fluoride	mg/l	1	1.5
26	Hardness (as CaCO ₃)	mg/l	200-500	-
27	Iron	mg/l	0.3-1.0	-

⁶ Textual annotations are as follows.

(1) Maximum amount of ammonia presence in water is 1.2 mg/l (as nitrogen molecule) which is used for pisciculture.

(2) For water used in irrigation, Electrical Conductivity-2250 micro mho/cm (at 25°C). Sodium less than 26 mg/l, Boron less than 2 mg/l

No.	Parameter	Unit	Standard Limit	WHO Guidelines
28	Nitrogen (Total)	mg/l	1	-
29	Lead	mg/l	0.05	0.01
30	Magnesium	mg/l	30-35	-
31	Manganese	mg/l	0.1	0.4
32	Mercury	mg/l	0.001	0.006
33	Nickel	mg/l	0.1	0.07
34	Nitrate	mg/l	10	3
35	Nitrite	mg/l	Less than 1	-
36	Odor		Odorless	-
37	Oil & Grease	mg/l	0.01	-
38	pH		6.5-8.5	-
39	Phenolic compounds	mg/l	0.002	-
40	Phosphate	mg/l	6	-
41	Phosphorus	mg/l	0	-
42	Potassium	mg/l	12	-
43	Radioactive Materials (gross alpha)	Bq/l	0.01	-
44	Radioactive Materials (gross beta)	mg/l	0.1	-
45	Selenium	mg/l	0.01	-
46	Silver	mg/l	0.02	-
47	Sodium	mg/l	200	-
48	Suspended particulate matters	mg/l	10	-
49	Sulfide	mg/l	0	-
50	Sulfate	mg/l	400	-
51	Total dissolved solids	mg/l	1000	1000
52	Temperature	III	20-30	-
53	Tin	mg/l	2	-
54	Turbidity	JTU	10	-
55	Zinc	mg/l	5	-

(Source: The Environmental Conservation Rules 1997, Guidelines for Drinking-water Quality WHO 2008)

Table 2.1-7 Wastewater Discharge Standards ⁷

No.	Parameter	Unit	Inland Surface Water	Public Sewer at Secondary Treatment plant	Irrigated Land	IFC Guideline (Thermal power: 2008)
1	Ammoniacal Nitrogen (N molecule)	mg/l	50	75	75	-
2	Ammonia (free ammonia)	mg/l	5	5	15	-
3	Arsenic (As)	mg/l	0.2	0.05	0.2	0.5

⁷ Textual annotations are as follows.

(1) These standards shall be applicable to industrial units or projects other than those given under Quality Standards for Classified Industries (Schedule 12).

(2) These quality standards must be ensured at the moment of going into trial production for industrial units and at the moment of going into trial production for industrial units and at the moment of going into operation for other projects.

(3) The value must not exceed the quality standard during spot checks at any time; if required, the quality standards may be stricter to meet the environment terms in certain areas.

(4) Inland Surface Water shall mean drains, ponds, tanks, water bodies or water holes, canals, rivers, springs and estuaries.

(5) Public sewer shall mean sewers connected with fully combined processing plant including primary and secondary treatment.

(6) Irrigated land shall mean appropriately irrigated plantation areas of specified crops based on quantity and quality of waste water.

(7) Inland Surface Quality Standards (Schedule 13) shall be applicable for any discharge taking place in public sewers or land not defined in Notes 5

No.	Parameter	Unit	Inland Surface Water	Public Sewer at Secondary Treatment plant	Irrigated Land	IFC Guideline (Thermal power: 2008)
4	BOD ₅ 20°C	mg/l	50	250	100	-
5	Boron	mg/l	2	2	2	-
6	Cadmium (Cd)	mg/l	0.05	0.5	0.5	0.1
7	Chloride	mg/l	600	600	600	-
8	Chromium (total Cr)	mg/l	0.5	1.0	1.0	0.5
9	COD	mg/l	200	400	400	-
10	Cr ⁶⁺ (hexavalent Cr)	mg/l	0.1	1.0	1.0	-
11	Copper (Cu)	mg/l	0.5	3.0	3.0	0.5
12	Dissolved Oxygen (DO)	mg/l	4.5-8	4.5-8	4.5-8	-
13	Electrical Conductivity	micro mho/cm	1200	1200	1200	-
14	Total Dissolved Solids	mg/l	2,100	2,100	2,100	-
15	Fluoride (F)	mg/l	7	15	10	-
16	Sulfide (S)	mg/l	1	2	2	-
17	Iron (Fe)	mg/l	2	2	2	1
18	Total Kjeldahl Nitrogen (N)	mg/l	100	100	100	-
19	Lead (Pb)	mg/l	0.1	1.0	0.1	0.5
20	Manganese (Mn)	mg/l	5	5	5	-
21	Mercury (Hg)	mg/l	0.01	0.01	0.01	0.005
22	Nickel (Ni)	mg/l	1.0	2.0	1.0	-
23	Nitrate (N molecule)	mg/l	10.00	Undetermined	10	-
24	Oil & grease	mg/l	10	20	10	10
25	Phenol compounds(C ₆ H ₅ OH)	mg/l	1.0	5	1	-
26	Dissolved Phosphorus (P)	mg/l	8	8	10	-
27	Radioactive Materials.	As determined by Bangladesh Atomic Energy Commission				-
28	pH		6-9	6-9	6-9	6-9
29	Selenium	mg/l	0.05	0.05	0.05	-
30	Zn (Zn)	mg/l	5.0	10.0	10.0	1
31	Total Dissolved solid	mg/l	2,100	2,100	2,100	-
32	Temperature	Centigrade	40	40	40-Summer	-
			45	45	45-Winter	-
33	Total Suspended Solid (TSS)	mg/l	150	500	200	50
34	Cyanide (CN)	mg/l	0.1	2.0	0.2	-

(Source: The Environmental Conservation Rules 1997. IFC Environmental Health and Safety Guidelines 2008)

(3) Noise and Odor

In regards to noise, the standard limit is set for every category of zone class. Table 1.1-8 shows the noise standards in Bangladesh.

Table 2.1-8 Standards for Noise⁸

No	Zone Class	Limits in dBA			
		ECR		IFC Guideline (General: 2007)	
		Day	Night	Day	Night
a)	Silent Zone	45	35	55	45
b)	Residential Zone	50	40		
c)	Mixed Zone (this area is used combining residential, commercial and industrial purposes)	60	50	70	70
d)	Commercial Zone	70	60		
e)	Industrial Zone	70	70		

(Source: The Environmental Conservation Rules, 1997 IFC Environmental Health and Safety Guidelines 2008)

Ammonia is used in SCR, which is possible to be introduced for the purpose of nitrogen oxide reduction. Including ammonia, Table 1.1-9 shows the odor emission standards in Bangladesh.

Table 1.1-9 Standards for Odor⁹

Parameter	Unit	Standard Limit
Acetaldehyde	ppm	0.5 – 5
Ammonia	ppm	1 – 5
Hydrogen Sulfide	ppm	0.02 – 0.2
Methyl Disulfide	ppm	0.009 – 0.1
Methyl Sulfide	ppm	0.01 – 0.2
Styrene	ppm	0.4 – 2.0
Trim ethylamine	ppm	0.005-0.07

(Source: The Environmental Conservation Rules 1997)

⁸ Textual annotations are as follows.

(1) Day time is considered from 6 a.m. to 9 p.m. and night time is from 9 p.m. to 6 a.m.

(2) From 9 at night to 6 in the morning is considered night time.

(3) Areas within 100 meters of hospitals, education institutions, educational institutions or government designated / to be designated / specific institution / establishments are considered Silent Zones. Use of motor vehicle horns or other signals and loudspeaker are forbidden in Silent Zones.

⁹ Textual annotations are as follows.

(1) Following regulatory limits shall be generally applicable to emission/exhaust outlet pipes of above 5 meter height: $Q = 0.108 \times He^{2.7} C_m$ (Where Q = Gas Emission rate Nm³/hour)
He = Height of exhaust outlet pipe (m)
Cm = Above mentioned limit (ppm)

(2) In cases where a special parameter has been mentioned, the lower limit shall be applicable for warning purposes, and the higher limit shall be applicable for prosecution purposes or punitive measures.

(4) Electric and magnetic fields

IFC EHS Guideline (Electric Power Transmission and Distribution; 2007) recommends the following methods for managing EMF (Electric and magnetic fields) generated by transmission line.

- Evaluating potential exposure to the public against the reference levels developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). Average and peak exposure levels should remain below the ICNIRP recommendation for General Public Exposure (Table 2.1-10).
- Considering siting new facilities so as to avoid or minimize exposure to the public. Installation of transmission lines or other high voltage equipment above or adjacent to residential properties or other locations intended for highly frequent human occupancy, (e.g. schools or offices), should be avoided;
- If EMF levels are confirmed or expected to be the recommended exposure limits (Table-10), application of engineering techniques should be considered to reduce the EMF produced by power lines, substations, or transformers. Examples of these techniques include:
 - o Shielding with specific metal alloys
 - o Burying transmission lines
 - o Increasing height of transmission towers
 - o Modifications to size, spacing, and configuration of conductors

Table 2.1-10 Recommended exposure limits for general public exposure to electric and magnetic fields
(IFC Guideline: “Transmission and Distribution”, 2007)

Frequency	Electric Field (V/m)	Magnetic Field (μT)
50 Hz	5,000	100
60 HZ	4,150	83

Source: International Commission on Non-Ionizing Radiation Protection (1998): “Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).

2.2 Protected areas and environmentally controlled areas

Classification of protected areas and environmentally-controlled areas in Bangladesh are shown in Table 2.2-1. These areas are declared as National Parks, Wildlife Sanctuaries, Game Reserves, Botanical Gardens and Eco-parks under the Wildlife (Preservation) Order, Reserved Forests and Protected Forests under the Forest Act and Ecologically Critical Areas (ECA) notified under the Environmental Conservation Act.

Table 2.2-1 Classification of protected areas and environmentally controlled areas

Classification		Competent Authority	Governing law
A	National Parks	Department of Forest	Wildlife (Preservation) Order
B	Wildlife Sanctuaries		
C	Game Reserves		
D	Botanical Gardens, Eco-parks		
E	Reserved Forests, Protected Forests		Forest Act
F	Ecologically Critical Areas	Department of Environment	Environmental Conservation Act

(Source: Power System Master Plan 2010)

There are fifteen national parks, thirteen wildlife sanctuaries, five botanical gardens and eco-parks in Bangladesh classified under the Wildlife (Preservation) Order, having a total area of 2,702.2 km². A list of the protected areas and environmentally-controlled areas declared under the Wildlife (Preservation) Order are shown in Table 2.2-2.

There are nine ECAs with a total area of 8,063.2 km² excluding the Gulshan–Banani-Baridhara Lake in Dhaka. Table-13 shows a list of ECA designated areas under the Bangladesh Environmental Conservation Act (BECA). BECA provides for ECA declarations by the Director General of the Department of Environment in cases where an ecosystem or biodiversity area is considered to be threatened to reach a critical state. Along with the ECA declaration, each ECA has notifications declared in which specific activities to be restricted in that ECA are specified.

Table 2.2-2 List of protected areas and environmentally controlled areas

Item	No	Name	Place	Size (km ²)
A	1	Bhawal National Park	Gazipur	50.2
	2	Modhupur National Park	Tangail/ Mymensingh	84.4
	3	Ramsagar National Park	Dinajpur	0.3
	4	Himchari National Park	Cox's Bazar	17.3
	5	Lawachara National Park	Moulavibazar	12.5
	6	Kaptai National Park	Chittagong Hill Tracts	54.6

Item	No	Name	Place	Size (km ²)
B	7	Nijhum Dweep National Park	Noakhali	163.5
	8	Medha Kachhapia National Park	Cox's Bazar	4.0
	9	Satchari National Park	Habigonj	2.4
	10	Khadim Nagar National Park	Sylhet	6.8
	11	Baraiyadhala National Park	Chittagong	29.3
	12	Kuakata National Park	Patuakhali	16.1
	13	Nababgonj National Park	Dinajpur	5.2
	14	Shingra National Park	Dinajpur	3.1
	15	Kadigarh National Park	Mymensingh	3.4
	1	Rema-Kalenga Wildlife Sanctuary	Hobigonj	18.0
	2	Char Kukri-Mukri Wildlife Sanctuary	Bhola	0.4
	3	Sundarban (East) Wildlife Sanctuary	Bagerhat	312.3
	4	Sundarban (West) Wildlife Sanctuary	Satkhira	715.0
	5	Sundarban (South) Wildlife Sanctuary	Khulna	369.7
	6	Pabla Khali Wildlife Sanctuary	Chittagong Hill Tracts	420.9
D	7	Chunati Wildlife Sanctuary	Chittagong	77.6
	8	Fashiakhali Wildlife Sanctuary	Cox's Bazar	32.2
	9	Dudh Pukuria-Dhopachari Wildlife Sanctuary	Chittagong	47.2
	10	Hazarikhil Wildlife Sanctuary	Chittagong	29.1
	11	Sangu Wildlife Sanctuary	Bandarban	57.6
	12	Teknaf Wildlife Sanctuary	Cox's Bazar	116.2
	13	Tengragiri Wildlife Sanctuary	Barguna	40.5
	1	National Botanical Garden	Dhaka	0.8
	2	Baldha Garden	Dhaka	-
	3	Madhabkunda Eco-Park	Moulavibazar	2.7
	4	Sitakunda Botanical Garden and Eco-park	Chittagong	8.1
	5	Dulahazara Safari Parks	Cox's Bazar	6.0

(Source: <http://www.bforest.gov.bd/conservation.php>, accessed January 2011)

Table 2.2-3 List of Environmental Critical Areas

Item	No	Name	Place	Size (km ²)
F	1	The Sundarbans	Bagerhat, Khulna, Satkhira	7,620.3
	2	Cox's Bazar (Teknaf, Sea beach)	Cox's Bazar	104.7
	3	St. Martin Island	Cox's Bazar	5.9
	4	Sonadia Island	Cox's Bazar	49.2
	5	Hakaluki Haor	Moulavi Bazar	183.8
	6	Tanguar Haor	Sumamganj	97.3
	7	Marjat Baor	Jhinaidha	2
	8	Gulshan-Banani-Baridhara Lake	Dhaka	-
	9	Rivers (Buriganga, Turag, Sitalakhya and Balu) around Dhaka city	Dhaka	-

(Source: Biodiversity National Assessment and Programme of Action 2020, DOE Bangladesh, 2010)

Chapter 3

Project Data Sheet

Chapter 3

Project Data Sheet

Table of Contents

3.1	Project Proponent	1
3.2	Comparison of Energy Option for Generation	5
3.3	Unit Capacity	6
3.4	Economic Effect brought by the Project	7
3.5	Selection of Suitable Site	7
3.6	Design Condition	9

3.1 Project Proponent: Basic Concept

The project includes first experience items for Bangladesh such as large size high efficiency coal-fired power plant, coal import and deep sea port development. In addition, it is the first step for future development.

Concerning the importance of the Project in Bangladesh, in this study, the following 5 items are configured as “Basic Concept”, and the study was conducted in order to achieve them.

- 1st Unit with State-of-art Technology
- Environmental Friendly
- Power System Stability
- Expansion Potential in the Future
- Social Community Development

According to the power development scenario, a specific coal power development plan was formulated. Regarding domestic coal, it is assumed that it will take time for domestic coal development progress. On the other hand, import coal could be considered soon. However, in considering coal imports, the problem is that it is almost shallow around the Bay of Bengal. To achieve efficient coal imports, the direct approach of large scale coal ships should be necessary. However, there is only a small area in the southeast of Bangladesh with a deep sea. Therefore, at an early stage, a power station with a deep sea port should be developed at the site in the south east area, after that the site will be developed into a “coal center”, and the coal transportation system from the coal center will be formulated. This system will make the stable coal supply.

In the PSMP2010 power development scenario, operations of the first imported coal fired power plant are slated to start in 2016. However, it is impossible to build a port that can dock large-scale vessels until 2016. Therefore, until the completion of a large-scale port and coal center by 2020, it is planned to have the coal transportation vessels anchor offshore and from there, small-size barges will shuttle coal to the power plants. However, the Matarbari Coal Fired Power Station is not scheduled to begin operations until 2023. Given this extended period of time, it is possible to develop a port that would be able to accommodate large-scale vessels. This would allow the vessels to dock directly and thus it would be unnecessary to have the vessels anchor offshore. That is why this project is the first step of coal-fired power development in Bangladesh. In the future, by developing an

import coal power station in other areas (inland areas) and establishing a coal center, the power station can serve as a hub of coal supply.

In addition, the Deep Sea Port Project, whose implementation was planned to take place at Sonadia Island by the Ministry of Shipping in Bangladesh, is not progressing as this island has been designated as an Environmental Critical Area. To sum up, the port being developed by this project would be the first Deep Sea Port in Bangladesh. Once completed, this port has the possibility to contribute to not only coal imports but also the large-scale commercial development of the Matarbari area.

3.2 Comparison of Energy Option for Generation

From various points of views, coal has its advantages except as an environment load. It means that, as the future stable energy for Bangladesh, it would be the best solution to apply coal by considering countermeasures to reduce environmental load.

Table 0 Comparison of Fuel Option for Thermal Power Generation for Bangladesh

	Natural Gas ↖ LNG, Shale Gas ↗	Oil	Coal
Price Stability	Fluctuate per the world situation. (dominantly synchronized with oil prices) No experience in importing Shale Gas	Fluctuate per the world situation.	Stable. Cheaper than LNG
Supply Flexibility	Production area is limited. Reserve 58.6 years Currently shale gas is in the USA	Production area is limited to the Middle East Reserve 46.2 years	Everywhere Reserve 118 years Solid biomass fuel can be accepted.
Easiness of Market Entry	Difficult to join	Possible to extend current imports	Easy to join
Facility Investment	Large port Storage (tank) vaporizer	Large port Storage (tank) (Refinery)	Large port Coal storage and transportation facility
Environment Load	Low (Low CO ₂ emissions No sulfur)	Middle (Middle CO ₂ emissions Little sulfur (depends on production area))	High (High CO ₂ emissions Sulfur (depends on production area))
CO ₂ Emission Factor(*1)	56.1 t-CO ₂ /TJ (58% for Coal)	73.3 t-CO ₂ /TJ (76% for Coal)	96.1 t-CO ₂ /TJ (100)
Others	High demand in the residential/commercial sectors	High demand in the residential/commercial sectors	Only for the power sector

(*1): 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.3 Unit Capacity

It is important to determine the unit capacity during the development of the new power station. Generally, equipment with bigger unit size has the advantage of scale so that the construction costs can be decreased. However such equipment has a big impact to the whole of the power grid in case it stops due to trouble. Therefore, the optimum unit capacity should be determined via a comparison of the related items taking in account the stability of the power grid.

For a decision of the unit capacity of this project, the following 3 candidate types were compared.

Table 0 Case for Comparison

	Case 1	Case 2	Case 3
Unit Capacity	300MW	600MW	800MW
Steam conditions	16.6MPa	24.1MPa	24.1MPa
	566III/566III	566III/566III	566III/566III
Unit construction costs	1,690USD/kW	1,600USD/kW	1,500USD/kW
Efficiency (LHV)	42.0%	43.8%	43.8%
Auxiliary power ratio	7.0%	7.0%	7.0%
Forced outage rate	8%	8%	8%

* Forced outage rate = (Annual forced outage time) / (8760 hour – Annual planned outage time)

(Source: JICA Study Team)

For the above, one candidate would be selected by comparing the following five points. The “Economy” and the “Possibility of a system collapse” are given special consideration.

- Economy
- Possibility of a system collapse
- Reliability level
- Environment (CO₂)
- Operations and maintenance

Generally, for the comparison of a newly installed generation facility, the economy is the important point. However, in this case, as mentioned later, the unit capacity is the issue of having an impact for the stability of the whole power system, so the possibility of a system collapse is also an important point.. Therefore, these 2 points should be made compared weighing their respective areas of importance.

For each point, the comparison is conducted. In this comparison, the economy and possibility of a system collapse should be weighed. Regarding the economy, 600MW or 800MW should be chosen because of the size and difference of type, and regarding possibility of a system collapse, the risk of 800MW is higher than 600MW. Considering that the level of the economy is almost the same, in this comparison, 600MW should be chosen by weighing the risk of a system collapse.

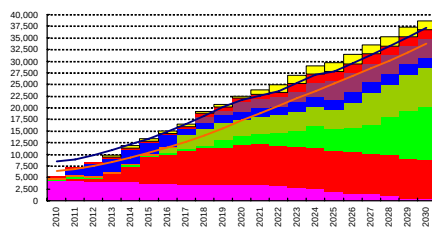
It is true that the larger the size, the more economical it is. Therefore, in the future, in case demand increases, the possibility of a system collapse could become lower. So in the future, the adoption of an 800MW unit or a 1,000MW unit could be considered.

3.4 Economic Effect brought by the Project

By implementing this project, not only will power supply be increased in Bangladesh, but other various associated effects can also be expected. Many type of economic effects could be estimated, the following shows some simple examples.

(1) Impact to GDP

The target of the elasticity of the power demand to the GDP is 1.4. Here “the elasticity” refers to the ratio between the electric energy consumption growth ratio (power demand growth ratio) and the economic growth ratio (GDP growth ratio). Suppose that the GDP growth is 5%, the GDP in 2022 when the project starts commercial operations would be Tk 13,468.9 billion. If the power demand at that time is 20,443MW, which is the same as the forecast, and if the increase of the 2 x 600MW = 1,200MW demand occurs via the newly started power plant (actually a part of the capacity is not an increase because some rental power plant would stop operations instead), the demand growth ratio is equal to about $1,200 / 20,443 = 5.9\%$. In case the elasticity is 1.4 at that time, it is equivalent to about 4.2% of GDP growth. It means that, the impact of the project to the GDP would be about Tk $13,468.9 \text{ billion} * 4.2\% = \text{Tk } 565.6 \text{ billion}$.



[Year 2022]
 Demand Forecast:
20,443MW
+1,200MW=+5.9%

More than
560
 Billion Tk/year
 Worth

Source: JICA Study Team

Figure 3.4 Image of Impact to GNP

(2) Impact to the power sector's finances

Currently, in order to mitigate power shortage, the power sector relies on rental power facilities even though the unit costs are high. In that situation, by installing a large scale coal-fired power plant whose generation costs are low, rental power facilities could be decreased so that total generation costs would be reduced. It means that, from a BPDB side, because the unit price of procurement is low, the procurement costs become low. For example, as an objective for comparison, the HFO-fired rental power plant with the same size (1,200MW) is concerned. According to Chapter 11, the current cost (procurement costs of BPDB) of the HFO-fired rental power plant is Taka 15.61 /kWh, while the price of the Project is Taka 7.04 /kWh. It means there is a difference of Taka 8.57/kWh in the procurement costs. By using 80% of the plant factor (annual power amount is $1,200\text{MW} * 24\text{hours} * 365\text{days} * 80\% = 8,409\text{GWh}$), as a result, it could be said that, the procurement costs of BPDB will decrease to more than Taka 70 billion /year.

3.5 Selection of Suitable Site

The study areas are Cox Bazaar district, Chittagong district, zone for transmission line, Chittagong city in Bangladesh and coal producing countries. A and B of the aerial photograph of Figure 3.5 are the main study areas.

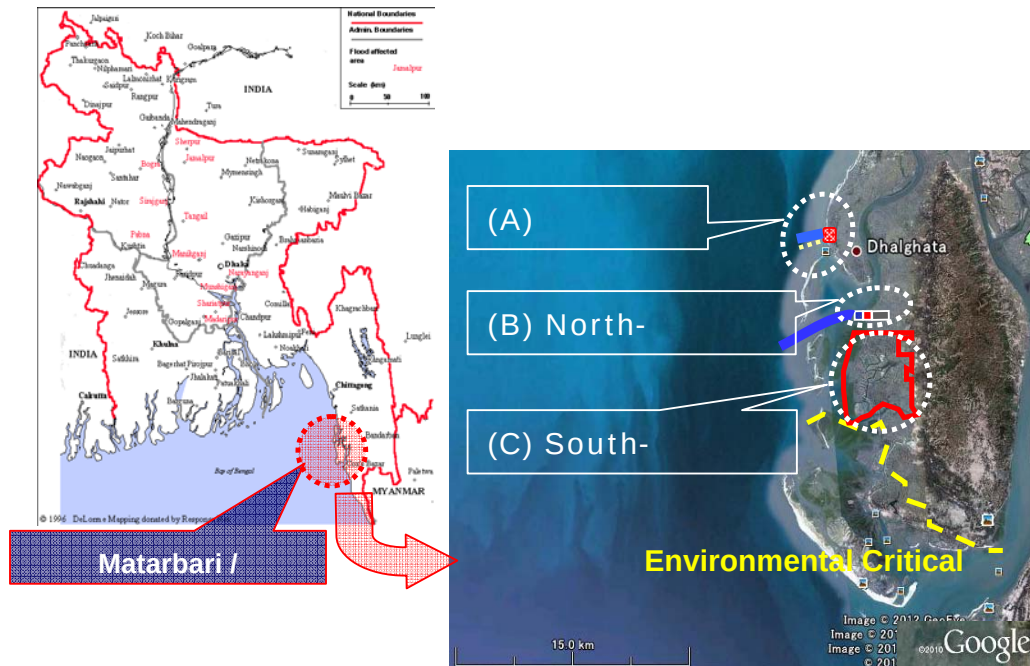


Figure 3.5 : The Study Areas

As the result of the Follow-up Survey, two candidate sites were selected and surveyed. As a first step of the Study, one candidate site should be selected for further detail study. The candidate sites which were selected on the Follow-up Survey were as follows.

According to the result of the Follow-up Survey, Matarbari has an advantage from the viewpoint of environmental issue. After the Follow-up Study, GOB and JICA signed the Minutes of Discussion which says that, Matarbari site would be considered on a priority basis over North-Maheshkhali but in-depth examination and further consideration will be required. As the first step of the Study, the confirmation of the suitability of the candidate site is conducted by detail including site survey and numerical simulation etc.

3.6 Design Condition

3.6.1 Flow Chart of the Study

The flow of the Study is shown in Figure 3.6.1

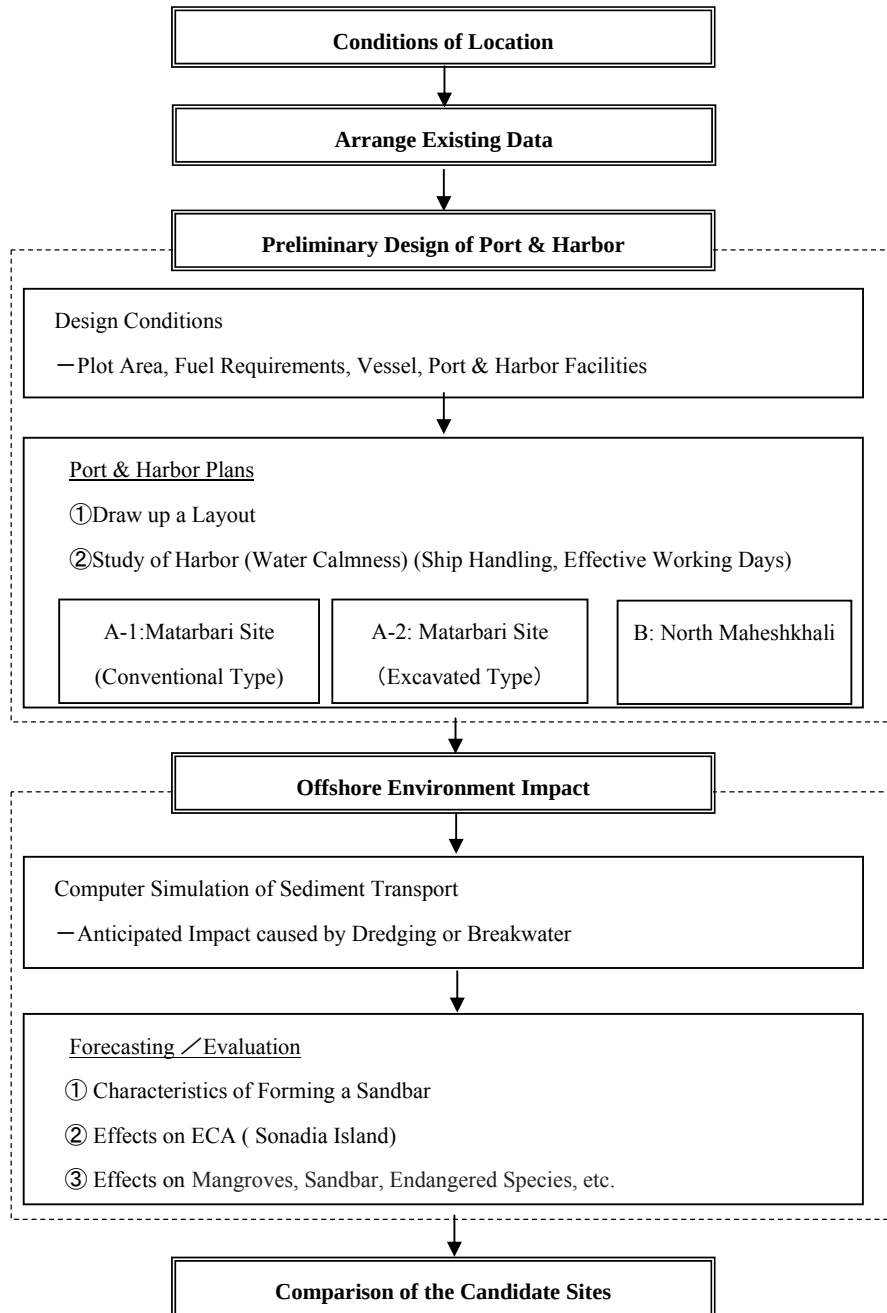


Figure 3.6.1 Flow Chart of the Study

3.6.2 Site Selection

(1) Proposed candidate site

On the basis of the results thus far, the JICA Study Team of port and harbor engineering has concluded that the Matarbari Site should have higher priority than the Maheshkhali Site. The comparative table is as shown below.

- ! The site conditions are based on field studies
- ! Maintenance dredging is based on the computer simulation of sediment transport results
- ! Operability is based on the calmness analysis results
- !

The expansion of port and harbor is based on the land–use planning with the related surrounding circumstances.

Table 3.6.2.1 Site Selection Result (from the viewpoint of port and harbor engineering)

Items	Matarbari Site	Maheshkhali Site
Site Conditions	It is possible to plan a power plant at this site.	It is possible to plan a power plant at this site.
Maintenance Dredging	Need maintenance dredging, but less than the Maheshkhali Site (approx. 600m in length).	Need continuous maintenance dredging throughout the channel (7 km in length).
Operability of Coal Vessels	Channel and mooring basin are calm because of the breakwater or the artificially excavated land, so there is no impact on cargo handling. (reduce wave length height about from 30% to 80% at port entrance)	Ship handling demands extreme care through the restricted channel on account of several dipper dredgers working on the channel (7 km in length).
Expansion of Port & Harbor	Can expand port and harbor, with little effect on coastal change.	To expand port and harbor increases risk of negatively impacting mangroves.
Results	Candidate site for a Power Plant	Unsuitable

Natural Environment Conditions

(1) Background

To get up-to-date information about the natural environment surrounding each project site, the JICA Study Team has conducted interviews with environmental specialists who have been working as nature commentators on site (Sonadia Island) and held a meeting with some environmental specialists at Cox's Bazar Field Office of the Bangladesh Government Department of Environment (DoE).

Environmental specialists have emphasized the importance of the protection of mangrove vegetation, sand dunes, beaches, sandy shoals, and mudflats in and around Sonadia Island (including Maheshkhali areas), as saying that they provide an excellent wintering ground for migratory waterfowl and shorebirds, and a nursing and feeding ground for fish and shrimp species, especially the sand dunes provide nesting grounds for marine turtles.

(2) Number of preliminary alternative sites to have been assessed of their relative merits

The JICA Study Team has adopted three preliminary alternative sites, in which two sites have been considered as candidate project sites by the “Study for the Master Plan (2010),” and the additional site has been added at the stage of this Preparatory Survey (2012) from the perspective of avoiding risks to the mudflats and its ecosystem.

(3) Results of evaluations on Matarbari and Maheshkhali

a) Result of 1st field survey conducted by the JICA Study Team

Table 3.6.2.2 shows a comparison of the Matarbari and Maheshkhali sites from the viewpoint of the natural environment based on the 1st field survey conducted by the JICA Study Team. Both the Matarbari and Maheshkhali sites have poor vegetation and a limited number of animals were observed on land, thus there is no difference between the two sites as a better project site. However, the Maheshkhali site has a huge mangrove forest and sandbar at the sea side of the site; therefore, it is predicted that the mangrove forest and sandbar may be affected during the construction and operation phase of the power plant, if the Maheshkhali site is selected as the project site.

Table 3.6.2.2 Comparison of Matarbari & Maheshkhali from Natural Environment Conditions

Items	Matarbari	Maheshkhali
Vegetation	- Site: Poor - Forest: There are few trees place on the nearest residence area - Mangrove: No Mangrove	- Site: Poor - Forest: There are few trees place on the nearest residence area - Mangrove: <u>There are huge mangrove forests offshore.</u>
Animal	- Site: Sedentary birds observed - Surrounding area: Sedentary birds observed	- Site: Sedentary birds observed - Surrounding area: Sedentary birds are observed over the mangrove forests
Endanger species	- Site: Not observed - Surrounding area: Not observed	- Site: Not observed - Surrounding area: Not observed
Habitat condition surrounding the site	- Corral reef: Not observed - Seaweed bed: Not observed - Sandy beach: Observed - Mudflat: Observed - Sandbar: Not observed	- Corral reef: Not observed - Seaweed bed: Not observed - Sandy beach: Not observed - Mudflat: Observed - Sand bar: <u>There is a sandbar in estuarine region around 4km away from the site</u>

a) Simulation of Waves and Currents

To evaluate the effects of some main activities planned in each project site on the surrounding natural environment of alternative project sites, the following types of simulations have been conducted.

- i. Simulation of wave-height and its effects on geological conditions offshore
- ii. Simulation of tidal currents and its effects on geological conditions offshore
- iii. Simulation of dredging and its effects on geological conditions offshore

Table 3.6.2.3 shows the main results of simulation on environmental issues (project sites) caused by dredging activity.

Table 3.6.2.3 Main results of simulation on environmental issues (project sites)

Project sites Items	Matarbari	Maheshkhali
Wave-height	A little (almost negligible) ✓ A little change on the mud-sediment around the dredging site	Notable ✓ Mud-erosion around dredging site covered with mangroves
Tidal current	None	Notable ✓ Mud-sediment around dredging site covered with mangroves Mud-erosion around dredging site covered with mangroves
Dredging	A little ✓ Periodical dredging is needed but less frequently than Alternative III	Notable ✓ Periodical dredging covering a wide area is needed

a) Comparison of the Matarbari and Maheshkhali sites

Both the Matarbari and Maheshkhali sites have been compared to each other by rating in the degree of environmental impact. The rating using a quantifiable method for the natural environment is not established as an academic discipline yet, therefore, numbers (from 0 to -3) are used to evaluate the natural environment of alternative sites, just as a qualitative tendency.

0: *No impact*

-1: *A small impact but not serious*

-2: *Serious impact but not irreversible*

-3: *Irreversible impact*

From a comparison of the two project sites, the negative points of each alternative site is as below (Table 3.6.2.4).

Matarbari: -2

Maheshkhali: -10

The Maheshkhali site receives a larger negative point and there are impacts on the surrounding mangrove forest, which is an ecologically sensitive area. From the viewpoint of environmental consideration, the Maheshkhali site is not recommended.

Table 3.6.2.4 Comparison of project alternative sites

Impact		Matarbari		Maheshkhali	
Impact on mudflats		(By wave, a little -1)	-1	(By wave, serious -2) (By current, serious -2)	-4
Impact on sea bottom		(By dredging, serious-2)	-2	(By dredging, serious-2)	-2
Impact on sand beach		(By drifting, serious-2)	-2	(By drifting, a little-1)	-1
Impact to flora and fauna	Impact on migratory birds	None	0	None	0
	Impact on sea turtles	None	0	(By dredging near turtle habitat, a little -1)	-1
	Impact on dolphins	None	0	None	0 ¹
	Impact no young fish	None	0	None	0
	Impact on mangroves	None	0	(By wave, serious -2) (By current, serious -2)	-4 ²
	Impact on benthos ³	(By dredging, a little -1)	-1	(By dredging, a little-1)	-1
Distance to Sonadia ECA		None	0	None	0
Evaluation			-6		-13

Note) 0¹ : There is some apprehension regarding impact on dolphins by dredging with 7Km front to offshore, but no information or data available

-4² : There is no direct impact of cutting down mangrove vegetation, but deterioration of habitat by losing mudflats near its root would cause many harsh consequences, such as mangroves falling down

Benthos³ : Including sea grass and

Social Environment

(2) Overview of each site

The overview of each site is summarized in the tables below. Unlike the evaluation for the natural environment conditions, Alternatives I and II have been examined together as the design difference in this case will not likely have a large impact on the social environment. The Matarbari site includes at least Sairer Dail village and the Maheshkhali site includes Kalaghagir Para village. As it is not easy at this moment to identify all villages where alternative sites are located, a complete comparison of the two sites stays at the same level (Table 3.6.2.5).

Table 3.6.2.5 Specifications of Located Unions

Project		Matarbari	Maheshkhali
sites Items			
Located Union		Matarbari Union* (Note) Part of Dhalghata Union may be included as the site is located at the union border.	Hoanak Union
1	Area	6,682 acres (approximately 2,704 ha)	9,165 acres (approximately 3,721 ha)
2	Population	8,168 households (44,937 people) living in 21 villages of the union.	9,373 households (51,587 people) living in 28 villages of the union.
3	Population density	1,661 people per square km	1,386 people per square km
4	Land use	Cultivated land: 600 ha Rice production: 2,328 metric ton	Cultivated land: 1,150 ha Rice production: 4,450 metric ton
5	Employment status	6,944 are employed out of 19,436 aged 7 and above not attending school	9,498 are employed out of 22,689 aged 7 and above not attending school
6	Field of activity	Agriculture: 75.6%, industry: 3.2%, service: 21.3%	Agriculture: 90.1%, industry: 1.7%, service: 8.1%
7	Source of drinking water	Tap: 0.2%, tube well: 95.0%, other: 4.8%	Tap: 0.2%, tube well: 91.3%, other: 8.5%
8	Literacy rate	27.7% (male: 26.1%, female: 29.4%)	29.9% (male: 28.8%, female: 31.1%)
9	Type of house structure	Permanent: 4.4% Semi-permanent: 4.8% Mud / bamboo: 71.7% Temporary: 19.1%	Permanent: 1.4% Semi-permanent: 3.4% Mud / bamboo: 93.8% Temporary: 1.3%
10	Toilet facility	Sanitary (water-sealed): 2.2% Sanitary (non water-sealed): 36.6% Non-sanitary: 49.6% None: 11.6%	Sanitary (water-sealed): 1.4% Sanitary (non water-sealed): 21.7% Non-sanitary: 69.6% None: 7.3%

Source: Population Census 2011, data provided at the Agricultural Division of Maheshkhali Upazila Nirbahi Office.

Conclusion

Table 3.6.2.6 provides the total assessment results of the study. The Matarbari site is considered to be more advantageous than the Maheshkhali site. Therefore, the JICA Survey Team suggests the Matarbari site to the CPGCBL as the project site.

Table 3.6.2.6 Results of the Site Selection

Impact	Matarbari Site		Maheshkhali Site
Technical and economic aspects (port engineering)	- A channel will be necessary for continuous maintenance dredging but to a lesser extent than the Maheshkhali site. - The Matarbari site has greater potential for expansion.	↗	- A channel will be necessary with continuous maintenance dredging throughout the channel, 7 km in length. The maintenance dredging work will be a financial burden. - There is no real opportunity for expansion of the port and harbor because of increased risks of negatively impacting the mangrove forest.
Natural environment	- There is no mangrove forest near the Matarbari site, and the site will not be affected during the construction and operation phase of the power plant, since the amount of dredging soil will be less than the Maheshkhali site.	↗	- The Maheshkhali site has a huge mangrove forest and sandbar at the seaside of the site, therefore, it is predicted that the mangrove forest and sandbar may be affected during the construction and operation phase of the power plant.
Social environment	- Local residents of the small disaster-stricken area will be forced to vacate. - Local residents will lose their private lots, standing crops, shrimps and fish that are their principal source of income.	↔	-The Maheshkhali site has no local residents to vacate. - Local people will lose their private lots, standing crops, shrimps and fish that are their principal source of income as is the case of the Matarbari site. - This case will not likely have a large impact on the social environment.

In conclusion, Matarbari site is more superior as a project site from the viewpoint of technical, economical and natural environmental aspects, but not superior from the social environmental point of view. The impacts to the affected people will be mitigated through appropriately

preparing and implementing Land Acquisition and Resettlement Action Plan (LARAP). Therefore, the over-all evaluation concludes Matarbari site to be more superior as a project site.

3.7 Project Overview

Basically, the project consists of a coal-fired thermal power plant with two units of 600 MW each and a circulating cooling water system, including proper intake and discharge tunnels, and a 275m high stack. The Power Plant will be designed in such a way so that the construction of future additional units is possible. A typical diagram of a coal based thermal power plant is shown in Figure 3.7.1.

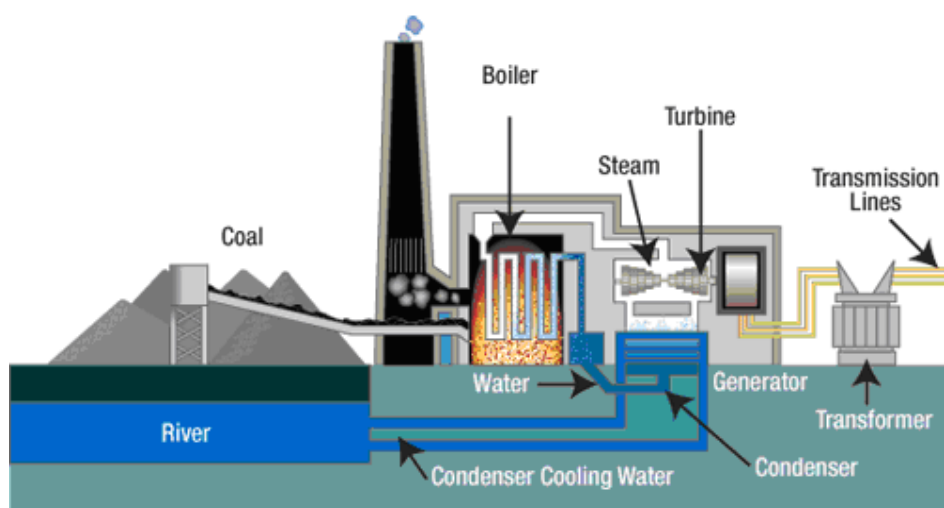


Figure 3.7.1: Typical diagram of a coal fired thermal power plant

The main project facilities are comprised of a power house and auxiliary facilities that include a switch yard, desalinization plant (Seas Water Reverse Osmosis), demineralization plant, circulating cooling water system, coal handling system (unloaders, stackers, reclaimers, conveyor belt and stockpiles), ash handling and disposal system, and a waste water treatment plant. Other project facilities that will be constructed by BPDB include an embankment along the sea shore. In addition, Flue Gas Desulphurization (FGD) and Electrostatic Precipitator (ESP) will be installed for flue gas treatment.

The proposed 2 x 600 MW (gross power output) ultra-supercritical (USC) bituminous pulverized coal plant will be constructed at a greenfield site. The turbine shaft configuration is a tandem compound design. The step up voltage level has been assumed

as 400 KV as the capacity of the project will be 2 x 600 MW. The 400 KV double circuit line from Matarbari to Anowara will be built by Power Grid Company of Bangladesh LTD (PGCB), Bangladesh. The primary fuel of the plant will be bituminous coal with a Gross Calorific Value (GCV) of 4700 Kcal/kg. The capacity factor (CF) for the plant is 80% without sparing of major train components. A summary of plant performance data for the USC plant is presented in Table 3.7.1 below.

Table 3.7.1: Basic plant information of the proposed coal based thermal power plant (estimated)

Component	Design Condition
Plant type	USC
Gross power output	1,200 MW (2 x 600 MW)
Primary fuel (type)	Sub-bituminous Coal having GCV of 4200-5200 kcal/kg and low Sulfur content (1.0 wt.% or less)
Coal flow (at 100% ECR)	12,800 ton/day
Annual coal requirement	3.73 mil. ton/year (considering 80% load factor)
Ash production	20%
Temperature of flue gas at stack	75°C
Flue Gas Flow	2 x 4.47 x 10 ⁶ Nm ³ /hr
Flue Gas Treatment System	Low NO _x burner and over fire air, seawater FGD and electrostatic precipitator will be facilitated to reduce emissions and pollutions and to meet WHO standard for ambient on qualities
Maximum emission of SO _x	Less than 820 mg/Nm ³
Maximum emission of NO _x	Less than 460 mg/Nm ³
Particulate matter	50 mg/Nm ³ (from each unit)
Stack height	275 m
Water Intake	Necessity of water volume: 25(m ³ /sec/unit) × 2 units = 50(m ³ /sec)
Water discharge after treatment	Into sea

3.8 Project Design and Construction

3.8.1 Design

The project is being designed in accordance with the international standards for USC steam power plants. The design of support facilities and associated works is in accordance with appropriate national and international standards. The plant design will cope with local seismic conditions.

The design life of the plant will be at least 25 years. Civil works structures and foundations will be designed for a life exceeding 45 years.

3.8.2 Construction

The port and harbor facilities for the arrival of coal vessels shall be excavated through the land. Dredging channel work, excavation work and berth work shall be the main construction work of the port and harbor facilities. The dredging work shall be performed working toward the land from the ocean, and the dredged soil shall be sent by a discharge pipe and stored in a temporary depot.

The power plant site must be a raised height for the prevention of flood damage caused by cyclones. The dredged sand shall be used as part of site renovation.

The site requires filling and grading to establish the final landform. Site soil will consist of sandy to sandy loam topsoil and subsoil, which will require that excavation be undertaken with bulldozers and excavators. Site leveling will use all excess soil produced from excavation with additional soil (if necessary) brought onto the site from outside sources.

Civil works will involve the construction of the main power plant and auxiliary facilities and buildings, and the water supply pipeline from the nearest source. Mechanical and electrical works will include both on-site and off-site fabrication, assembly, installation, and erection of power plant equipment, pollution control equipment including FGD units and the chimney structure, demineralization plant, control system, power system, and various utility systems.

Construction will require between approximately 4,000 and 8,000 skilled and unskilled workers. Construction workers will be engaged by contractors responsible for different

construction packages. Construction water will be sourced through authorized vendors and from ground water sources prior to the operation of the plant water supply pipeline.

3.9 Project layout

A detailed layout plan of the proposed project shall be developed by the feasibility study team considering the tentative capacity of the proposed power plants with related auxiliary facilities. However, a land allocation plan for a coal based power plant and port and harbor of different capacity is given below.

Table 3.9.1: Important features of the Matarbari coal-fired Power Plant

Sl No.	Component	Land Requirement (tentative)
01.	Coal based power plant 2×600 MW = 1,200 MW	40 hectares
02.	Ash pond	183 hectares
03.	Coal stock yard	33 hectares
04.	Port and harbor	77 hectares
05.	400 KV switch yard	122 hectares
06.	Others(Township, Embankment, Intake etc.	122 hectares
Total potential capacity: 1,200 MW		Total land: 455 hectares (848 acres)

In the plant layout, adequate space shall be kept for lay-down and pre-assembling activities of open stores, contractor's offices and stores, etc. Construction offices and storage sheds area shall be located close to the main approach road to the plant. The administrative building is proposed to be located outside the plant boundary near the main approach road. The total land requirement area (455 hectares) is shown in the above table, which does not include the access road, township, greenbelt and other use areas. The following major components shall be included in the layout plan, but it is not an all-inclusive list:

A: Industrial (plant area)

1. Main power plant (boiler, turbine, generator, workshop store, etc.)
2. Electrostatic precipitator, FGD as required, and chimney
3. Greenbelt and open space
4. Open air sub-station and network control room
5. Water treatment, sewerage treatment plant and sewerage channel
6. Coal terminal including jetty and coal conveyer belt
7. Ash handling control room, ash silo, ash disposal area
8. Coal stock yard (open and covered)
9. Port and harbor facilities

B: Township

10. Residential buildings, school, mosque, playground, community hall, rest house, dormitory, health center, club, etc.
11. New alternative road construction instead of the existing community road, administrative building, auditorium and parking area including cafeteria, and social building

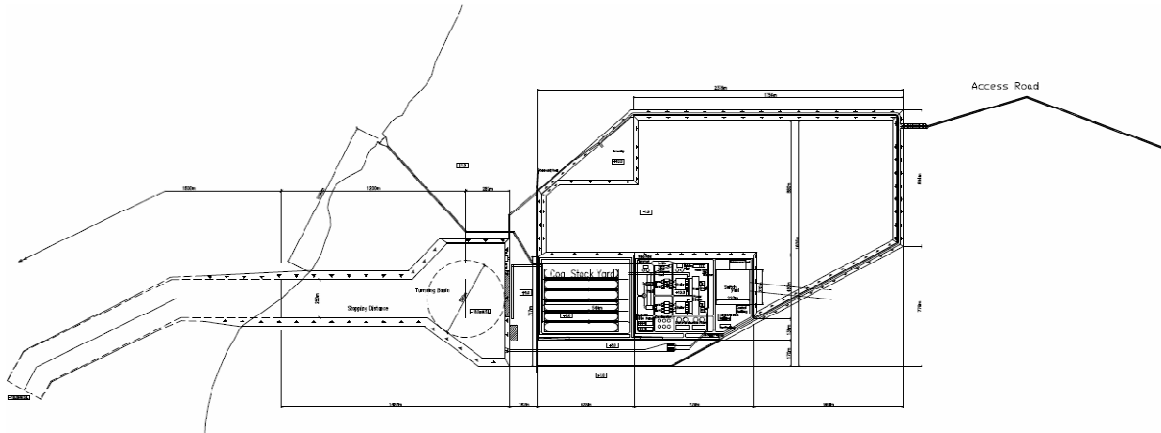


Figure 3.9.1 Plant layout plan

Administrative approval in connection with the acquisition of the required land will be obtained in the future. A land acquisition proposal (after necessary revision as per suggestions of the DC office) will also be submitted to the office of the DC, Cox's Bazar.

3.10 Project Activities

Pre-construction phase

- a) Selection of candidate sites
- b) Environmental and feasibility study
- c) Selection of site
- d) Land acquisition and site establishment

Construction phase

- a) Dredging work and berth work
- b) Civil construction and technological installation work
- c) Post erection check and pre commissioning test
- d) Monitoring of mitigation measures for environmental impact of the plant

- e) Commissioning test
- f) Reliability test run
- g) Commercial operation of the plant
- h) Overall project management
- i) Alternative road
- j)

The existing road along the shoreline will be cut off by the construction of the power plant. A new alternative road, instead of the existing road, shall be constructed and the route/ location of the alternative new road is planned between the east side of the harbor and the west side of the coal stock yard. Also, during the construction period, a temporary alternative road, instead of the existing road, will be used.

Operation phase

- a) Commercial operation of the plant
- b) Monitoring of EMP
- c) Proper O&M for efficient running of the plant

3.11 Fuel Requirement

The main fuel to be used for generating electricity will be coal. Based on the estimations of the Feasibility Study, the daily coal requirement for generation of 1,200 MW power by operating 2 x 600 MW power plants shall be 3.7 million ton per year considering 80% plant load factor at ECR. In addition, light diesel fuel oil will also be used for boiler start up, flame stabilization and low-load operation. Annual light diesel fuel oil consumption is estimated to be 40,000 m³.

3.12 Water Requirement and Source

Water will be required for steam generation, condenser cooling, coal management and domestic purposes. It is estimated that 180,000 m³/hr water will be required for meeting total demand and approximately 2500 m³/day water will be required for steam generation. This water will be collected from the nearby sea. The project will adopt the Reverse Osmosis Process for desalinization of saline water to meet the sweet water requirement.

After use (consumptive and non-consumptive) of intake water, 350 m³/day will be discharged after treatment through effluent treatment and monitoring sump.

3.13 Resources and Utility Demand

The proposed project shall provide employment opportunities for unskilled, semi-skilled and skilled categories of employment. Employment potential shall increase with the start of construction activities. During the operation phase there will also be employment opportunities, mainly in the service sector.

3.14 Process Description of Individual Project Components

3.14.1 Power Generation

The power plant consists of 2 x 600 MW units. Each unit will have steam-based, pulverized coal-fired boiler units of USC type, steam turbines and generators. Each boiler unit will comprise a boiler proper, regenerating type air heater, and 2 forced draft (FD) fans and 2 induced draft (ID) fans. In addition to coal, light diesel fuel oil will be used for start-up as well as flame stabilization during low-load operation.

3.14.2 Boiler and Auxiliaries

The boilers shall both be pulverized coal firing, radiant, reheat, and variable pressure operation once through boilers for outdoor installation. The boilers shall be designed for low NO_x emission by employing low NO_x burners and over fire air (two stage firing) systems.

The main parameters of the boilers will be as follows:

Table 3.14.2 Boiler parameters

Parameter	Measures
Type	Radiant reheat, variable pressure operation, once-through boiler (outdoor installation)
Quantity	2 units
Main steam flow	1.760 t/h
Reheat steam flow	1.490 t/h
Main steam pressure	25.4 MPa(g) at superheater outlet
Main steam temperature	604°C at superheater outlet
Reheat steam temperature	602°C at reheater outlet
Firing system	Pulverized coal firing with low NO _x burners and two stage firing and light oil (30% capacity) for unit start up and low load operation
Draft system	Balanced draft

3.14.3 Firing System

The coal firing system will comprise of coal mills of vertical spindle type which include bowl mills, roller mills, balls and race mills or any approved equivalents. The number and capacities of the mills shall be selected so that they can fire the worst and design coals at boiler maximum continuous rating (BMCR) without using the one standby mill.

Start-up, warm up and low load carrying shall be done by light oil. Boilers will be so designed that oil firing for flame stabilization will not be required beyond any loads higher than 30% maximum continuous rating.

3.14.4 Soot Blowing System

A fully automatic, sequentially controlled, microprocessor based steam soot blowing system, complete with provision for individual operation of any soot blower pair, operation and facility to bypass any soot blower, will be provided.

3.15.5 Electrostatic Precipitator

Each boiler will be equipped with an ESP with parallel gas paths. The ESP will have a dust collection efficiency of not less than 99.8% while firing coal with the highest ash content of 15% to meet particulate emission to IFC standard value (i.e., 50 mg/Nm³).

3.14.6 Flue Gas Desulphurization System

Provision of the FGD system will be installed in the plant, based on the sulfur content in the coal, to meet the ground level SO₂ concentration standards of Ministry of Environment & Forest.

3.14.7 Turbine and its Auxiliaries

The scope of each turbine unit of the 2 x 600 MW power plants shall broadly cover the Steam Turbines along with its integral systems and auxiliaries, like lube oil system, control-fluid system, condensers, condenser air evacuation system, HP & LP Bypass system, complete regenerative feed heating system, condensate pumps and drives, boiler

feed water pumps and drives, automatic control system, instruments, turbine protection and interlock system, automatic turbine testing system and turbine hall overhead crane.

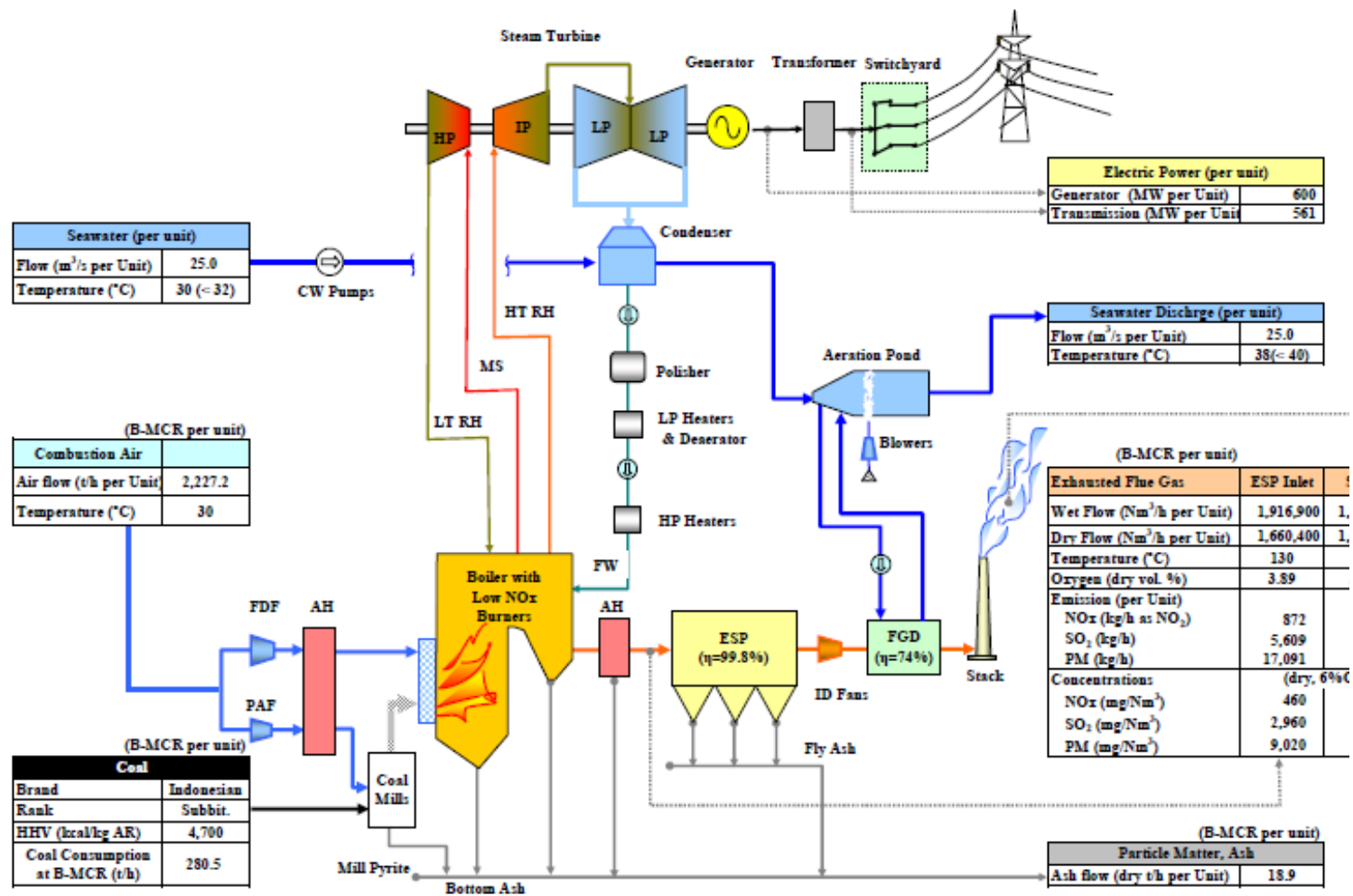


Figure 2.8-1: Process flow diagram

3.14.8 Condenser

The purpose of a surface condenser is to condense the exhaust steam from a steam turbine into cycle water (steam condensate) so that it is reused in the boiler as boiler feed water. A single pass-one division of tube and shell circuit schematics is preferable, even for condenser types for large-sized turbines, being based on the Heat Exchange Institute (HEI) standard.

Based on the data of a similar power plant with the same capacity and same steam conditions, and adding an appropriate amount of bearing cooling water, etc., the total required amount of cooling water was estimated at 50 m³/s for two units. Chlorination system will be adopted to avoid adhesion of organism.

3.14.9 Coal Source and Transportation System

BPDB has conducted a detailed study on coal sourcing, transportation and handling to attain a sustainable solution taking into consideration the environmental safety of the project surrounding environment.

(1) Coal specification and requirements

Considering the safety of the surrounding ecosystem, public health and safety, the specifications of the coal have been selected. The specifications define the sulphur content lower than 1.0%, total moisture content maximum 25%, and a target of higher heating values (HHV) 4,700 kcal/kg with the allowable range of 4,200 - 5,200 kcal/kg. Since the power plant shall be equipped with coal-mixing facilities between the coal storage yard and the coal bunkers, some deviation of coal quality from these specifications may be acceptable for each imported coal.

Table 3.14.2 Tentative Quality of the Coal Available in Selected Source Country

Items	Min - Max
Total moisture (As received %)	18.3 - 38.0
Inherent moisture (Air dry %)	10.2 - 25.0
Ash (Air dry %)	3.0 - 15.1
Sulfur (Air dry %)	0.1 - 1.0
Gross Caloric Value (As received kcal/kg)	4,200 – 5,200

Coal requirement depends on the calorific value of used coal, the operating loads and numbers of units, and the generation heat rate of units. The annual coal requirement of 2 x 600 MW units shall be about 3.7 million tons based on HHV of 4,700 kcal/kg, plant capacity factor of 80%, and gross generation efficiency of 41.29% (unit heat rate of 2,082.5 kcal/kWh).

Coal requirements have been estimated using the formula:

Annual Coal Requirement: $\{(2 \times 600,000 \text{ kW}) \times 24 \text{ hours/day} \times 365 \text{ days/year} \times 859.85 \text{ kcal/kWh} \times 80\% \} / (41.29\% \times 4,700 \text{ kcal/kg}) = 3.726 \text{ million tonnes}$

Where, 859.85 kcal/kWh is the conversion factor of energy from kWh to kcal.

(2) Coal sources

Considering suggested coal specification, availability, cost of coal, cost of transportation and reliability to supply coal, it has been judiciously planned to import coal from Indonesia, Australia and South Africa under long term/short term agreements with coal producers and suppliers. In such case, good quality Sub-bituminous coal can be imported from Indonesia and Bituminous coal can be imported from South Africa and Australia. In this case of multiple sources, GCV of average 4,700 (GCV 4,200 - 5,200 as received basis) kcal/kg to be achieved through blending of different coals of different grades has been considered for planning purposes.

BPDB will engage third parties to supply coal and transport coal to the project site under Coal Supply Agreement and Coal Transportation Agreements with outsourced agencies.

(3) Coal transportation

The required amount of coal, maritime routes, transport options, chartering terms and conditions, voyage times, freight costs and navigational aids are the key parameters for deciding the mode of maritime coal transportation. After studying all the parameters in the Feasibility study phase, the mode of transport of coal shall be selected. The mode of transportation of coal from the sea port of the potential coal sourcing countries to Bangladesh (Maheshkhali project site) will all be the same.

3.14.10 Coal Handling and Storage

(1) External coal handling system

The proposed sea port may be used for unloading coal from mother vessels throughout the year as there will be no draught problems. The coal received from the vessels shall be unloaded through rail mounted continuous bucket type unloaders and shall be conveyed to the plant end by parallel double stream high capacity through conveyors via a series of transfer points.

(2) Internal coal handling system

The coal as received from the port end through parallel conveyors shall drop onto two dedicated sets of screening feeders and crushers. An independent coal handling plant is proposed to cater to each of the two units of the 600 MW power plants. The coal handling plant will have an optimum capacity coal conveying system (with 100% standby parallel stream) along with stackers/ reclaimers, etc., moving to the boiler.

The coal shall be conveyed to the stock yard through parallel stream conveyors and shall be stocked in the stock yard by the stackers.

Further reclaimers are proposed to convey the coal to boiler bunkers by means of one set of parallel double stream belt conveyors (one working and one stand by). An interconnection is also to be used to convey coal directly to the boiler bunker, and Figure 2.8-2 shows an indicative flow diagram of the coal handling system. The overall operation hours of the coal handling plant shall be 18 hours spread over three shifts per day. The proposed coal handling plant shall cater to the peak daily requirement of coal for the plant in five bunker filling cycles in 12 hours effective operation. All chutes will be lined to ensure smooth flow and discharge of coal, and the longer operating life of the chutes. All junction towers and the crusher house will have floor cleaning chutes. Motorized travelling trippers shall be provided to feed crushed coal into the raw coal bunkers of the boilers.

Coal stock for 60 days is envisaged. In practice this amount might be changed. Stock requirements will be decided based on forecasts of maximum numbers of days for which port operation is possible in a year and the continuous periods when the operation is likely

to be affected due to unfavorable weather. In the layout plan, there is space provision for two months storage of coal.

A centralized main coal handling plant control room shall be provided to control and monitor the operations of the entire coal handling system.

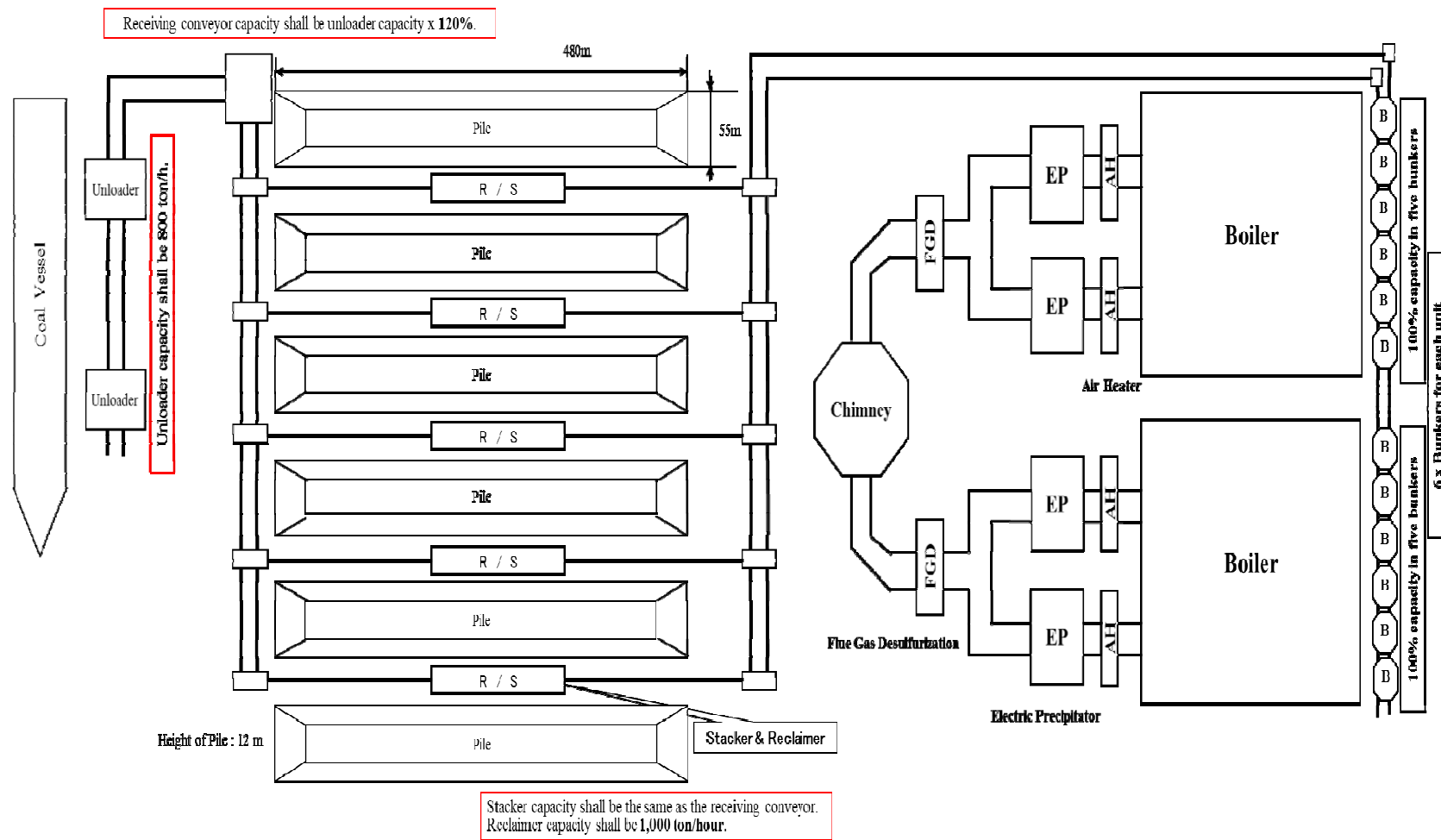


Figure 3.14.2 Indicative flow diagram of internal coal handling system

3.14.11 Fuel Oil Transport, Unloading and Storage

A fuel oil unloading and storage system shall be designed to handle light oil to be used for unit startup and low load operation of the steam generator. The capacity of the light oil firing system shall be 30% unit load.

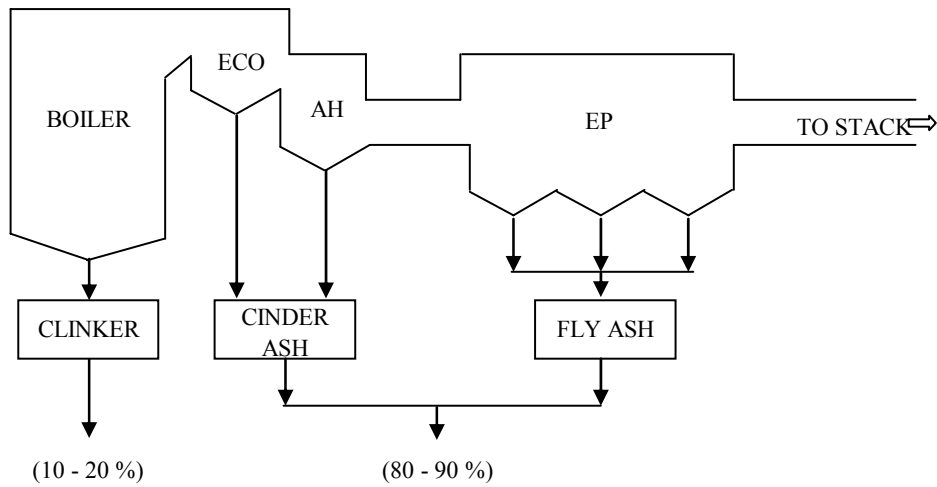
3.14.12 Chimney

The DOE rules of maintaining a minimum stack height of 275 m for power plants over 500 MW capacity under ECR, 1997, has been considered in the design conditions.

3.14.13 Ash Handling and Transportation System

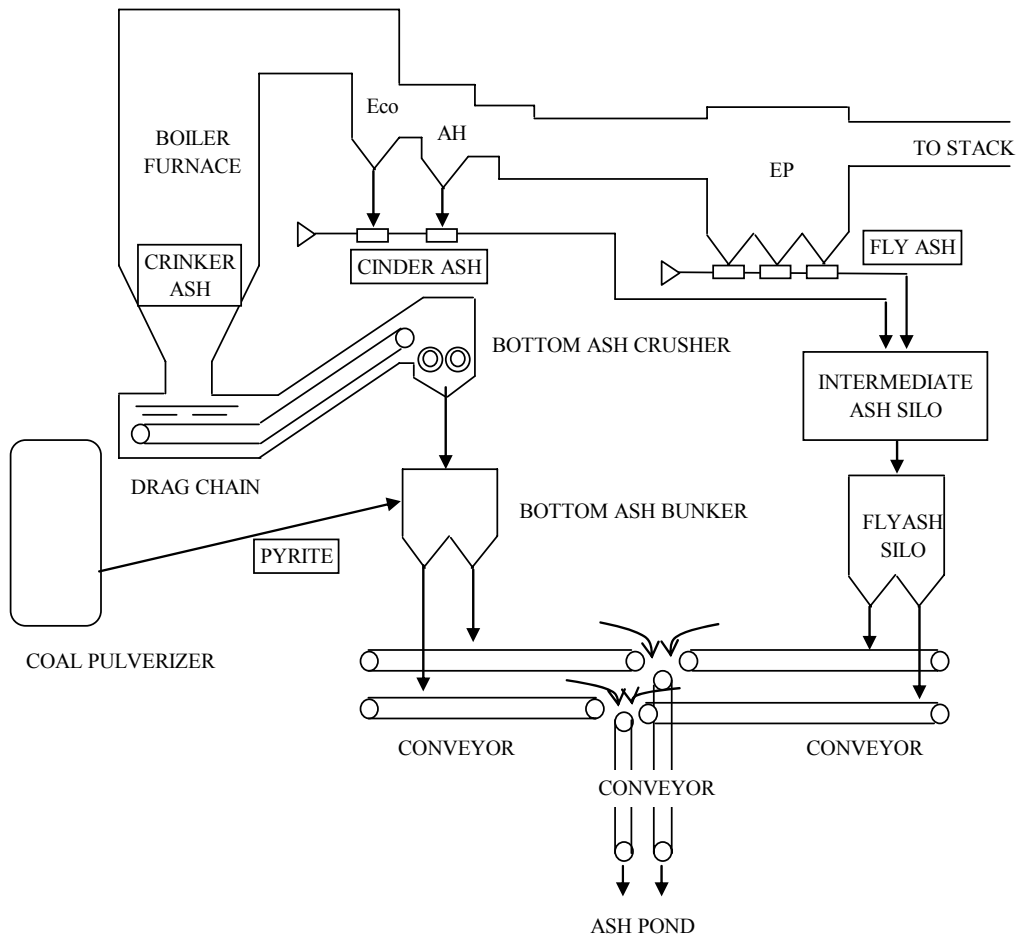
In general, ash in coal is captured in various parts in the flue gas flow (outlined below) in the course of the combustion of coal in the boiler until the flue gas is discharged from the stack.

- ⌚ Ash which is melted by the coal combustion falls to the bottom hopper of the boiler furnace and is captured. This is called clinker. About 10 - 20% of the amount of all ash is captured in this way.
- ⌚ Part of the combustion ash which floats in the flue gas falls to the bottom hopper of the economizer and the air heater in the downstream of flue gas and is captured. This combustion ash is called cinder ash. 5% or less of the amount of all ash is captured here.
- ⌚ The combustion ash which is captured by the electrostatic precipitator is caught in the bottom hopper of the electrostatic precipitator. It is called fly ash. In general, 80 - 90% of the amount of all ash is captured here.



The collected coal ash is generally transported and processed through ash handling systems that may be roughly categorized into two systems.

- ⌚ The first system handles clinker that falls to the bottom hopper of the boiler and the pyrite exhausted from the coal pulverizer.
- ⌚ The second system handles the cinder ash and fly ash that falls to the bottom hopper of the economizer, air heater and electrostatics precipitator.



(1) Bottom Ash handling system

Bottom ash handling systems are classified into typical types, such as the water sealed drag chain system and the air sealed drag chain system. The air sealed system is superior to the water sealed system, because there is no discharge of wastewater. However, the air sealed system has only been recently developed and there is limited experience using this system. The boiler sealed system is very important for the reliable operation of boilers. For the purposes of this study, the most popular type, the water sealed drag chain system, is described.

The water sealed drag chain system handles clinker ash that falls to the bottom hopper of the boiler and the pyrite exhausted from the coal pulverizer. The clinker that falls to the bottom hopper of the boiler is collected using the water sealed conveyor and is dehydrated for transport to a bottom ash bunker for temporary storage. The pyrite flows into the

bottom of the ash bunker. The clinker ash and pyrite are transported to the ash disposal pond by belt conveyer in order to keep the power station roads clean.

(2) Fly ash handling system

Fly ash handling systems are classified into the vacuum system, pneumatic system and vacuum - pneumatic system. The vacuum system is superior to the pneumatic system, because the ash does not disperse if the piping is damaged. However, the vacuum system can only be adopted for short distance transportation. Therefore, the vacuum - pneumatic system is often adopted in large scale power plants. For the purposes of this study, the most popular type, the vacuum – pneumatic system is described.

The vacuum – pneumatic system handles the cinder ash and fly ash that falls to the bottom hoppers of the economizer, air heater and electrostatic precipitator. The cinder ash and fly ash are transported to intermediate ash silos using a vacuum, and then transported from intermediate ash silos to the fly ash silos for temporary storage using compressed air. Finally, the fly ash is transported to the ash disposal pond by belt conveyer in order to keep the power station roads clean.

(3) Ash utilization

Various studies have been conducted regarding effective utilization of coal ash produced in large quantities in boilers, and the following uses have proven practical.

- Clinker
- ✓ Road bed material
- Fly ash
- ✓ Material for cement
- ✓ Concrete aggregate
- ✓ Road pavement
- ✓ Fertilizer

The JICA Study Team was informed that ash produced in power plants cannot be utilized for the cement industry and it is therefore imported from India by train, since its usage has not been signed into law. If the ash can be utilized effectively, the ash disposal area will be smaller than the study result and rest of the area will be utilized for other activities of the project keeping environmental consideration as top priority.

(4) Ash slurry disposal system

The ash disposal site (ash pond) of Matarbari CFPP will be located to the north east of the power plant site. In order to sufficiently preserve the environment around the power plant area, the ash disposal area shall be a controlled type, taking into account the environmental aspects of the surrounding area so that any ash, rain water and wastewater, etc., will not be leaked directly to the outside area.

The ash pond shall be coffered with soil banking, and ash will be disposed into the pond. The nominal capacity of the ash disposal pond is calculated based on the total volume of the ash to be accumulated for the duration of 25 years operation with 80% capacity factor of the two units.

3.14.14 Water Treatment System

(1) Desalination plant

The Reverse Osmosis (“RO”) process is planned to be adopted for the desalination of sea water. The desalination system shall be equipped with a water pre-treatment section, such as clarification, and chemical dosing as per the standard practice of the suppliers. Service water produced by the desalination plant will be utilized as the source of demineralized water for boiler make-up, cooling water for bearing of equipment, ash disposal and firefighting water, etc.

(2) Demineralization plant

Following the desalination process, a demineralized water plant will be required for feeding into the closed cooling water, as well as boiler feed water for power cycle make up. The demineralization plant has been designed based on the latest cost effective ion exchange technique of counter current regeneration. Wastewater from the plant produced during the regeneration of resins will be neutralized in a neutralization pit.

(3) Conceptual schematic diagram of water treatment system

Figure 3.14.3 shows the conceptual schematic diagram of the water treatment system. Figure 3.14.4 shows an Estimated Water Balance Diagram.

3.14.15 Wastewater Treatment System

The general treatment concepts of the various effluent streams are as follows:

- i) The process wastewater shall be treated in the wastewater treatment plant, after which it shall be discharged into the cooling water discharge line with quality levels meeting IFC Guidelines as well as the Bangladesh Environment standards for effluents. The process wastewater includes waste streams from plant oily waste, drains, and other miscellaneous streams. Wastewater sample points shall be provided in the plant.
- ii) Boiler blowdown shall be directed to the boiler blowdown tank with quenching by cooling water, after which it shall be directed into the boiler sump pit.
- iii) Oil-contaminated effluents shall be treated in an oil/water separator, after which the effluents shall be routed into the wastewater storage pit.
- iv) In no case shall the untreated effluent be discharged either directly or indirectly into any surface or ground water source.
- v) Sanitary wastewater from buildings in the plant shall be routed directly to an on-site sewage treatment plant.
- vi) Roof drain, storm water and water tanks overflow shall be conveyed into a check pit and discharged into the cooling water discharge line after checking water quality (at least pH value and oil content).
- vii) Coal yard rainwater shall be treated separately using the coagulation and filtration method.
- viii) Wastewater from the coal conveyer cleaning system shall be treated separately using the coagulation and sedimentation method. Concentrated coal slurry shall be returned to the coal yard.
- ix) Ash pond wastewater shall be treated separately using the sedimentation and neutralization method.

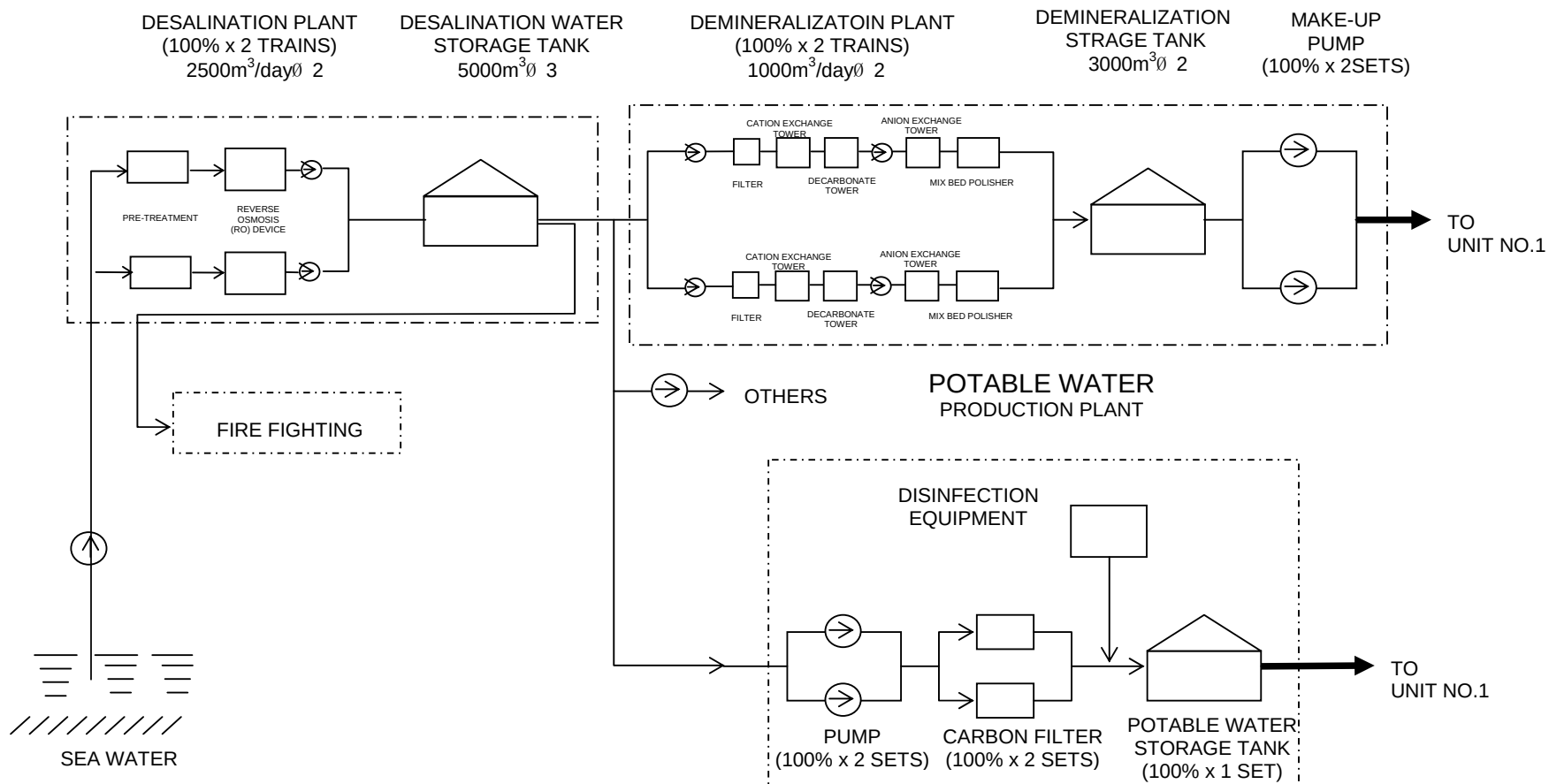


Figure 3.14.3 Conceptual Schematic Diagram of Water Treatment System

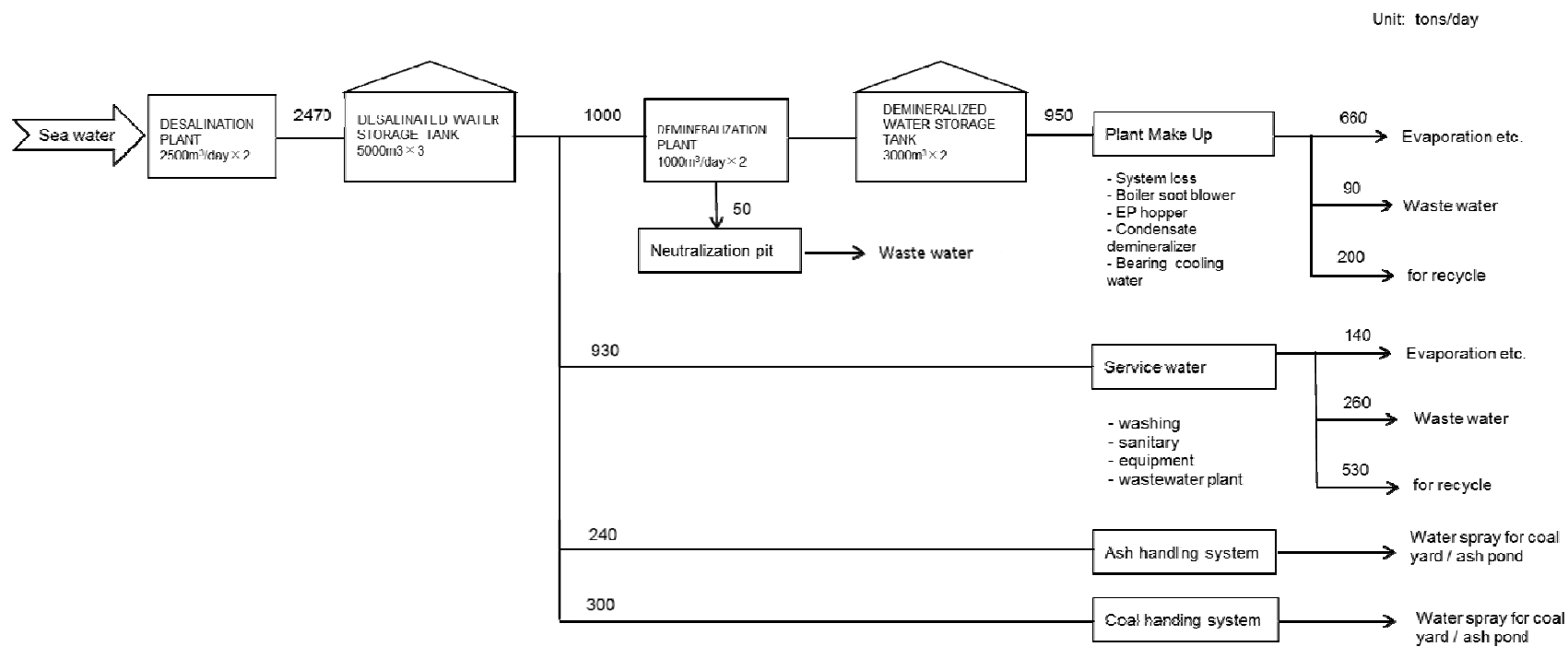


Figure 3.14.4 Estimated Water Balance Diagram

3.14.16 Waste Management

Dredging work will be carried out in the channel for vessels and for port construction. Some sediment will be spread into the ocean during the dredging work. Water turbidity will be the major waste to be generated into the ocean and the details of water pollution control are described here.

As a preventative measure against causing water pollution into the sea, a nonproliferation membrane shall be installed. Moreover, water quality will be constantly monitored to assure proper levels. Sludge collected by the wastewater treatment plant shall be transferred to an appropriate disposal site.

3.14.17 Electrical System

(1) Power evacuation

400 kV and 230 kV transmission systems are planned to be adopted together with the proposed power plant. PGCB will design and implement the necessary transmission systems. Power generated from each 600 MW unit will be stepped up to the evacuation voltage level through a suitably rated Generator Step Up Transformer. In the end, this power shall be distributed to the consumer end through different grid and distribution substations.

(2) Start-up power requirements

The startup power of the plant has been envisaged to be drawn from the nearby available grid line by constructing the required inter connection transmission line. The availability of the 400 kV Double Circuit line interconnection from the nearby substation needs to be ensured that it meets the project start up power schedule.

(3) Auxiliary power supply scheme

The plant auxiliary power supply scheme has been evolved along with suitably rated unit auxiliary transformers and station auxiliary transformers associated with each unit.

(4) Generator

The main parameters of the generator are as follows:

a) Nominal rating	600 MW
b) Rated output	750 MVA
c) Power factor	0.80 (lag) - 0.95 (leading)
d) Rated Voltage	As per manufacturer's standard (in the range of 18-25 kV)
e) Speed	3000 rpm
f) Short Circuit ratio	Not less than 0.50

(5) High voltage switchyard and power distribution

A 400 kV air insulated switchyard shall be installed in this power plant with the required number of buses and incoming outgoing feeders. As per the power purchase agreement, the evacuated power from the plant generated by the project will be sold to distribution companies owned by the Government of Bangladesh. The main components of the switchyard are two generator step up transformer circuits, two station auxiliary transformer circuits, two transmission lines, the required number of circuit breakers as per requirements and design along with Current Transformers (CT), Potential Transformers (PT), Lighting Arrestors (LA), and communication equipment, etc.

3.14.18 Central Control and Monitoring

One central control room for two units in the operating floor along with a control equipment room will be installed. The boilers, turbine and generators along with their associated auxiliaries will be controlled and monitored from the central control room by the Distribution Control System (DCS). To achieve environmental efficiency, SO_x, NO_x, O₂, CO₂, CO and dust emission measurements shall be provided.

3.14.19 Civil Structure and Urban Facilities

A large numbers of civil structures and facilities are planned with the project. Possible civil and urban facilities to be constructed are listed below:

- Infrastructure and civil structures
 - Site establishment
 - Office building
 - Dozer maintenance shed
 - Workshop, permanent stores
 - Steel foundation for the plant
 - Ash storage facility
 - Water treatment, drainage and sewerage network
 - Security fencing
 - Coal terminal
 - Coal corridor
 - Coal handling, storage and transportation facilities
- Residential facilities
 - Rest house
 - Officials quarters

- o Staff quarters
 - o Guard shed
 - o Canteen
- Township
 - o School
 - o Mosque
 - o Medical centre
 - o Officers club
 - o Sports complex, playground, fitness center, etc.
 - o Police camp
 - o Social facilities-community center, club, auditorium, bank, post office, shopping center, etc.
 - o Transportation facilities-transport center, petrol pump
 - o Community centre for workers/ labors
- Pollution mitigation facilities
 - o Greenbelt around the power plant
 - o Eco-park
 - o Water treatment plant
 - o Central effluent monitoring basin
 - o Chimney of 275m height
- Road network
 - o Access road - double lane bituminous access road
 - o Necessary bridges, culverts, sluices, etc.
 - o Patrol road, internal road network, etc.

3.15 Pollution Mitigation Measures

3.15.1 Air Pollution Control System

The boiler shall be designed for low NO_x formation by adopting low NO_x burners and over fire (two stage firing) system. High efficiency ESPs will be installed to limit the particulate emissions to 100mg/Nm³. An FGD system will also be installed to reduce SO₂ to at least 90%. To facilitate wider dispersion of remaining particulates and gaseous pollutants (SO₂ and NO_x), a chimney of 275 m height shall be used. To control emissions of fugitive dust within and around the coal handling plant and coal stockyard, a water spray system shall be installed. The chimney shall also be provided with facilities for online monitoring of stack emissions.

3.15.2 Noise Control

The major noise generating sources are the turbines, turbo-generators, compressors, pumps, fans and coal handling plant, etc., from where noise is continuously generated. Equipment will be designed to control the noise level to below 90 dB (A). Wherever it is not technically possible to meet the required noise levels at the work place, personnel protection and equipment, like ear plugs/ear mufflers, shall be provided to the workers. The buffer area around the plant, including the boundary wall around the project, shall dampen noise levels so that the nearby community will not experience significant noise.

3.15.3 Intent of Water Reuse

The entire water consumption and management system has been designed with the provision of water use facilities. A circulating water system has been designed for the cooling system, boiler water, ash disposal and handling system.

3.15.4 Effluent Treatment

A wastewater treatment plant has been planned to collect, treat and dispose of plant effluents. Liquid effluents shall be collected and treated/ recycled as described in Section 3.14.15.

3.15.5 Thermal Pollution Control

About 180,000 m³/hr cooling water will be discharged through the discharge tunnel, after the condenser, with a temperature increase of 6.6°C. The cooling water facilities will be designed so that the discharged water temperature will be not higher than 40°C which is the maximum temperature allowed in the wastewater quality standards of Bangladesh.

3.15.6 Waste Management

All kinds of solid waste to be generated at the power plant will be disposed on site maintaining DOE's standards. Ash particles will be the major waste to be generated from the power plant and details of the ash management are described in Section 3.14.13. Some waste will also be generated from the coal storage yard and belt conveyor facilities. To control flying coal dust, a water spraying system will be installed in the coal yard.

3.15.7 Water Intake Structure

Water supply from the intake point to the pump pit shall be provided with sufficient screening to filter out larger aquatic organisms like fish, etc. Drum screens shall be adopted in order to limit the entrainment of fish in the cooling water system.

3.15.10 Post Operation Monitoring Program

Regular monitoring of pollutants in different environmental disciplines like air, stack emission, wastewater, etc., shall be conducted and the data shall be submitted to the DOE regularly following the EMP proposed under this study. The monitoring locations will be finalized in consultation with the DOE. Monitoring stations will be equipped with all necessary apparatus and manpower for ensuring effective monitoring.

The environmental monitoring officer shall monitor the EMP implementation and submit quarterly reports to the said department. In addition, an annual monitoring report with quarterly monitoring data shall be submitted to the DOE for renewing the ECC. Two trainings per year at the plant shall be planned for safety professionals.

Chapter 4

Environmental Background

Analysis and Detailed Description

Chapter 4

Environmental Background: Analysis and Detailed Description

Table of Contents

4.1	Environmental Base Maps	1
4.2	Description of the Features	3
4.2.1	Land Use	3
4.2.2	Natural Physical Resources	4
4.2.3	Natural Biological Resources	51
4.2.4	Socio-Economic Status	78
4.2.5	Environmentally Sensitive Areas of special or Unique Scientific, Socio-economic or Cultural Value	81

4.1 Environmental Base Maps

The proposed coal-fired power plant (Matarbari CFPP; 2 x 600MW, “Power Plant”) is located in the Matarbari Union and Dhalghata Union in Maheshkhali Upazila in Cox’s Bazar District, in the south-east area of Bangladesh (Figure 4.1.1).



Note: The location is 21° 42' 15" N, 91° 53' 16" E

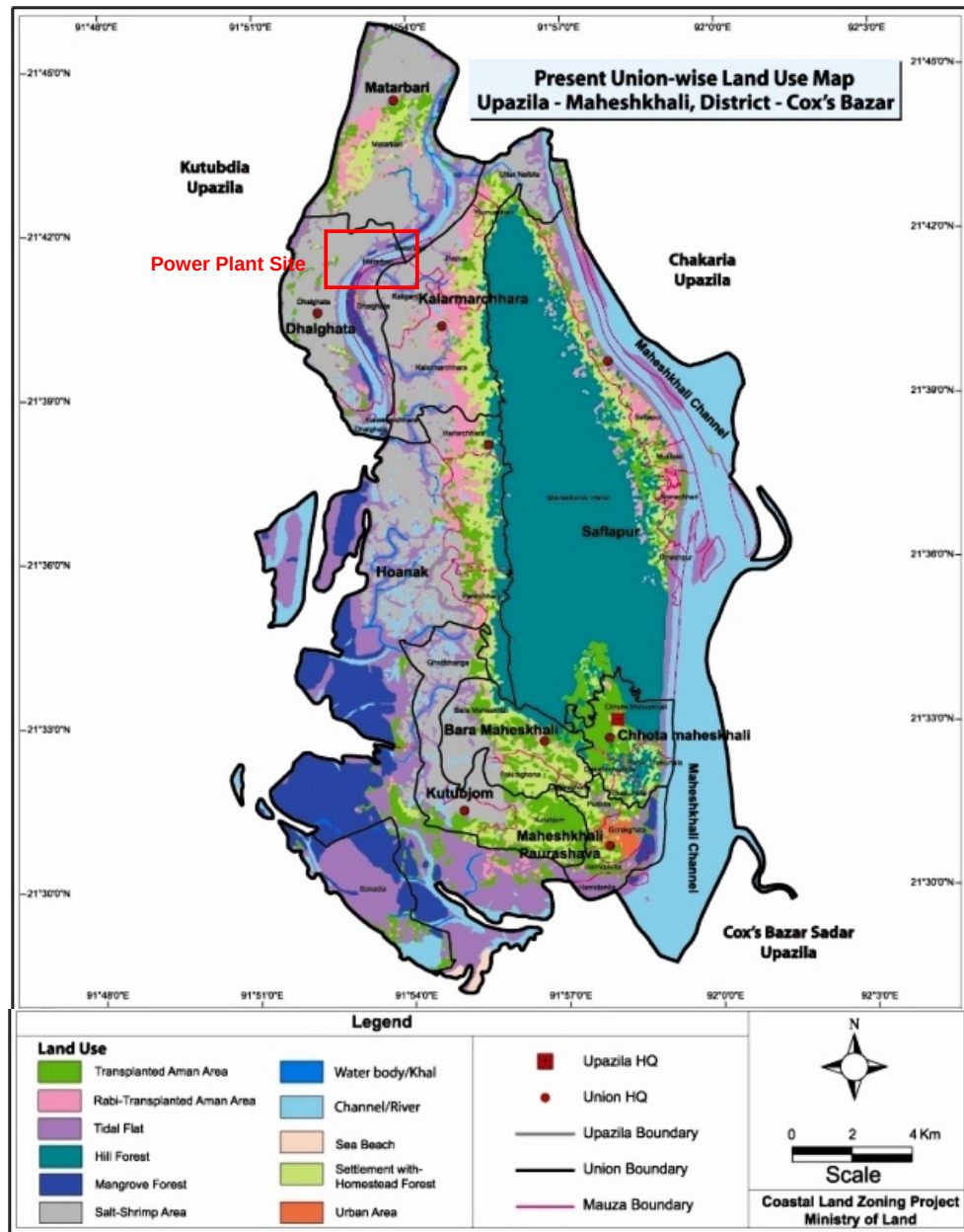
(Source: <http://www.in2bangla.com/upazilaMap.php?id=293>)

Figure 4.1.1 Location of the Power Plant

4.2 Description of the Following Features

4.2.1 Land Use

Land use map of Maheshkhali Upazila, Cox's Bazar District is shown in the figure below. The land use of the project site is categorized in "Salt-Shrimp Area" (Figure 4.2.1.1).



Note: Locations of potential sites for power plant on the map are marked by the Survey Team.
(Source: <http://www.landzoning.gov.bd/ZoneMaps/Maheshkhali.jpg> (accessed in August 2012))

Figure 4.2.1.1 Land Use Map of Maheshkhali Upazila, Cox's Bazar District

4.2.2 Natural Physical Resources

(1) Climate

The climate in Bangladesh is divided into three seasons: summer from March to June with high temperatures and high humidity, the monsoon season from June to October with high winds, and winter from October to March with low temperatures and low precipitation.

The meteorological observatories in the project area are Kutubdia Observatory, 10km north of the project site, and Cox's Bazar Observatory, 30km south of the site. The local meteorological observation results from 2000 to 2011 are shown below (Figure 4.2.2.1).



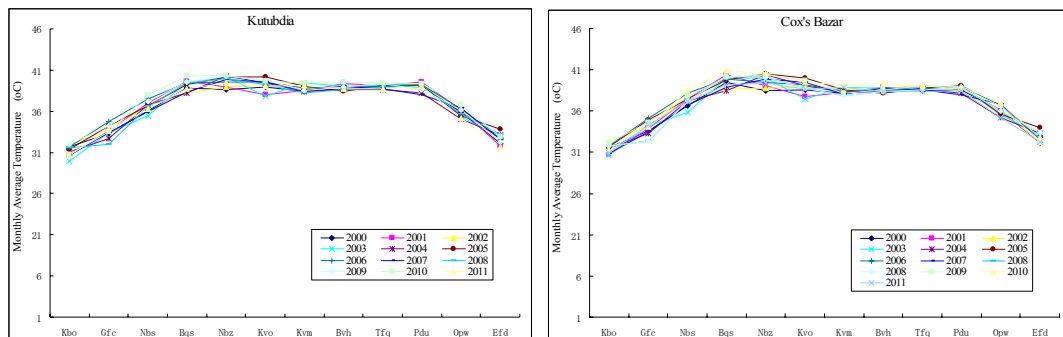
(Source: JICA Study Team)

Figure 4.2.2.1 Location of meteorological observatories

a) Temperature

The monthly average temperatures in Kutubdia and Cox's Bazar are shown in Figure 4.2.2.2. Climate fluctuations are stable every year in both areas in view of seasonal temperature change. The temperature in January is 19 - 21°C, and then gradually rises toward April to 28 - 29°C. The high temperature of 27 - 29°C continues from April to October, while it is a little lower from July to October compared to April to June. The temperature is in decline in November and December, and the average temperature in December is 21 - 23°C.

The maximum monthly average temperatures were 29.4°C in Kutubdia observed in May 2010, and 29.9°C in Cox's Bazar observed in April 2010. The minimum monthly average temperatures were 18.9°C in Kutubdia and 19.6°C in Cox's Bazar, both recorded in January 2003.

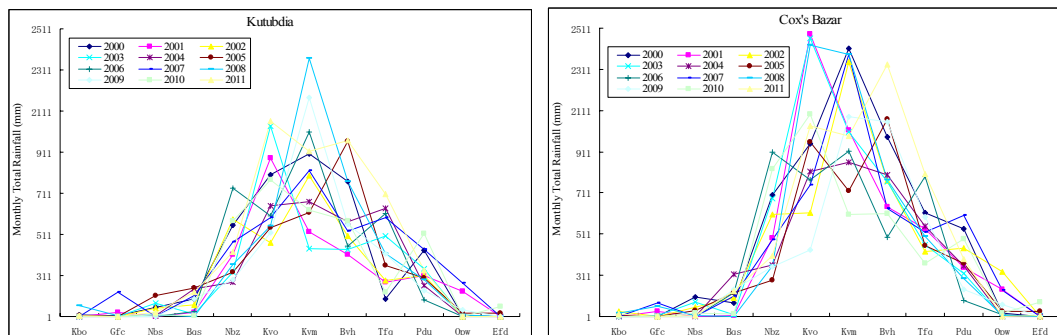


(Prepared based on the data of the meteorological observatories)

Figure 4.2.3 Monthly average temperatures

b) Rainfall

The monthly total rainfall in Kutubdia and Cox's Bazar is shown in Figure 4.2.2.3. The total annual rainfall is 4,321 - 5,905mm in Kutubdia, and 5,286 - 6,707mm in Cox's Bazar. Rainfall is concentrated between May and October; while very little or no rain is recorded from November to April. In this way, there is a definite difference of rainfall between the rainy season (monsoon season) and other seasons.

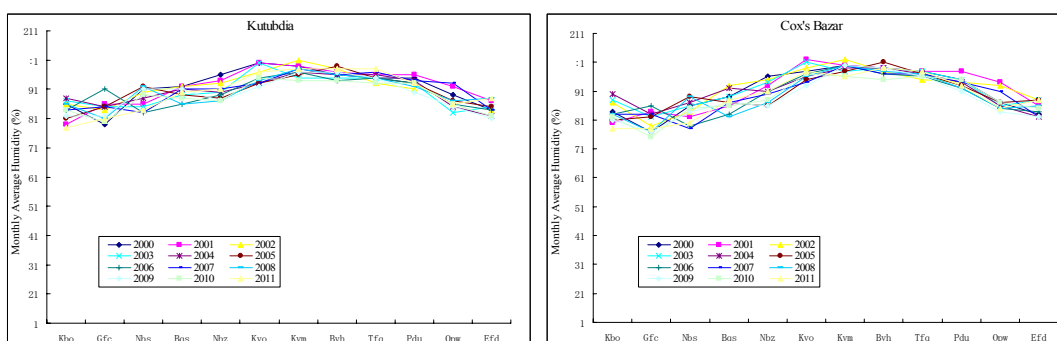


(Prepared based on the data of the meteorological observatories)

Figure 4.2.2.3 Monthly total rainfall

c) Humidity

The monthly average humidity in Kutubdia and Cox's Bazar is shown in Figure 4.2.2.4. Humidity fluctuations are stable every year in both areas in view of seasonal humidity change. The difference in the average humidity between respective months is rather small, in a range of 65 - 90%, while the average is 75 - 90% in the rainy season of May to October and 65 - 85% from November to April where little rain falls.

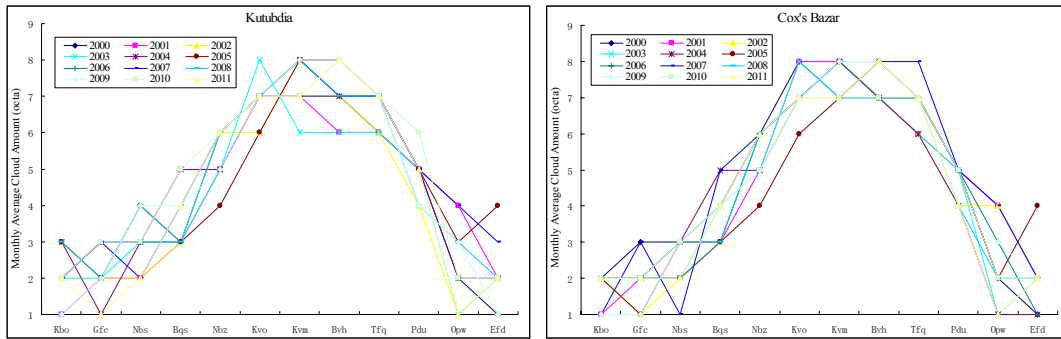


(Prepared based on the data of the meteorological observatories)

Figure 4.2.2.4 Monthly average humidity

d) Cloud amount

The monthly cloud amount in Kutubdia and Cox's Bazar is shown in Figure 4.2.2.5. Cloud amount fluctuations are stable every year in both areas in view of seasonal change in cloud amounts. The cloud amount is larger in the rainy season of May to October compared to November to April where little rain falls.

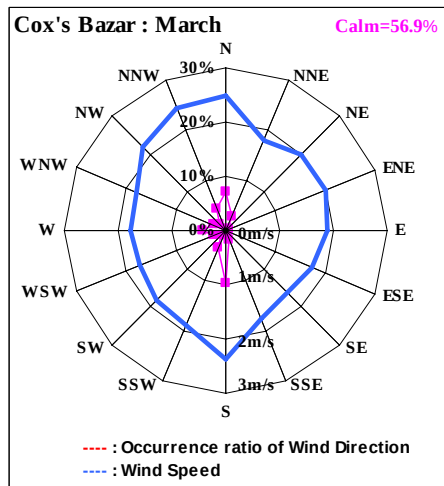
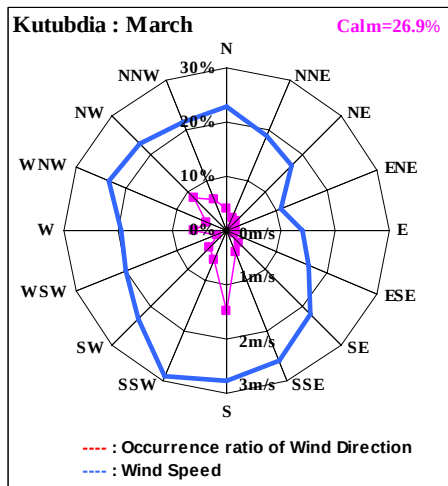
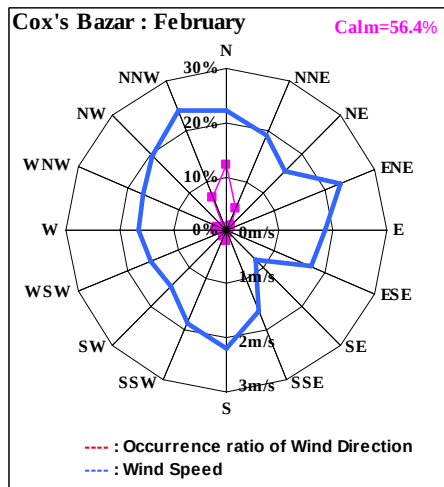
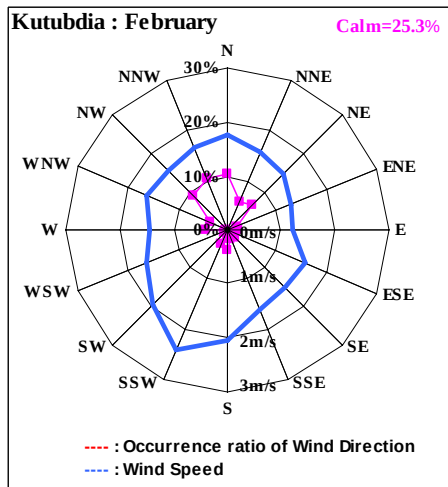
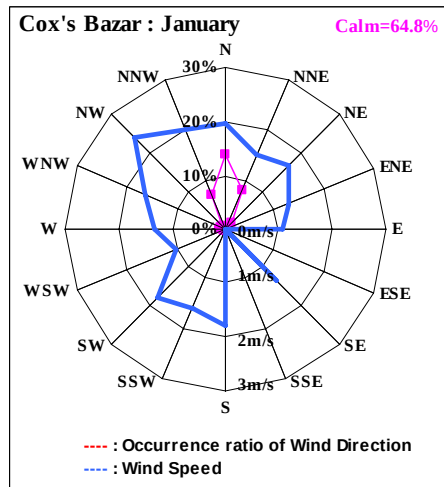
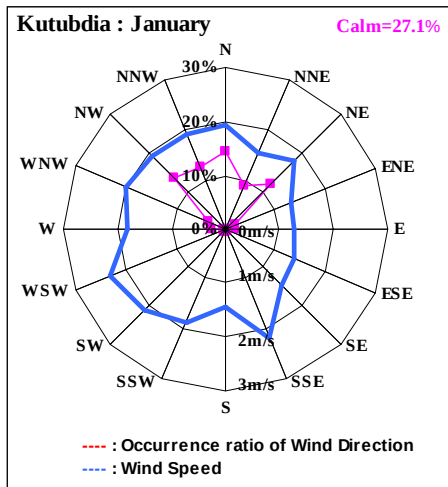


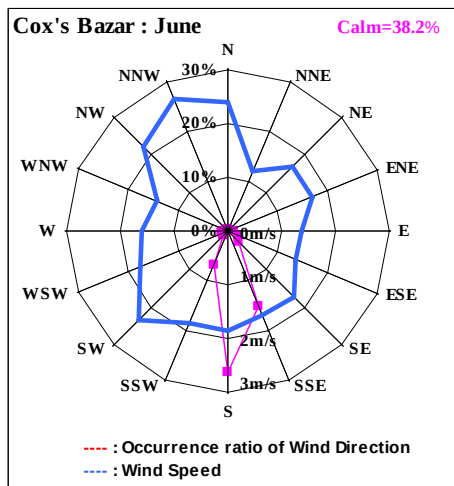
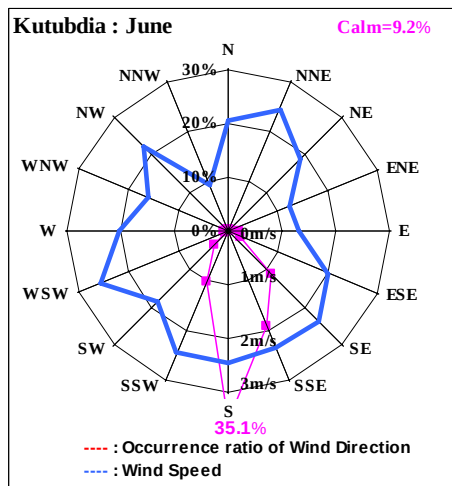
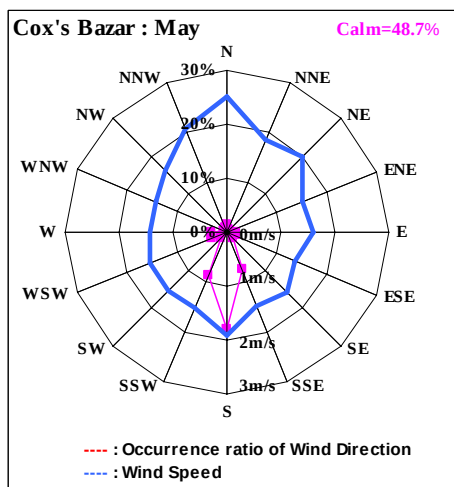
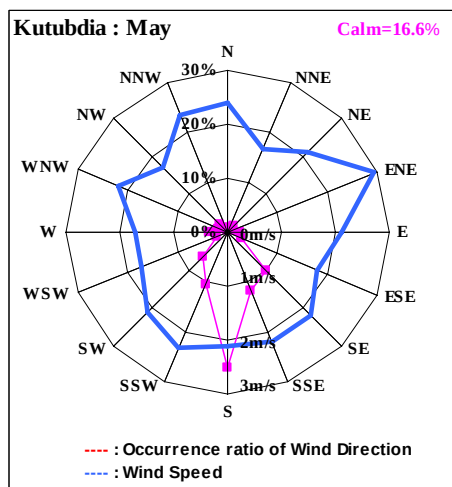
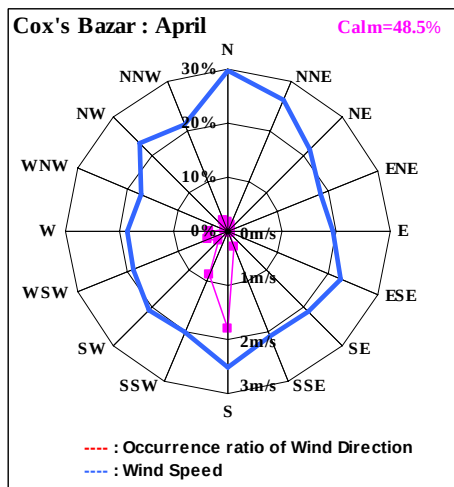
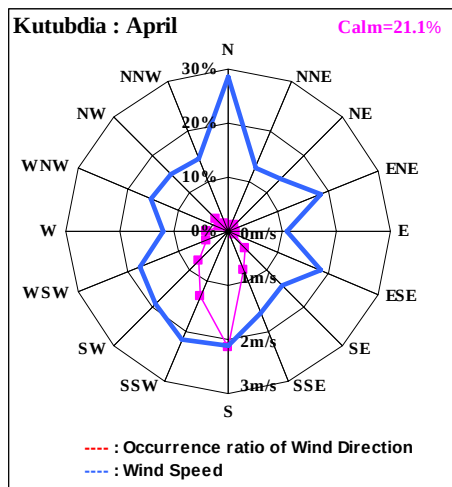
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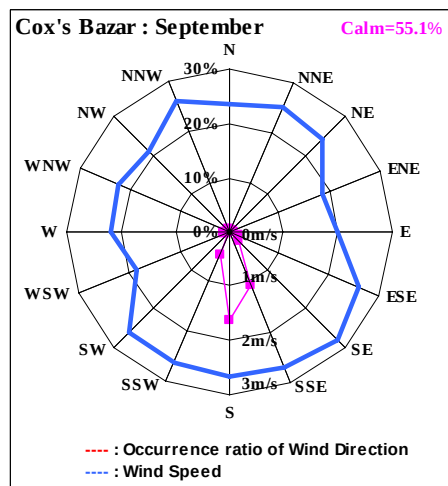
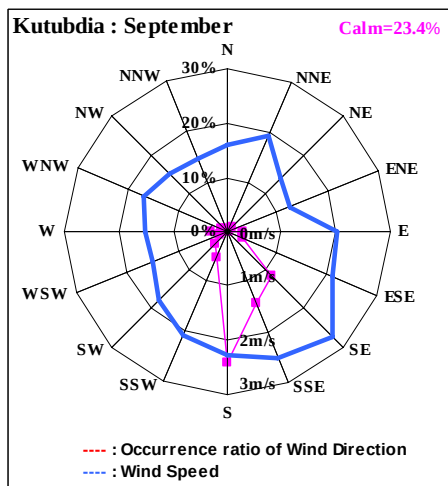
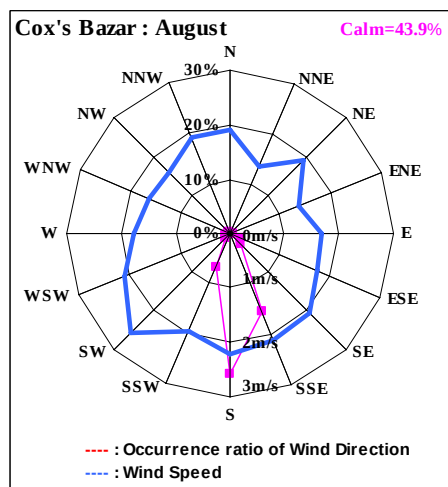
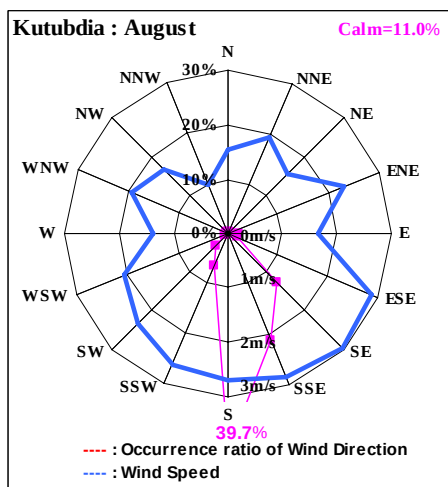
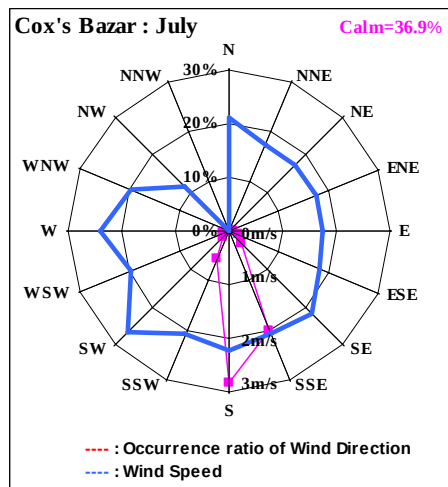
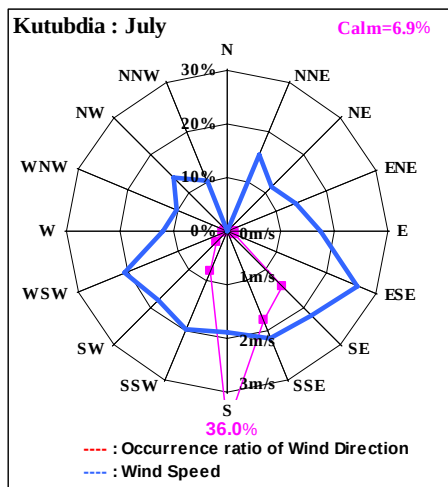
Figure 4.2.2.5 Monthly average cloud amount

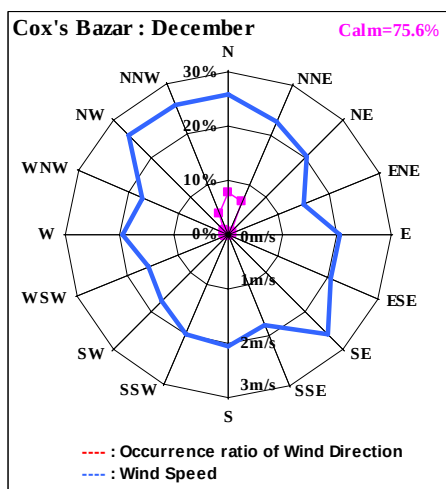
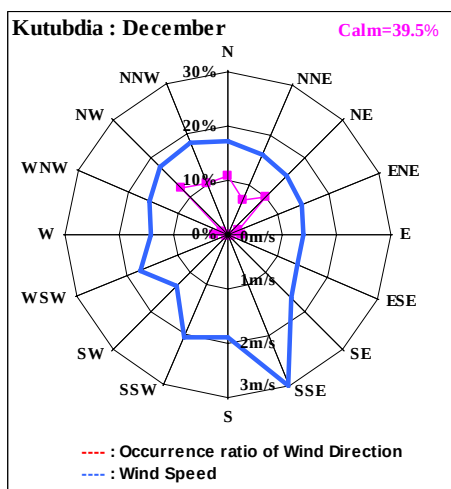
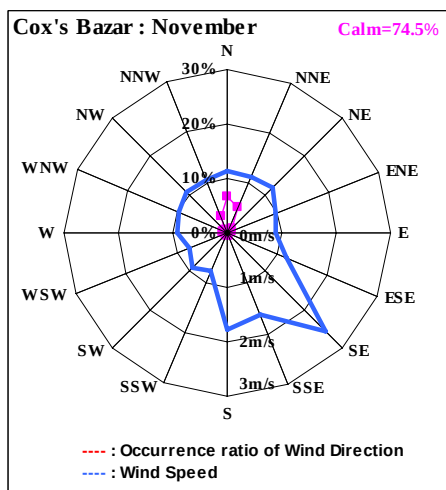
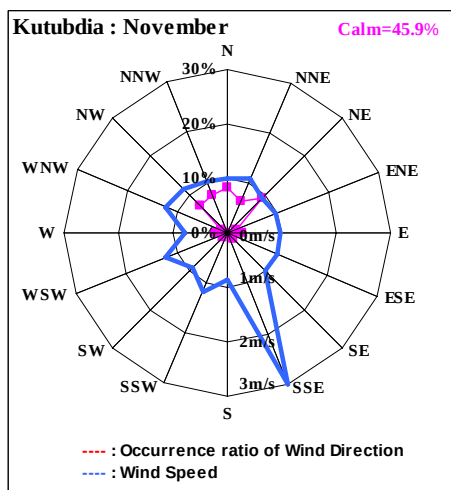
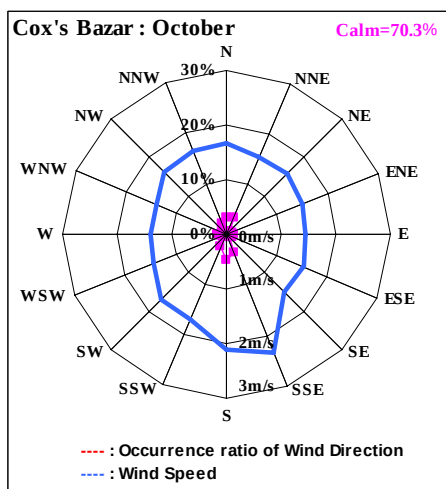
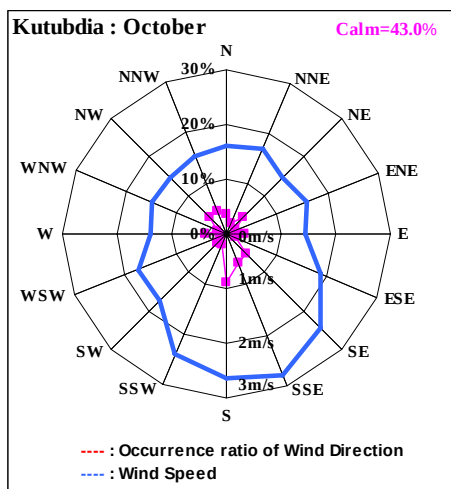
e) Wind

Figure 4.2.2.6 indicates the monthly frequency ratio of wind direction and the average wind speed for each wind direction in Kutubdia and Cox's Bazar. The data was missing in Kutubdia for 2006. In Cox's Bazar, "Calm (wind speed 0.5m/sec and lower)" occurs most frequently, accounting for more than 50% from September to March. Except for this difference, the wind directions in both areas show similar tendencies. Northerly winds are dominant in January and February, and no significant high wind speed was observed in specific wind direction. Southerly winds become dominant from March, especially from April to September. In July and August, there is a tendency of slightly higher wind speed in southwesterly winds, otherwise no significant high wind speed was observed in any specific wind direction. Wind direction shifts from southerly winds to northerly winds in October, and there is a tendency of high wind speed of southwesterly winds. Northerly winds are dominant in November and December, but high wind speed tends to occur in southwesterly winds.









(Prepared based on the data of the meteorological observatory)

Figure 4.2.2.6 Monthly wind rise

(3) Geology

The JICA Study Team carried out a detailed soil investigation of the Matarbari area. Ground investigation work is a main feature in the designing foundation of important structures in an intelligent, economic and satisfactory way. It provides necessary information of strength and compressibility characteristics of the sub-soil to the design engineers to enable the selection of suitable depths and types of foundation for the proposed structures.

The investigation work included the execution of nine borings from the existing ground level and execution of an SPT test, collection of disturbed samples at specified depths under consideration, and a record of ground water levels, etc. All of these items of the field investigation have subsequently been followed up by the performance of laboratory tests.

a) Boring points

The drilling implementation was determined on the basis of the power plant area and formation of a port.

A drawing of the boring points is shown in Figure 4.2.2.8.

b) Field Investigation

Core drilling was conducted in 9 boreholes with a total depth of 696 m. The deepest hole was 100 m and the shallowest was 30 m. Information about those boreholes, comprising the borehole numbers, location, coordinates and elevation are shown in Table 4.2.2.1 below, including the related Bore Logs.

Table 4.2.2.1 Pilling List

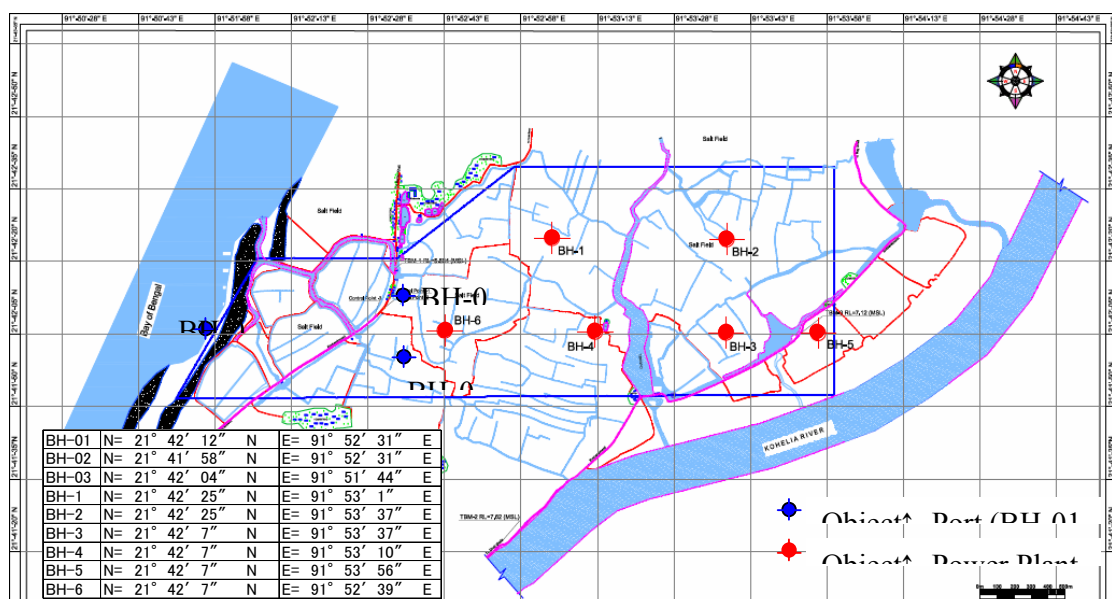
Bore No.	Coordinate		Depth	Loction	Ground Elevation	Bore Log
BH-01	N= 21° 42' 12" N	E= 91° 52' 31" E	33m	port	4.88mMSL	figure5.2.4-4
BH-02	N= 21° 41' 58" N	E= 91° 52' 31" E	33m	port	4.70mMSL	figure5.2.4-5
BH-03	N= 21° 42' 04" N	E= 91° 51' 44" E	30m	channel	3.68mMSL	figure5.2.4-6
BH-1	N= 21° 42' 25" N	E= 91° 53' 1" E	100m	Plant	–	figure5.2.4-7
BH-2	N= 21° 42' 25" N	E= 91° 53' 37" E	100m	Plant	–	figure5.2.4-8
BH-3	N= 21° 42' 7" N	E= 91° 53' 37" E	100m	Plant	–	figure5.2.4-9
BH-4	N= 21° 42' 7" N	E= 91° 53' 10" E	100m	Plant	–	figure5.2.4-10
BH-5	N= 21° 42' 7" N	E= 91° 53' 56" E	100m	Plant	–	figure5.2.4-11
BH-6	N= 21° 42' 7" N	E= 91° 52' 39" E	100m	Plant	–	figure5.2.4-12

c) Geological survey results

The subsurface geology of the proposed project site has been revealed using BH-01[BH-03 borehole logs of the project site. The maximum depth of the boreholes is 33.0m from the existing ground surface. Mainly seven soil layers were observed in the studied site, i.e., very soft to medium stiff clay, loose to very dense silty fine sand, stiff clay, medium dense to very dense silty fine sand, very stiff silt, hard clay, and very dense silty fine sand. The stratigraphy of the project site is given in the table below.

Table 4.2.2.2 The stratigraphy of the project site

Lithology	Average Thickness (m)
Unit-1: CLAY. It is very soft to medium stiff, grey to dark grey in color, medium to high plastic in nature.	8.0
Unit-2: Silty fine SAND. It is loose to very dense, grey to light grey in color with trace of mica.	4.0
Unit-3: CLAY. It is stiff, grey in color, medium plastic in nature.	2.0
Unit-4: Silty fine SAND. It is medium dense to very dense, light grey in color with traces of mica.	5.0
Unit-5: SILT. It is very stiff, light grey in color, non-plastic in nature.	2.0
Unit-6: CLAY. It is hard, grey spotted brown in color, medium plastic in nature.	4.0
Unit-7: Silty fine SAND. It is very dense, yellowish brown to reddish brown in color with traces of mica.	8.0



The details of the bore logs are shown in appendix C04-02.

Figure 4.2.2.8 Drawing of boring points

(4) Tidal

a) Tidal level

Water level was collected for one month from 29th September to 28th October. The location of the water level is shown in Figure 4.2.2.9.

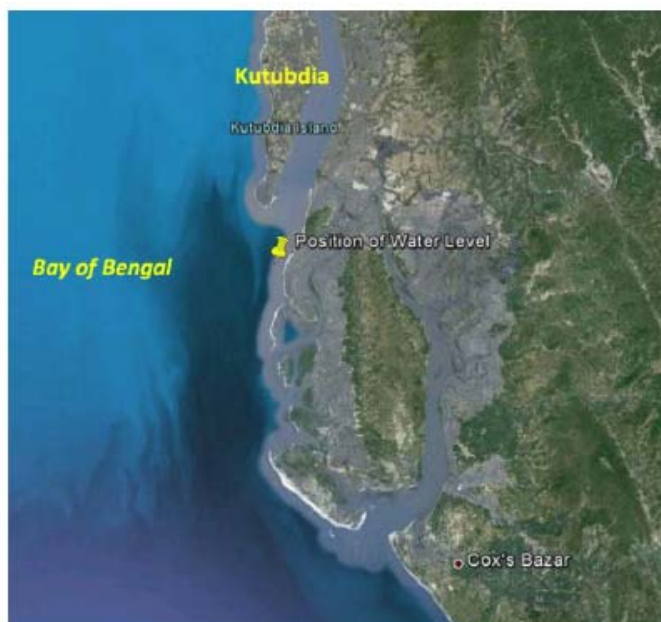


Figure 4.2.2.9 Location of water level station

-Design of Tidal Level (prediction of water level using harmonic analysis)

Harmonic analysis is the transformation of tidal observations from the time domain to the frequency domain. The tidal variations can then be given by the sum of the harmonic constituents, which period is associated with the period of the tide generating forces. The periods fall into three tidal species (long-period, lunar and semi- lunar). Each tidal species contains groups of harmonics, which can be separated by analysis of a month of observations. In turn each group contains constituents, which can be separated by analysis of a year of observations. Third lunar, fourth lunar and higher species of harmonics are generated by shallow water effects.

Normally long tidal records are needed to determine amplitude and phase for a larger number of constituents with high accuracy. Here we analyzed 30 days data and the calculated harmonic constituents are provided in Table 4.2.2.3. The water level of 2012 was predicted using these tidal/harmonic constituents and compared with the measured data.

Table 4.2.2.3 Component Tide

Component Tide	M2	S2	N2	K2	K1	O1	P1	M4	Ms4	Z0
Amplitude	1.34m	0.61m	0.27m	0.13m	0.17m	0.05m	0.05m	0.01m	0.006m	0.45m

- Nearly Highest High Water $\otimes \nearrow M2 + S2 + K1 + O1 \nearrow$ above M.S.L

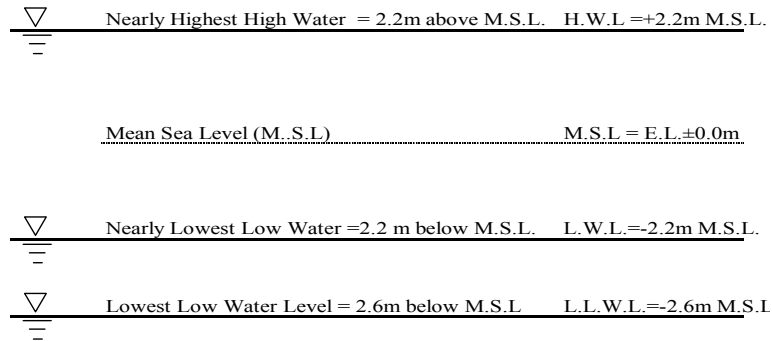
$\otimes$ 2.2 m above M.S.L

- Nearly Lowest Low Water $\otimes \nwarrow M2 + S2 + K1 + O1 \nwarrow$ below M.S.L

$\otimes$ 2.2 m above M.S.L

- Lowest Low Water Level $\otimes \nwarrow M2 + S2 + N2 + K2 + K1 + O1 + P1 + M4 + MS4 \nwarrow$ below M.S.L ! ! ! ! ! ! !

$\otimes$ 2.6 m above M.S.L



* The Chart Datum (CD) is 2.69m below M.S.L at SONADIA

The details of the investigation data are shown in appendix C04-03.

Figure 4.2.2.10 Tidal Conditions at Matarbari

b) Tidal current

Current speed data was collected for 15 days for four selected locations. The four locations are provided in Figure 4.2.2.11.

Of the four locations, three locations are almost close but location 3 is more towards the sea. It is evident from the results of the investigation that the current speed varies from 0.03 m/s to 1.26 m/s (location 1), and 0.025 m/s to 1.5 m/s (locations 2 and 3), and the dominant direction follows 0 to 90 degrees and 180 to 270 degrees (locations 1,2 and 3). In addition, it was found that the current speed of location 4 varies from 0.06 m/s to 1.88 m/s and the dominant direction is 0 to 90 degrees.

From all the current profiles it is evident that almost 90% of the direction falls either from 0 to 90 degrees (Northeast direction) or from 180 to 270 degrees (Southwest direction). This happens because it represents the tide. When there is a flood tide the water goes towards shore/land, then it follows a southwest direction (180 to 270 degrees), whereas when there is an ebb tide the water goes towards the sea then it follows a northeast direction (0 to 90 degrees).

Table 4.2.2.4 Tidal Current Observation Point/Line

SL	NAME/ID	LAT (WGS84)	LON (WGS84)	EASTING (UTM)	NORTHING (UTM)	REMARKS
1	TC-01	21°42' 20"N	91°51' 35"E	382048	2400946	at -5m depth
2	TC-02	21°41' 45"N	91°51' 18"E	381526	2399615	at -5m depth
3	TC-03	21°41' 45"N	91°50' 49"E	380699	2399600	at -15m depth
4	TC-04	21°38' 39"N	91°53' 21"E	385033	2393849	RIVER END

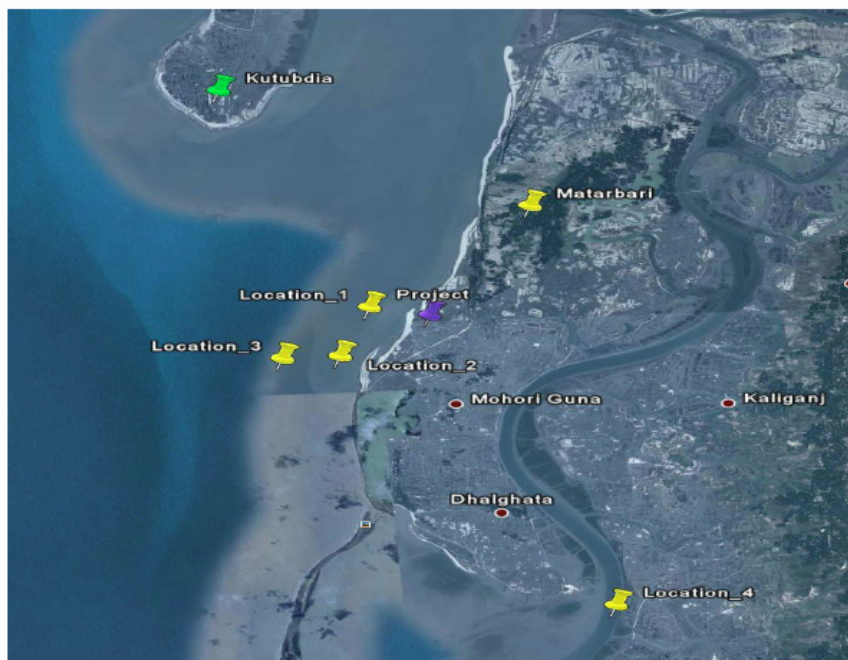


Figure 4.2.2.11 Point Map

(5) Wave

a) Water Depth

The water depth as charted by the hydrographic chart applies to the sea area of the candidate site. The hydrographic chart is shown in the next page.

b) Ordinary Deepwater Waves

a. Outline of Estimated Global Wave Database

An estimated global wave database has been calculated using the Wave Estimation Model “JWA3G” developed by the Japan Weather Association, based on the objectively analyzed sea surface wind values of the European Center for Medium-Range Weather Forecasts (ECMWF) as input conditions.

Model JWA3G is the most advanced model for estimating irregular waves approaching from various directions based on the spectral method

b. Deepwater Waves Data

- Period : 2006.1.1 ~ 2010.12.31
- Extraction Point : Long. 91°30' E, Long. 20°30' N
- Time Interval : 1 hour
- Data Elements : Significant wave height, period and direction

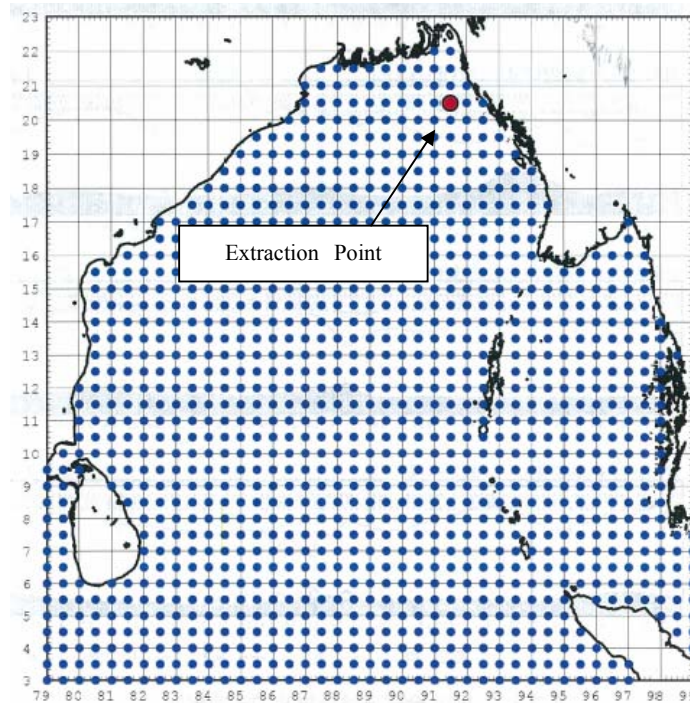


Figure 4.2.2.13 Area of wave forecasting data

Statistical analysis of ordinary deepwater waves has been carried out based on wave estimation data. The composite occurrence frequency table and chart of significant wave height, period and direction are indicated respectively in Table 4.2.2.5 and Figure 4.2.2.14.

Table 4.2.2.5 (1) Composite frequency of significant wave height and period (deepwater, annually)

Point : E91.5 , N20.5

Term : 2006.1.1 ~ 2010.12.31

Wave Direction : ALL

Height (m) \ Period (s)	~ 2.9	3.0 ~ 3.9	4.0 ~ 4.9	5.0 ~ 5.9	6.0 ~ 6.9	7.0 ~ 7.9	8.0 ~ 8.9	9.0 ~ 9.9	10.0 ~ 10.9	11.0 ~ 11.9	12.0 ~ 12.9	13.0 ~ 13.9	14.0 ~ 14.9	15.0 ~	Sum	Total amount
~ 0.49			18 (0.0)	75 (0.2)	187 (0.4)	323 (0.7)	378 (0.9)	346 (0.8)	131 (0.3)	17 (0.0)					1475 (3.4)	1475 (3.4)
0.50 ~ 0.99		6 (0.0)	255 (0.6)	948 (2.2)	1729 (3.9)	2533 (5.8)	3765 (8.6)	3280 (7.5)	1734 (4.0)	484 (1.1)	189 (0.4)	19 (0.0)	13 (0.0)		14955 (34.1)	16430 (37.5)
1.00 ~ 1.49			186 (0.4)	590 (1.3)	1089 (2.5)	2579 (5.9)	2952 (6.7)	1929 (4.4)	1389 (3.2)	917 (2.1)	350 (0.8)	110 (0.3)	18 (0.0)		12109 (27.6)	28539 (65.1)
1.50 ~ 1.99				144 (0.3)	1295 (3.0)	2644 (6.0)	2617 (6.0)	1209 (2.8)	609 (1.4)	122 (0.3)	61 (0.1)	70 (0.2)	4 (0.0)		8775 (20.0)	37314 (85.1)
2.00 ~ 2.49				14 (0.0)	765 (1.7)	1560 (3.6)	1158 (2.6)	462 (1.1)	129 (0.3)	67 (0.2)	42 (0.1)				4197 (9.6)	41511 (94.7)
2.50 ~ 2.99					267 (0.6)	681 (1.6)	369 (0.8)	173 (0.4)	28 (0.1)	13 (0.0)	26 (0.1)				1557 (3.6)	43068 (98.3)
3.00 ~ 3.49					13 (0.0)	256 (0.6)	128 (0.3)	13 (0.0)	1 (0.0)	13 (0.0)					424 (1.0)	43492 (99.2)
3.50 ~ 3.99					131 (0.3)	36 (0.1)	36 (0.1)	9 (0.0)							176 (0.4)	43668 (99.6)
4.00 ~ 4.49						34 (0.1)	35 (0.1)	6 (0.0)							75 (0.2)	43743 (99.8)
4.50 ~ 4.99						2 (0.0)	17 (0.0)	10 (0.0)							29 (0.1)	43772 (99.9)
5.00 ~ 5.49							13 (0.0)	4 (0.0)	2 (0.0)						19 (0.0)	43791 (99.9)
5.50 ~ 5.99							6 (0.0)	7 (0.0)	4 (0.0)						17 (0.0)	43808 (100.0)
6.00 ~ 6.49								5 (0.0)	5 (0.0)						10 (0.0)	43818 (100.0)
6.50 ~ 6.99									6 (0.0)						6 (0.0)	43824 (100.0)
7.00 ~															0 (0.0)	43824 (100.0)
Sum	0 (0.0)	6 (0.0)	459 (1.0)	1771 (4.0)	5345 (12.2)	10743 (24.5)	11474 (26.2)	7453 (17.0)	4038 (9.2)	1633 (3.7)	668 (1.5)	199 (0.5)	35 (0.1)	0 (0.0)	43824 (100.0)	
Total amount	0 (0.0)	6 (0.0)	465 (1.1)	2236 (5.1)	7581 (17.3)	18324 (41.8)	29798 (68.0)	37251 (85.0)	41289 (94.2)	42922 (97.9)	43590 (99.5)	43789 (99.9)	43824 (100.0)	43824 (100.0)		

upper : frequency , (lower) : ratio

Table 4.2.2.5 (2) Composite frequency of significant wave height and direction (deepwater, annually)

Point : E91.5 , N20.5

Term : 2006.1.1 ~ 2010.12.31

Direction Height (m)	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	Sum
~ 0.49	10 (0.0)	1 (0.0)	1 (0.0)		1 (0.0)	3 (0.0)	66 (0.2)	890 (2.0)	375 (0.9)	52 (0.1)	19 (0.0)	23 (0.1)	17 (0.0)	12 (0.0)	3 (0.0)	2 (0.0)	1475 (3.4)
0.50 ~ 0.99	55 (0.1)	3 (0.0)	1 (0.0)	2 (0.0)		7 (0.0)	37 (0.1)	2921 (6.7)	8670 (19.8)	1486 (3.4)	288 (0.7)	251 (0.6)	239 (0.5)	317 (0.7)	389 (0.9)	289 (0.7)	14955 (34.1)
1.00 ~ 1.49	15 (0.0)					7 (0.0)	39 (0.1)	816 (1.9)	8201 (18.7)	1781 (4.1)	182 (0.4)	105 (0.2)	92 (0.2)	138 (0.3)	424 (1.0)	309 (0.7)	12109 (27.6)
1.50 ~ 1.99						11 (0.0)	40 (0.1)	532 (1.2)	6711 (15.3)	1396 (3.2)			2 (0.0)	3 (0.0)	28 (0.1)	52 (0.1)	8775 (20.0)
2.00 ~ 2.49						12 (0.0)	86 (0.2)	353 (0.8)	2906 (6.6)	838 (1.9)	2 (0.0)						4197 (9.6)
2.50 ~ 2.99						1 (0.0)	74 (0.2)	125 (0.3)	847 (1.9)	508 (1.2)	2 (0.0)						1557 (3.6)
3.00 ~ 3.49							17 (0.0)	73 (0.2)	258 (0.6)	76 (0.2)							424 (1.0)
3.50 ~ 3.99							33 (0.1)	22 (0.1)	80 (0.2)	41 (0.1)							176 (0.4)
4.00 ~ 4.49							22 (0.1)	5 (0.0)	35 (0.1)	13 (0.0)							75 (0.2)
4.50 ~ 4.99							5 (0.0)	9 (0.0)	15 (0.0)								29 (0.1)
5.00 ~ 5.49							7 (0.0)	6 (0.0)	6 (0.0)								19 (0.0)
5.50 ~ 5.99								7 (0.0)	10 (0.0)								17 (0.0)
6.00 ~ 6.49								6 (0.0)	4 (0.0)								10 (0.0)
6.50 ~ 6.99								1 (0.0)	5 (0.0)								6 (0.0)
7.00 ~																	0 (0.0)
Sum	80 (0.2)	4 (0.0)	2 (0.0)	2 (0.0)	1 (0.0)	41 (0.1)	426 (1.0)	5766 (13.2)	28123 (64.2)	6191 (14.1)	493 (1.1)	379 (0.9)	350 (0.8)	470 (1.1)	844 (1.9)	652 (1.5)	43824 (100.0)

upper : frequency , (lower) : ratio

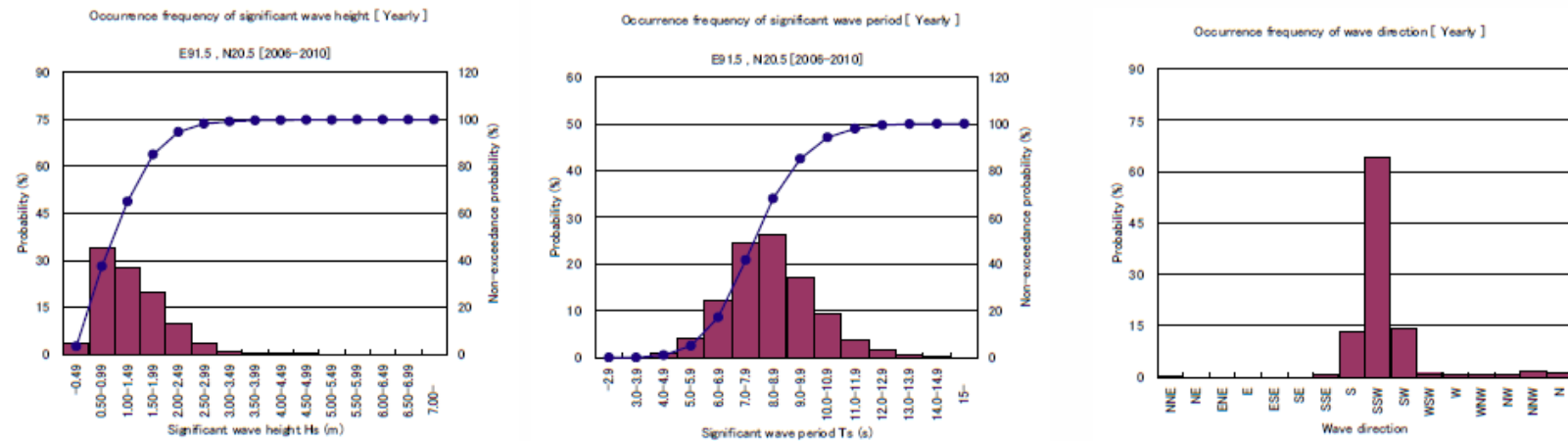


Figure 3.2.2-14 (1) Frequency of significant wave height and direction (deepwater, annually)

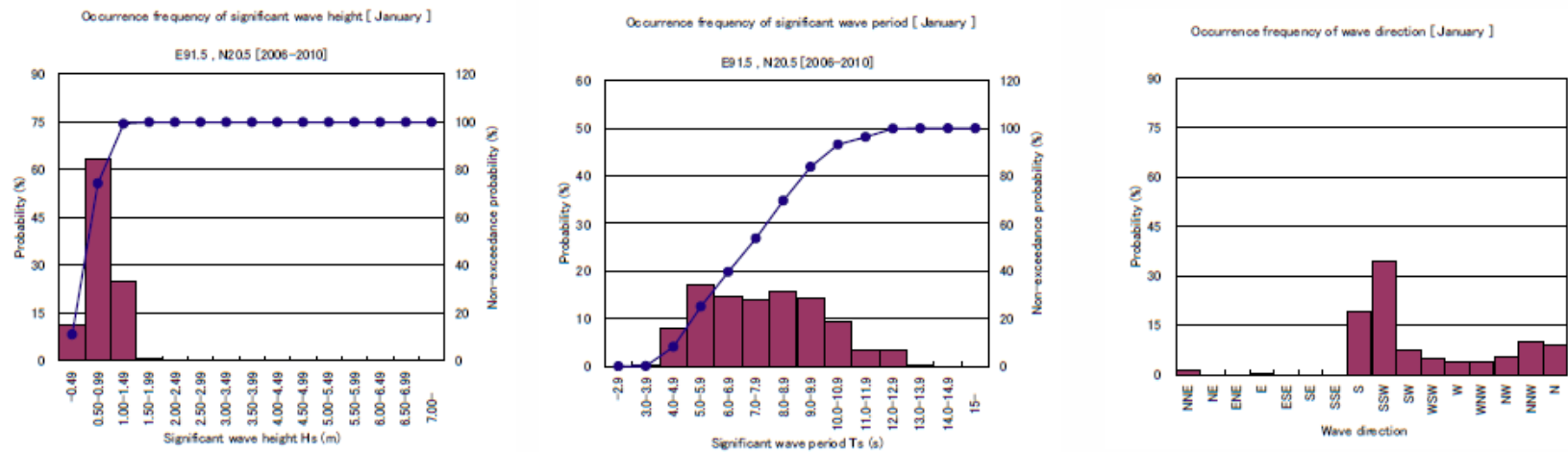


Figure 4.2.2.14 (2) Frequency of significant wave height and direction (deepwater, Jan.)

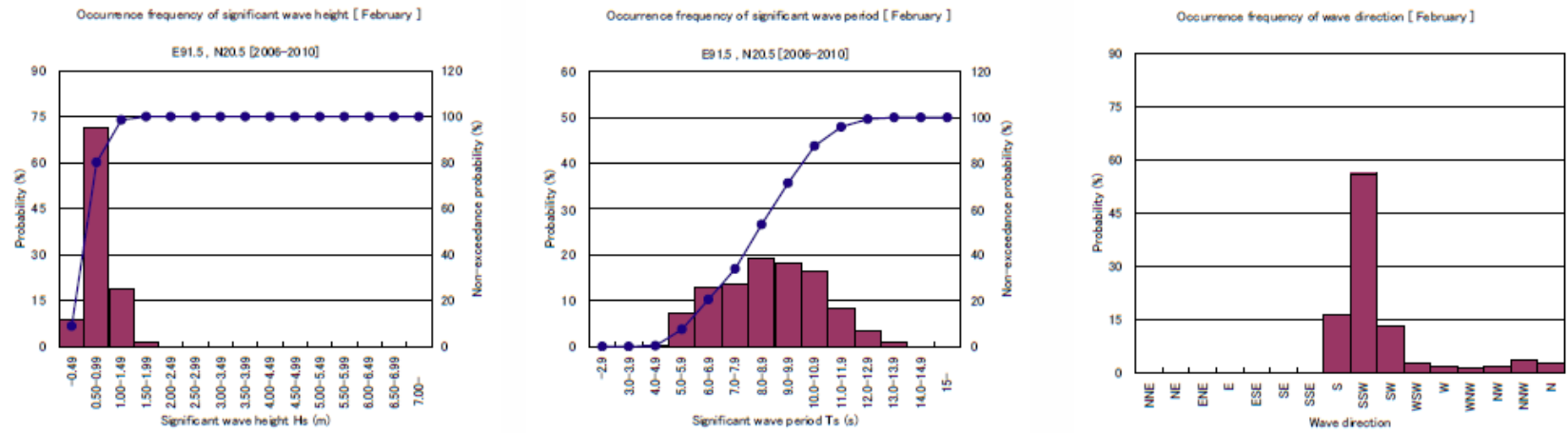


Figure 4.2.2.14 (3) Occurrence frequency of significant wave height and direction (deepwater, Feb.)

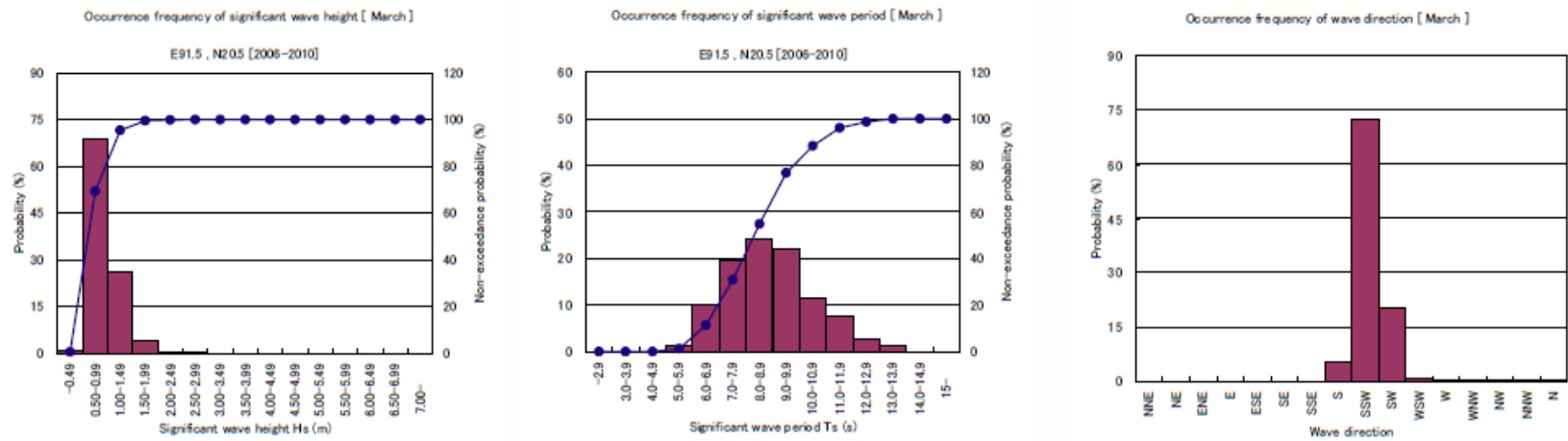


Figure 4.2.2.14 (4) Frequency of significant wave height and direction (deepwater, Mar.)

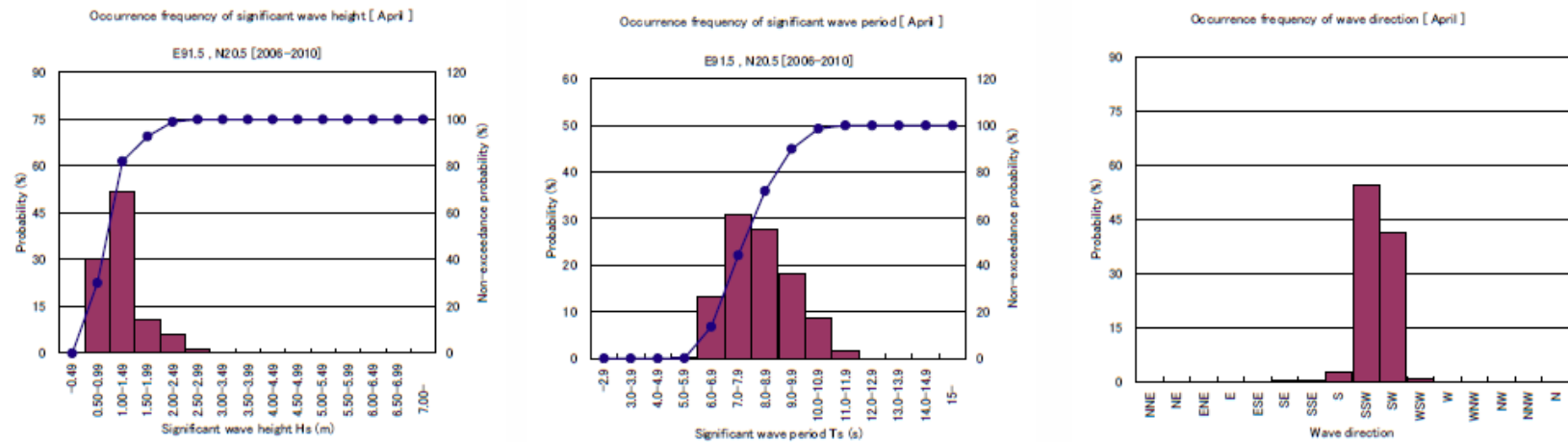


Figure 4.2.2.14 (5) Frequency of significant wave height and direction (deepwater, Apr.)

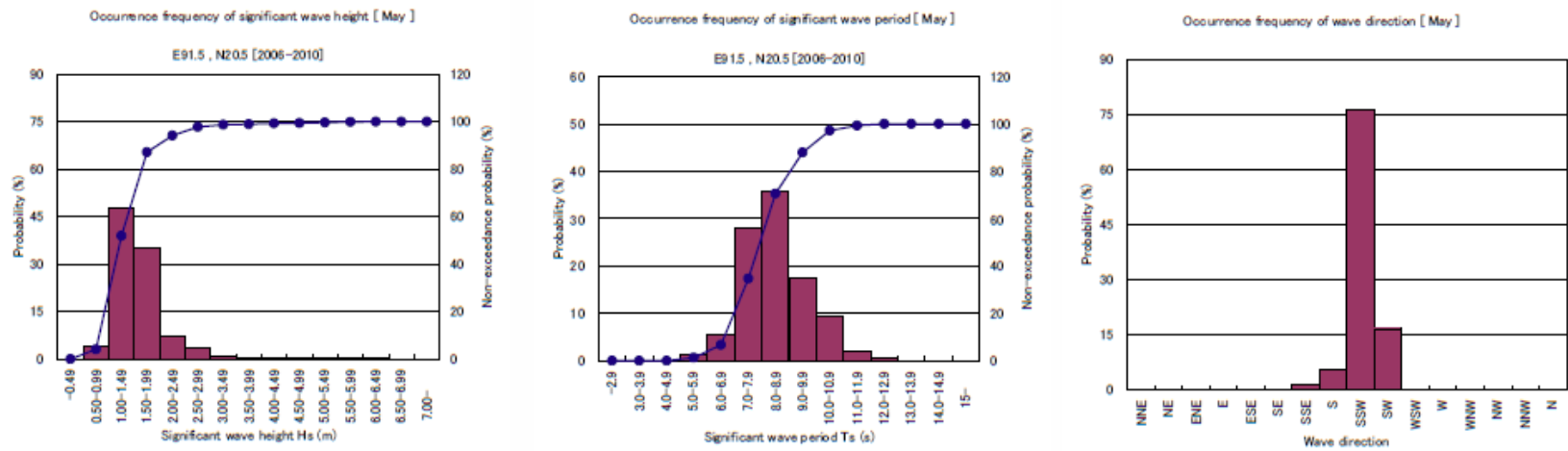


Figure 4.2.2.14 (6) Frequency of significant wave height and direction (deepwater, May)

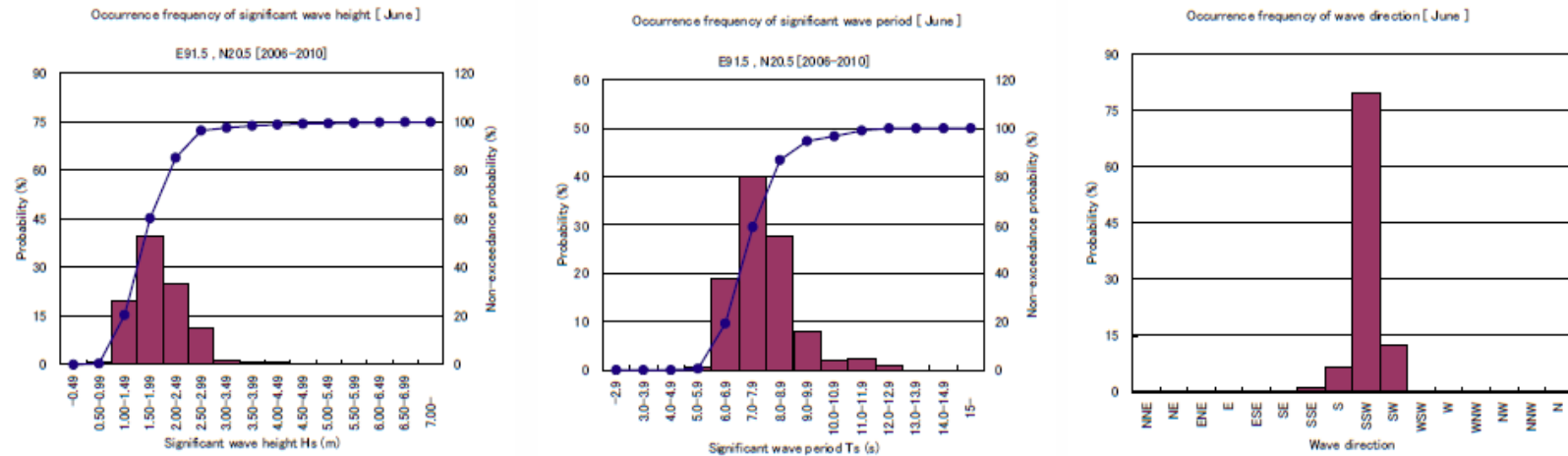


Figure 4.2.2.14 (7) Frequency of significant wave height and direction (deepwater, Jun.)

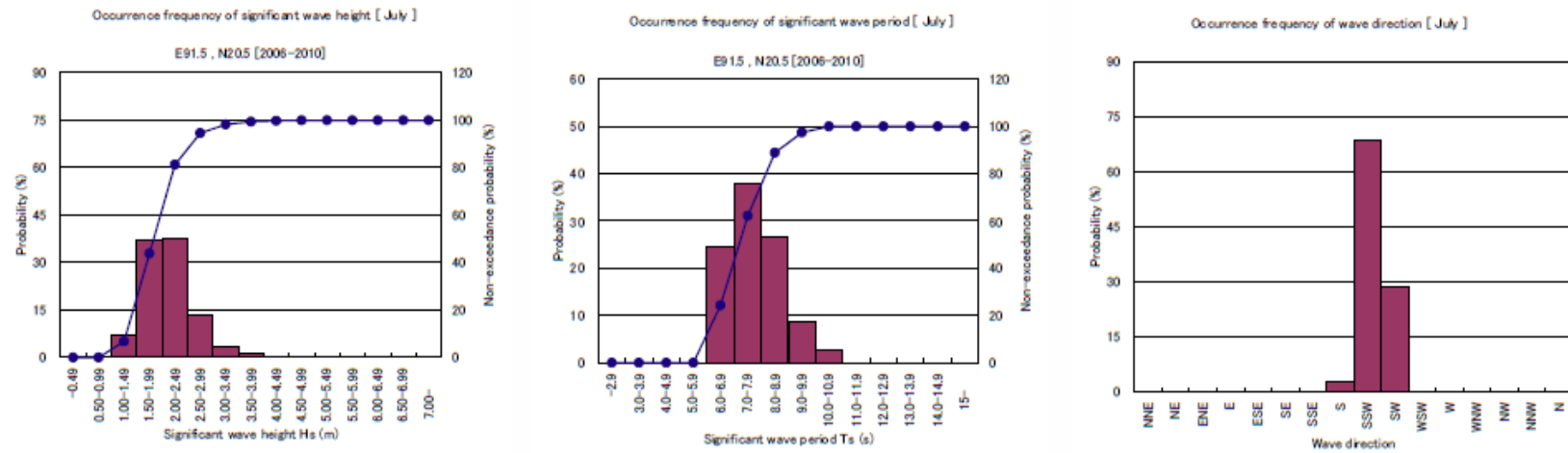


Figure 4.2.2.14 (8) Frequency of significant wave height and direction (deepwater, Jul.)

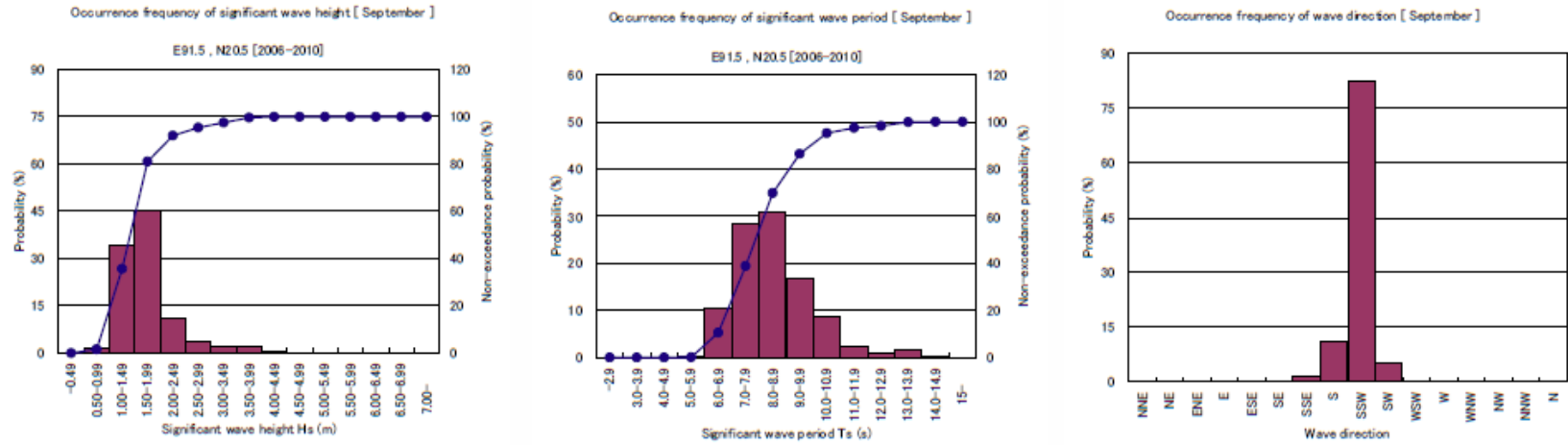


Figure 4.2.2.14 (9) Frequency of significant wave height and direction (deepwater, Aug.)

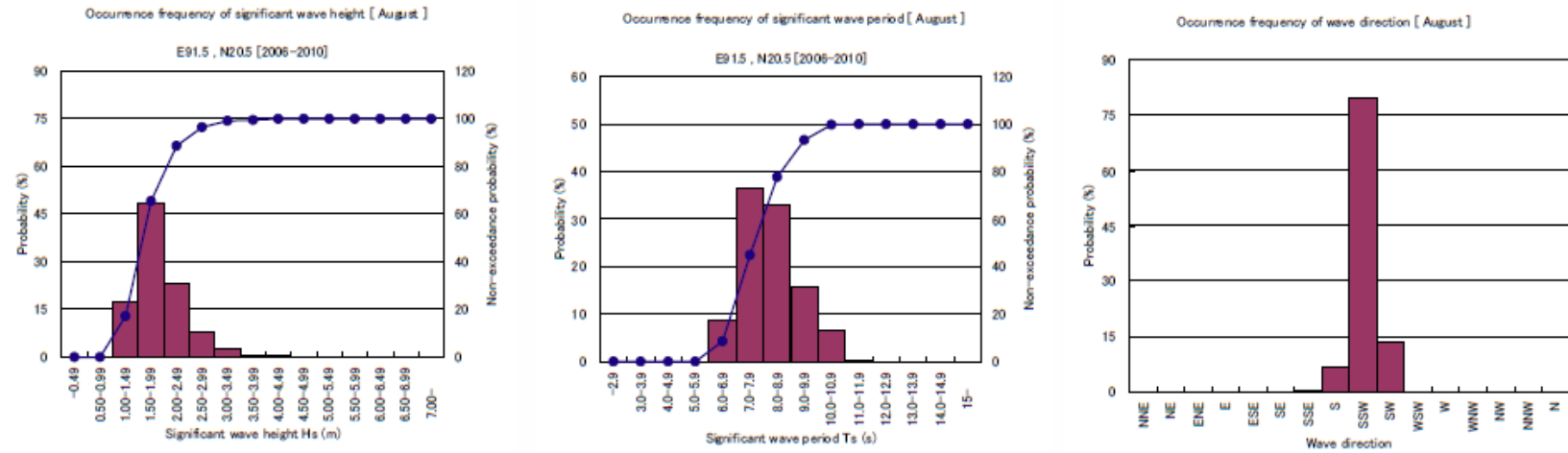


Figure 4.2.2.14 (10) Frequency of significant wave height and direction (deepwater, Sep.)

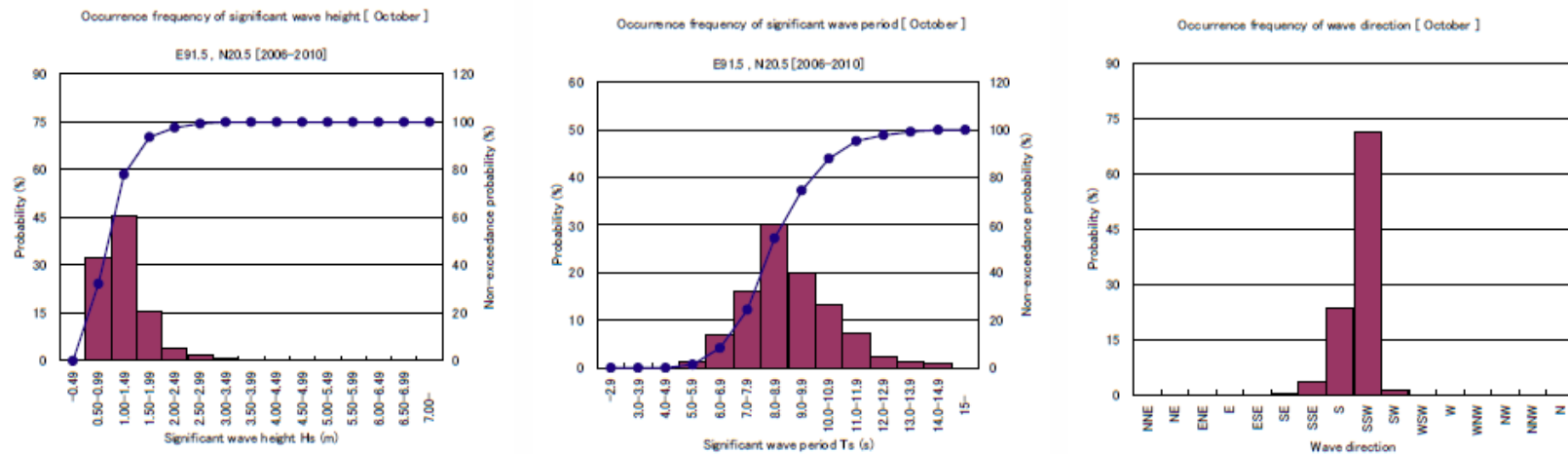


Figure 4.2.2.14 (11) Frequency of significant wave height and direction (deepwater, Oct.)

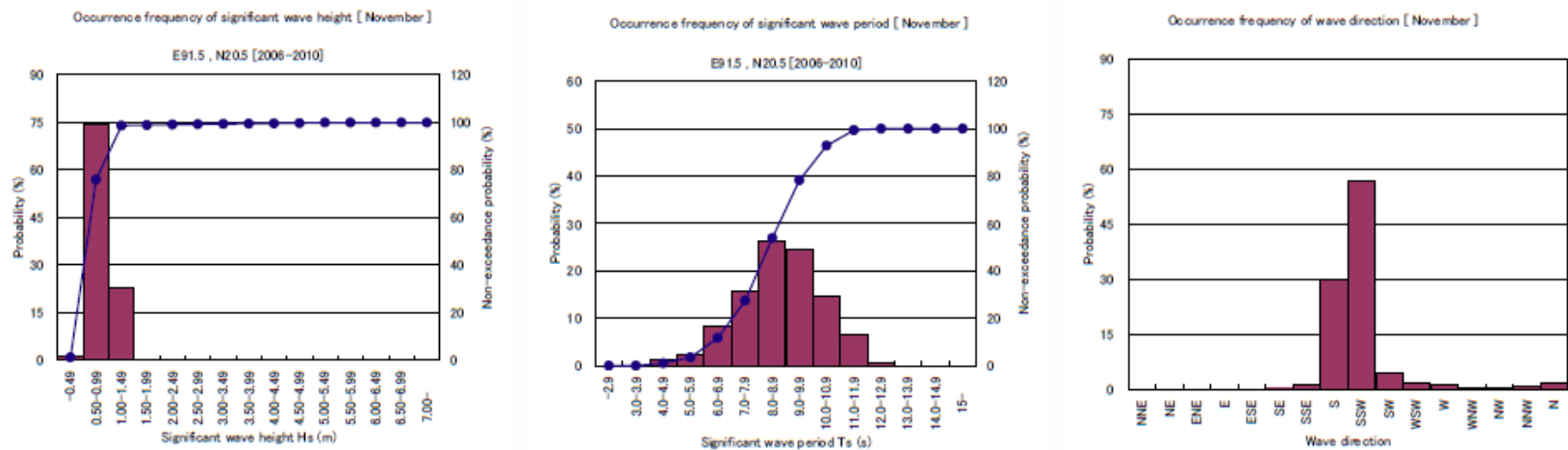


Figure 4.2.2.14 (12) Frequency of significant wave height and direction (deepwater, Nov.)

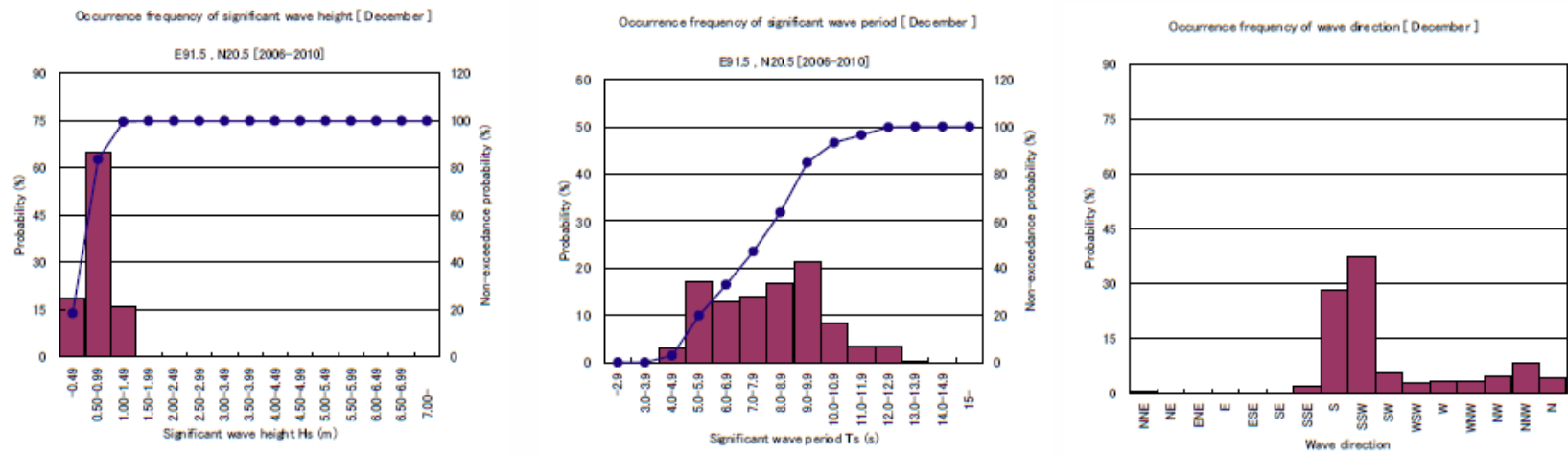


Figure 4.2.2.14 (13) Frequency of significant wave height and direction (deepwater, Dec.)

c) Current

Table 4.2.2.6 Current around Sonadia Island

Flood		Ebb	
Velocity	Direction	Velocity	Direction
1.45	NNE	1.20	SSW

(m/s)

Source: based on current observation data (unreliable data source)

d) Tidal Levels

Table 4.2.2.7 Tidal Levels of Sonadia Island

H.W.L	M.S.L	L.W.L
+1.94	±0.00	-2.08

Source: based on tidal observation data (unreliable data source)

(6) Flood types

There are generally four types of floods in Bangladesh¹ (Figure 4.2.2.15).

Normal Floods: This type of flood generally occurs in the Gangetic deltas where natural drainage systems are deteriorating due to amounts of rainfall that are larger than drainage capacity. They also occur in towns where natural drainage systems have been disturbed because of human interference, mainly due to construction of unplanned rural roads and illegal occupation of river courses.

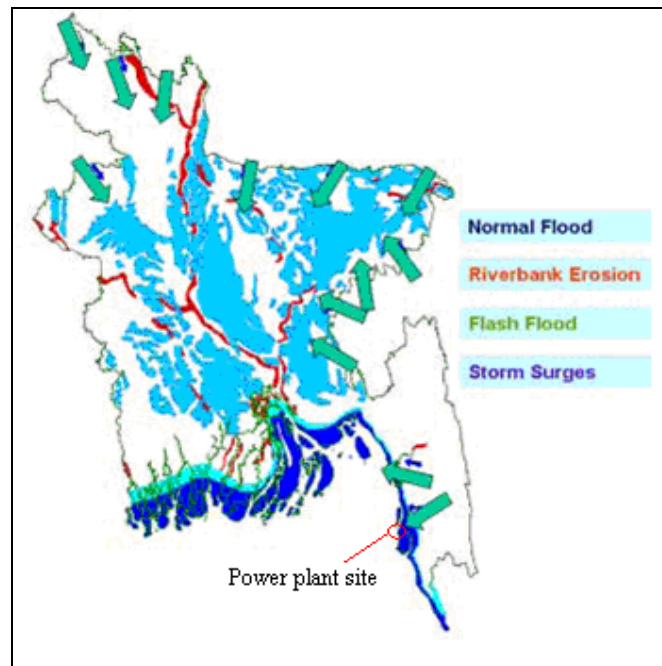
Riverbank Erosion: This type of flood is the most common phenomenon in the country from time immemorial. They normally occur in the monsoon season along the river. In the case of extreme floods, 50~70% of the country are inundated extending into areas far beyond the riverbanks.

Flash Floods: This type of flood is characterized by a rapid rise and fall in water levels. Flash floods occur mostly in the northern area, north-central part, northeastern part and southeastern part of the country.

Storm Surges: This kind of flood mostly occurs along the coastal areas of Bangladesh which has a coast line of about 800km along the northern part of the Bay of Bengal. This coastal area is shallow and the coastal line in the eastern

¹ World Meteorological Organization, 2003: Integrated Flood Management Case Study; BANGLADESH, FLOOD MANAGEMENT

portion is conical in shape. Therefore, Storm Surges are likely to occur due to flood tides of cyclones and southwestern monsoon winds. The power plant site is located in this Storm Surges area.



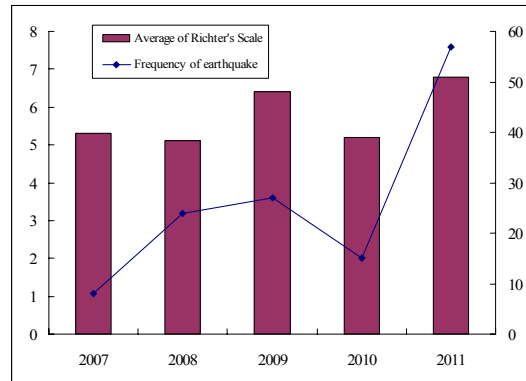
(Source: World Meteorological Organization, 2003)

Figure 4.2.2.15 Areas of four flood types

(7) Seismic coefficient

Earthquakes which have occurred in Bangladesh and the surrounding area since 2007 are recorded by the Bangladesh Meteorological Department (only major earthquakes that caused serious damage had been recorded prior to 2007). Eight earthquakes were recorded in 2007, while 24 to 27 earthquakes were recorded from 2008 to 2009. Fifteen earthquakes were recorded in 2010, while the number increased to 81 in 2011. The number recorded in 2011 included earthquakes with remote epicenters, of which 57 had been recorded prior to 2011 (Figure 4.2.16).

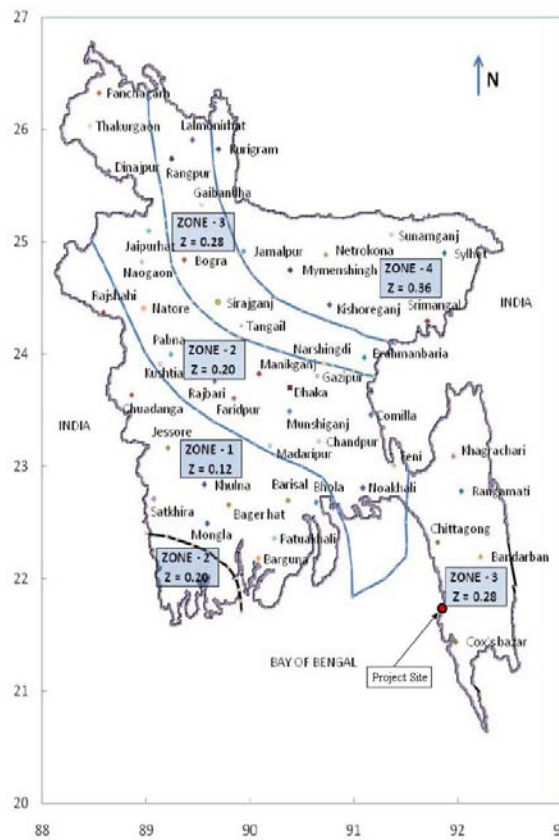
Regarding the intensity of earthquakes as indicated by the Richter Scale, the records of yearly maximums on the Richter scale show that strong earthquakes occurred more often in 2009 and 2011 than in the other 3 years between 2007 and 2011 (Figure 4.2.17).



(Prepared based on the data of Bangladesh Meteorological Department)

Figure 4.2.17 Frequency of earthquakes and maximums on the Richter Scale

Bangladesh is divided into four seismic zones, and the design strength of buildings is stipulated in each seismic zone. The project site is located in Zone -3, the same as Chittagong, where moderate levels of strength designs for buildings will be necessary (Figure 4.2.2.17).



(Source: Bangladesh National Building Code)

Figure 4.2.2.17 Seismic Zone Map of Bangladesh

The seismic coefficient shall be determined from the following relation by the BANGLADESH NATIONAL BUILDING CODE 2006.

$$k = \frac{Z \cdot I \cdot C}{R}$$

where, k = Seismic coefficient

Z = Seismic zone coefficient given in Table 4.2.2.8

I = Structure importance coefficient given in Table 4.2.2.9

R = Response modification coefficient for structural systems given in Table 4.2.2.11

C = Numerical coefficient given by the relation;

$$C = \frac{1.25S}{T^{2/3}}$$

S = Site coefficient for soil characteristics as provided in Table 4.2.2.10

T = Fundamental period of vibration in seconds

Table 4.2.2.8 Seismic Zone Coefficients (Z)

Seismic Zone	Zone Coefficient
1	0.12
2	0.20
3	0.28
4	0.36

(Source: Bangladesh National Building Code)

Table 4.2.2.9 Structure Importance Coefficients (I)

Structure Importance Categories	Structure Importance Coefficients	
	I	I'
Essential facilities	1.25	1.50
Hazardous facilities	1.25	1.50
Special occupancy structures	1.00	1.00
Standard occupancy structures	1.00	1.00
Low-risk structures	1.00	1.00

Table 4.2.2.10 Site Coefficient (S)

Site Soil Characteristics		Coefficient, S
Type	Description	
S_1	A soil profile with either : a) A rock-like material characterized by a shear-wave velocity greater than 762 m/s or by other suitable means of classification, or b) Stiff or dense soil condition where the soil depth is less than 61 metres	1.0
S_2	A soil profile with dense or stiff soil conditions, where the soil depth exceeds 61 metres	1.2
S_3	A soil profile 21 metres or more in depth and containing more than 6 metres of soft to medium stiff clay but not more than 12 metres of soft clay	1.5
S_4	A soil profile containing more than 12 metres of soft clay characterized by a shear wave velocity less than 152 m/s	2.0
Note : (1) The site coefficient shall be established from properly substantiated geotechnical data. In locations where the soil properties are not known in sufficient detail to determine the soil profile type, soil profile S_3 shall be used. Soil profile S_4 need not be assumed unless the building official determines that soil profile S_4 may be present at the site, or in the event that soil profile S_4 is established by geotechnical data.		

Table 4.2.2.11 Response Modification Coefficient for Structural Systems (R)

Basic Structural System ⁽¹⁾	description of Lateral Force Resisting System	R ⁽²⁾
a. Bearing Wall System	1. Light framed walls with shear panels	
	i) Plywood walls for structures, 3 storeys or less	8
	ii) All other light framed walls	6
	2. Shear walls	
	i) Concrete	6
	ii) Masonry	6
	3. Light steel framed bearing walls with tension only bracing	4
	4. Braced frames where bracing carries gravity loads	
b. Building Frame System	i) Steel	6
	ii) Concrete ⁽³⁾	4
	iii) Heavy timber	4
	1. Steel eccentric braced frame (EBF)	10
	2. Light framed walls with shear panels	
	i) Plywood walls for structures 3-storeys or less	9
	ii) All other light framed walls	7
	3. Shear walls	
	i) Concrete	8
	ii) Masonry	8
c. Moment Resisting Frame System	4. Concentric braced frames (CBF)	
	i) Steel	8
	ii) Concrete ⁽³⁾	8
	iii) Heavy timber	8
	1. Special moment resisting frames (SMRF)	
	i) Steel	12
	ii) Concrete	12
	2. Intermediate moment resisting frames (IMRF), concrete ⁽⁴⁾	8
d. Dual System	3. Ordinary moment resisting frames (OMRF)	
	i) Steel	6
	ii) Concrete ⁽⁵⁾	5
	1. Shear walls	
	i) Concrete with steel or concrete SMRF	12
	ii) Concrete with steel OMRF	6
	iii) Concrete with concrete IMRF ⁽⁴⁾	9
	iv) Masonry with steel or concrete SMRF	8
	v) Masonry with steel OMRF	6
	vi) Masonry with concrete IMRF ⁽³⁾	7
e. Special Structural Systems	2. Steel EBF	
	i) With steel SMRF	12
	ii) With steel OMRF	6
	3. Concentric braced frame (CBF)	
	i) Steel with steel SMRF	10
	ii) Steel with steel OMRF	6
	iii) Concrete with concrete SMRF ⁽³⁾	9
	iv) Concrete with concrete IMRF ⁽³⁾	6
	See Sec 1.3. 2, 1. 3. 3, 1.3.5	
	Notes : (1) Basic Structural Systems are defined in Sec 1.3.2, Chapter 1.	
	(2) See Sec 2.5.6.6 for combination of structural systems, and Sec 1.3.5 for system limitations.	
	(3) Prohibited in Seismic Zone 3.	
	(4) Prohibited in Seismic Zone 3 except as permitted in Sec. 2.5.9.3.	
	(5) Prohibited in seismic Zones 2 and 3. Sec 1.7.2.6.	

A seismic coefficient was calculated using each coefficient above.

In addition, the shear wave velocity and the natural period of each structure can be calculated as needed.

(8) Cyclone

During the years 1960 to 2010, Bangladesh was hit by 53 severe cyclones, 32 of which were accompanied by storm surges. Table 4.2.2.12 lists the disasters with particular reference to the wind speed, surge height, and loss of life. The height of the surges is limited to a maximum of 10 meters in the bay.

Table 4.2.2.12 List of Major Cyclonic Storms from 1960 to 2011

Date of Landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of Deaths	Surge Height
11.10.1960	S.C.S	Chittagong	160	3,450	6.0m
31.10.1960	S.C.S	Chittagong	193	5,149	6.6m
09.05.1961	S.C.S	Chittagong	160	11,468	5.0m
30.05.1961	S.C.S	Chittagong (Near Feni)	160	-	2.0 - 4.55m
28.05.1963	S.C.S	Chittagong-Cox's Bazar	200	11,520	6.0m
11.05.1965	S.C.S	Chittagong -Barisal Coast	160	19,279	3.7m
05.11.1965	S.C.S	Chittagong	160		6.1 - 7.6m
15.12.1965	S.C.S	Cox's Bazar	210	873	2.4 - 3.6m
23.09.1966	S.C.S	Noakhali coast	139	850	6 - 6.67m
07.12.1966	S.C.S	Cox's Bazar	81	-	-
08.11.1967	C.S	Khulna (Sundarban)	111 (sandheads)	1000 (India)	-
23.10.1967	S.C.S	Near Cox's Bazar	107(cox's) 145(M.mar)	51	-
23.10.1970	S.C.S of hurricane intensity	Bangladesh -West Bengal coast	163	300	4.7 m
12.11.1970	S.C.S with a core of hurricane winds	Chittagong	224	3,00,000	3 - 10m
8.05.1971	C.S	Chittagong	81	-	2.4 - 4.24m
29.09.1971	S.C.S	Sundarban coast	97-113	-	0.6m
6.11.1971	S.C.S	Chittagong-Noakhali coast	-	-	-
18.11.1973	S.C.S	Chittagong	102	-	-
30.05.1974	C.S	Patuakhali	74-83	-	-
28.11.1974	S.C.S	Chittagong-Cox's Bazar coast	163	20	3.0 - 5.1m
10.12.1981	C.S	Khulna	120	72	2.12 - 4.55m
15.10.1983	C.S	Chittagong	93	43	-
09.11.1983	S.C.S	Chittagong -Cox's Bazar coast	136	300	1.5m
24.05.1985	S.C.S	Chittagong	154	4,264	4.55m
29.11.1988	S.C.S with a core of hurricane winds	Khulna coast	160	5,683	4.4m
18.12.1990	Cyclonic Storm (crossed land as a depression)	Cox's Bazar Coast	115	-	-
29.04.1991	S.C.S with a core of hurricane winds	Chittagong	225	1,38,882	6-7.6m
31.05.1991	C.S	Noakhali coast	83	--	2.5m
02.05.1994	S.C.S with a core of hurricane winds	Cox's Bazar-Teknaf Coast	200-250	184	3.64-4.85m
25.11.1995	S.C.S	South of Cox's Bazar	55	---	---

Date of Landfall	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in kph	No. of Deaths	Surge Height
26.10.1996	C.S	Sundarban coast	70	09	1.5-2.0m
19.05.1997	S.C.S with a core of hurricane winds	Sitakundu	232	155	4.55 m
27.09.1997	S.C.S with a core of hurricane winds	Sitakundu	150	67	3.0-4.55m
20.05.1998	S.C.S with core of hurricane winds	Chittagong Coast near Sitakunda	173	14	0.9m
17.10.1999	S.C.S of hurricane intensity	Orissa Coast	-	-	-
25.10.1999	S.C.S of hurricane intensity	Orissa Coast	-	-	-
28.10.2000	Deep Depression (probably Cyclonic Storm)	Sundarban coast near Mongla	50-60	3	0.6-1.2m
16-10.2001	S.C.S	Andhra coast	65-85	-	-
12.11.2002	C.S	Sundarban coast near Raimangal river	65-85	2	1.5-2.1m
20.5.2003	C.S	Myanmar coast	65-85	-	0.9-1.5m
16.12.2003	S.C.S	Andhra coast	98-115	-	-
19.05.2004	C.S	Cox's Bazar & Akyab Coast	65-90	---	0.6-1.2m
28.10.2005	C.S	Andhra coast near Ongole.	-	-	-
10.12.2005	Cyclonic Storm (crossed land as a depression)	Tamilnadu coast near Nagapattanam.	-	-	-
29.04.2006	S.C.S with a core of Hurricane "Mala"	Arakan coast of Myanmar between Akyab & Sandoway	-	-	-
15.05.2007	C.S "AKASH"	Ctg- Cox's Bazar. Coast near	83	-	-
15.11.2007	S.C.S "SIDR" with a core of hurricane winds	Khulna-Barisal coast near Baleshwar river	223	3,363	4.6-6.1m
02.05.2008	S.C.S "NARGIS" with a core of hurricane winds	Myanmar coast near Bassein	-	-	-
26.10.2008	C.S "Rashmi"	Khulna-Barisal coast near Patharghata	-	---	1.5-2.1m
27.11.2008	C.S "Nisha"	Tamilnadu coast near Nagapattanam.	-	-	-
17.04.2009	C.S "BIJLI"	Chittagong-Cox's Bazar coast near Ctg.	90	---	---
25.05.2009	C.S "AILA"	West Bengal-Khulna (Bangladesh) coast near Sagar inland of India.	92	190	2.1-2.4m
20.05.2010	S.C.S "LAILA"	NE Andhra coast of India	-	-	-

S.C.S† Severe Cyclonic Storm, C.S† Cyclonic StormRefer to 4.1.2 Environmental Situation, (3) Cyclonic Storm Surges.

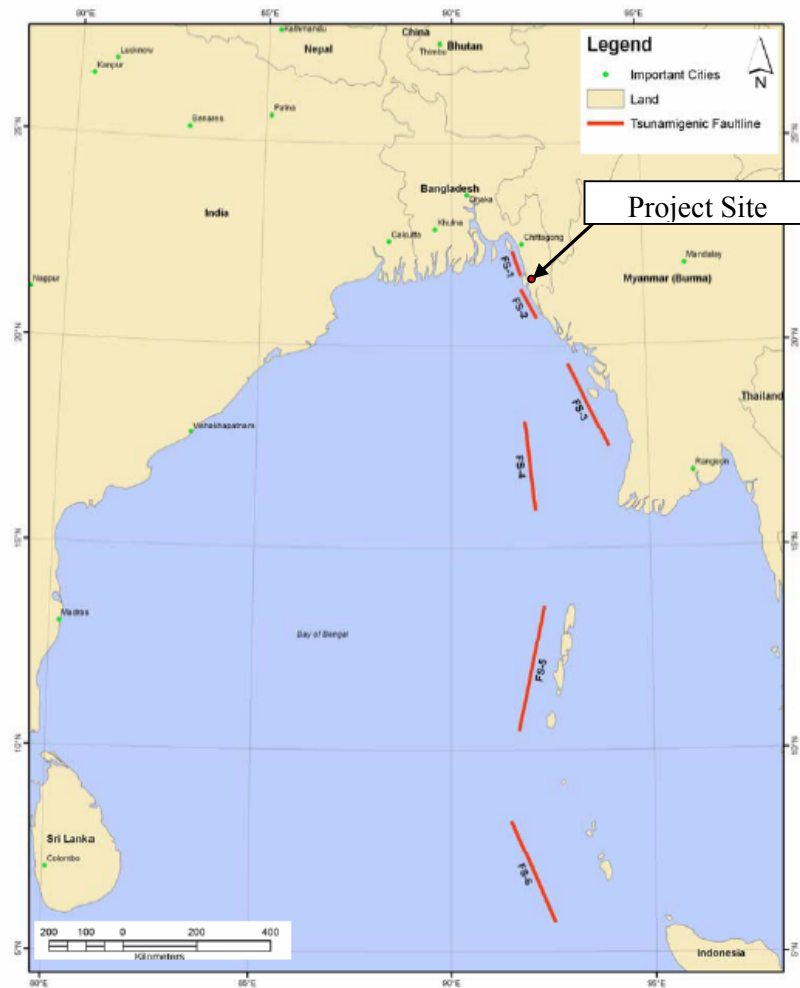
(9) Tsunami

A literature survey was carried out on the data concerning Tsunami.

Tsunamigenic Fault Source

Based on a report of the Ministry of Food and Disaster Management, a potential fault source map of the Bay of Bengal has been prepared and presented in Figure 4.2.2.18.

It shows six potential tsunamigenic fault sources.



(Source: Use Existing Data on Available Digital Elevation Models to prepare Useable Tsunami and Storm Surge Inundation Risk Maps for the Entire Coastal Region Final Report 2009)

Figure 4.2.2.18 Potential Tsunamigenic fault-source map

Inundation Risk Map

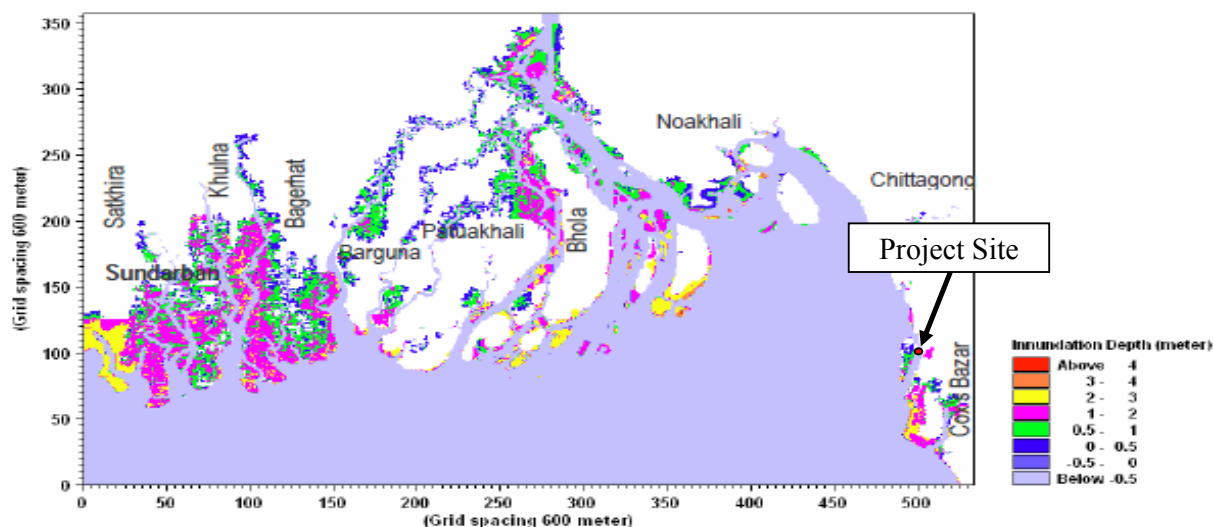
Based on a report of the Ministry of Food and Disaster Management, an Inundation Risk Map has been prepared and presented in Figure 4.2.2.19.

A tsunami model was developed for the Indian Ocean, the Arabian Sea, the Bay of Bengal and the coastal region of Bangladesh using the MIKE21 model system of DHI (Water Environment Health). The model was calibrated with the tsunami of December 26, 2004, which occurred on the West Coast of Sumatra due to an earthquake. The model was applied to simulate a tsunami propagation and inundation from its sources to the coast of Bangladesh.

An inundation risk map for the coastal region of Bangladesh was prepared based on six scenarios of tsunamis originating from six potential sources of earthquakes in the Bay of Bengal. Initially all the tsunamis generated from the potential sources were simulated using the MIKE 21 model system. Maximum inundation maps for all of the tsunamis were generated from the simulation results under Mean High Water Spring (MHWS) tide conditions. Finally, the inundation risk map was generated based on the maximum inundation maps using GIS tools.

The inundation risk map for tsunamis shows that the Cox's Bazaar coast near the project site would be inundated during a tsunami. Maximum inundations have been found Cox's Bazaar coast near the project site in the range of 1-3 m.

For reference, it was found that in the 2004 Sumatra case that first tsunami after the earthquake arrived within 2.2 hours with a maximum height of 31 cm at St. Martin Island.



(Source: Use Existing Data on Available Digital Elevation Models to prepare Useable Tsunami and Storm Surge Inundation Risk Maps for the Entire Coastal Region Final Report 2009)

Figure 4.2.2.19 Maximum Inundation Map for Tsunamis

Tsunami Conditions

Based on a report of the Ministry of Food and Disaster Management, which gives detailed descriptions of related tsunamigenic fault sources and tsunami simulations, a tsunami height of 1 - 3m is predicted.

As a result of this, tsunami height is considerably lower than the storm surge height in the range of 7 - 9m. Therefore, tsunami conditions have not been included in the design of the power plant ground level.

(10) Air quality

a) Sampling points

The residential areas within the site and in the north and the site were selected as sampling points for air quality and noise measurement. The survey was conducted in the rainy season (19 to 20 of October 2012) and in the dry season (29 to 30 of January 2013) to reflect the influence of precipitation in the fluctuation of air quality.



Sampling Point	Latitude (North)	Longitude (East)
AN-1	21°43'19"	91°53'03"
AN-2	21°43'56"	91°53'28"
AN-3	21°42'28"	91°52'43"

(Source: JICA Study Team)

Figure 4.2.2.20 Sampling points of air quality survey and noise measurement

b) Results

The main industries of Matarbari Island are agriculture and fishery, and it is not an industrial area. The air quality survey results indicated overall that the air quality in the rainy season is clean, with a slightly high concentration of dust (SPM) and a low concentration of SO_x and NO_x (Table 4.2.2.13).

Table 4.2.2.13(1) Results of air quality survey

(Rainy season: 19 20/October/2012)

Parameter	Unit	Results			Ambient Air Quality Standards	IFC EHS Guideline (General: 2007)
		AN1	AN2	AN3		
SPM	µg/m ³	54	56	42	200 (8hr) PM ₁₀ : 150 (24hr) PM ₁₀ : 50 (year)	SPM: - PM ₁₀ : 150 (24hr) PM ₁₀ : 70 (year)
SO ₂	µg/m ³	3.2	3.4	3.0	365 (24hr) 80 (year)	500 (10min) 125 (24hr)
NO ₂	µg/m ³	6.2	6.5	6.0	100 (year)	200 (1hr) 40 (year)

(Source: JICA Study Team)

Table 4.2.2.13 (2) Results of air quality survey

(Dry season: 29 30/January/2013)

Parameter	Unit	Results			Ambient Air Quality Standards	IFC EHS Guideline (General: 2007)
		AN1	AN2	AN3		
SPM	$\mu\text{g}/\text{m}^3$	59	62	45	200 (8hr) PM ₁₀ : 150 (24hr) PM ₁₀ : 50 (year)	SPM: - PM ₁₀ : 150 (24hr) PM ₁₀ : 70 (year)
SO ₂	$\mu\text{g}/\text{m}^3$	4.0	4.1	3.0	365 (24hr) 80 (year)	500 (10min) 125 (24hr)
NO ₂	$\mu\text{g}/\text{m}^3$	7.4	7.6	5.0	100 (year)	200 (1hr) 40 (year)

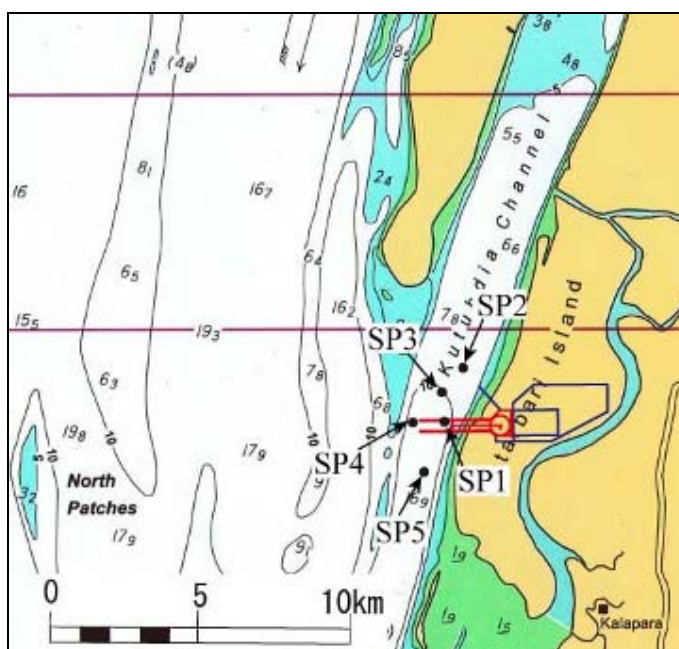
(Source: JICA Study Team)

(11) Water quality

a) Sea water

a. Sampling points

Five sampling points were selected in the sea front area of the power plant site in consideration of the discharge outlet of thermal wastewater and dredging the canal. The sampling was conducted in three layers, Surface (0.5m), Middle (1/2 depth), and Bottom (1m up from the bottom) in consideration of submerged discharge of thermal wastewater. Also, the survey was conducted in the rainy season (19 to 20 of October 2012) and in the dry season (29 of January 2013) to reflect the wide seasonal fluctuation of precipitation in Bangladesh.



Sampling Points	Latitude (North)	Longitude (East)
SP1	21°41'58.92"	91°51'04.99"
SP2	21°43'00.57"	91°51'32.44"
SP3	21°42'33.74"	91°51'08.55"
SP4	21°41'56.99"	91°50'29.11"
SP5	21°40'56.65"	91°50'43.90"

(Source: JICA Study Team)

Figure 4.2.2.21 Sampling points of the sea water quality survey

b. Results

<Rainy season>

The water temperature was in the range of 28.5 - 30.5 °C, with the tendency of higher temperatures near the surface layer and lowering towards the deeper layer. The salinity was in the range of 15.8 - 21.6, tending to be lower in the surface layer and becoming higher toward the deeper layer. It should be noted that, according to the database of the Japan Oceanographic Data Center², salinity in the surface layer in the sea areas of 21 - 22°N and 91 - 92°E are within the range of 23.95 - 31.93. The salinity in the sea front area of the project site is assumed to be influenced by the Padma River and other rivers. SS (suspended solids) concentration is very high (640 - 910mg/L) due to the strong effects of river water. COD is also very high (160 - 197mg/L), while BOD is not at a high level (0.6 - 1.1mg/L) (the water quality standard for surface water is 2mg/L or less). Concentration of heavy metals, with the exception of a rather high concentration of Iron (Fe), was not high.

Table 4.2.2.14 (1) Results of sea water quality survey

(Rainy season: 6 7/October/2012)

Parameter	Unit	SP-1			SP-2			SP-3		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth	M	0.5			0.5			0.5		
Temperature	°C	30.0	28.8	29.0	30.0	29.0	28.5	30.5	29.5	28.5
Salinity	-	15.8	17.5	18.5	16.5	18.0	18.5	16.3	16.5	17.2
pH	-	8.19	8.26	8.11	7.90	8.10	8.00	8.13	8.10	8.12
DO	mg/L	5.4	5.3	5.0	5.5	5.3	5.1	5.6	5.4	5.1
BOD	mg/L	1.0	0.7	0.6	1.0	0.8	0.7	0.8	0.7	0.6
COD	mg/L	180	182	160	184	182	182	178	180	180
Oil & Grease	mg/L	5.5	3.0	0.5	5.4	3.1	0.5	4.5	3.0	0.5
SS	mg/L	782	641	834	780	640	835	776	688	795
T-Cr	mg/L	0.011	0.014	0.057	0.019	0.023	0.050	0.009	0.010	0.016
Cu	mg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fe	mg/L	2.24	4.59	60.50	13.30	21.60	51.90	2.50	4.10	8.72
Zn	mg/L	0.1	0.1	0.13	0.1	0.1	0.11	0.1	0.1	0.1
Pb	mg/L	0.01	0.01	0.018	0.01	0.01	0.019	0.01	0.01	0.01
Cd	mg/L	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Hg	mg/L	0.003	0.002	0.006	0.002	0.003	0.005	0.004	0.005	0.005
As	mg/L	0.005	0.008	0.010	0.007	0.005	0.009	0.005	0.008	0.005

² http://www.jodc.go.jp/index_j.html

Parameter	Unit	SP-4			SP-5			Average		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth	M	0.5			0.5			-	-	-
Temperature	°C	29.0	28.5	30.0	30.5	30.5	29.0	30.0	29.3	29.0
Salinity	-	19.6	20.1	20.2	20.8	21.2	21.6	17.8	18.7	19.2
pH	-	8.15	8.00	8.20	8.18	8.15	7.95	8.11	8.12	8.08
DO	mg/L	5.4	5.2	4.9	5.4	4.9	4.6	5.5	5.2	4.9
BOD	mg/L	1.1	0.8	0.7	1.1	0.8	0.8	1.0	0.8	0.7
COD	mg/L	191	193	193	196	197	195	186	187	182
Oil & Grease	mg/L	4.4	3.0	0.5	5.5	3.0	0.5	5.1	3.0	0.5
SS	mg/L	770	752	883	782	761	910	778	696	851
T-Cr	mg/L	0.012	0.015	0.027	0.013	0.017	0.017	0.013	0.016	0.033
Cu	mg/L	0.1	0.1	0.23	0.1	0.1	0.1	0.10	0.10	0.13
Fe	mg/L	5.00	10.20	25.70	5.17	10.60	11.60	5.64	10.22	31.68
Zn	mg/L	0.1	0.1	1.21	0.1	0.1	0.1	0.10	0.10	0.33
Pb	mg/L	0.01	0.01	0.130	0.01	0.01	0.01	0.010	0.010	0.037
Cd	mg/L	0.002	0.002	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Hg	mg/L	0.003	0.004	0.008	0.005	0.003	0.004	0.003	0.003	0.006
As	mg/L	0.019	0.005	0.037	0.014	0.014	0.005	0.010	0.008	0.013

(Source: JICA Study Team)

<Dry season>

The water temperature was in the range of 18.0 - 19.0°C, and temperature differences by water depths were not observed. The salinity was in the range of 34.3 - 37.3 with no big difference between water depths, the same as the water temperature. The salinity in the sea front area of the project site is assumed to be influenced by the Padma River and other rivers. Suspended solids (“SS”) concentration is very high (46 - 329 mg/L) due to the strong effects of river water, especially at the bottom layer. COD is also very high (203 - 235 mg/L), while BOD is not at a high level (0.2 - 0.6 mg/L). Concentration of heavy metals, with the exception of a rather high concentration of Iron (Fe), was not high.

Table 4.2.2.14 (2) Results of sea water quality survey

(Dry season: 29/January/2013)

Parameter	Unit	SP-1			SP-2			SP-3		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth	M	0.5	5.0	9.0	0.5	5.0	9.0	0.5	4.5	8.0
Temperature	°C	19.0	19.0	19.0	18.0	18.0	18.0	18.0	18.0	18.0
Salinity	-	35.3	35.8	35.3	35.2	36.2	35.7	35.0	35.8	34.9
pH	-	8.03	8.01	7.91	7.86	7.91	8.02	8.00	7.82	7.85
DO	mg/L	6.0	5.8	5.4	6.1	5.9	5.4	6.2	6.0	5.8
BOD	mg/L	0.2	0.4	0.6	0.2	0.4	0.5	0.2	0.3	0.5
COD	mg/L	207	209	226	205	211	231	205	208	230
Oil&Grease	mg/L	4.4	3.0	0.5	4.3	3.1	0.5	4.2	3.0	0.5
SS	mg/L	52	73	281	49	84	293	51	81	308

T-Cr	mg/L	0.035	0.050	0.050	0.105	0.061	0.052	0.035	0.048	0.037
Cu	mg/L	0.1	0.11	0.31	0.1	0.58	0.54	0.1	0.30	0.31
Fe	mg/L	4.17	10.8	27.2	25.4	28.6	18.1	18.3	25.8	26.1
Zn	mg/L	0.05	0.10	0.18	0.05	0.16	0.12	0.05	0.11	0.14
Pb	mg/L	0.01	0.01	0.02	0.01	0.03	0.06	0.01	0.02	0.017
Cd	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Hg	mg/L	0.016	0.022	0.018	0.018	0.029	0.014	0.018	0.021	0.009
As	mg/L	0.005	0.005	0.007	0.007	0.010	0.005	0.006	0.005	0.008

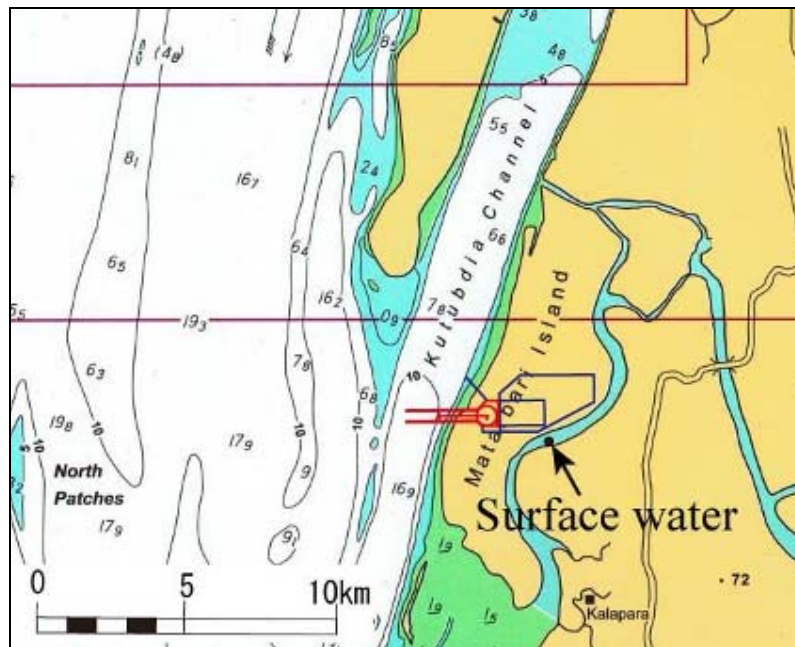
Parameter	Unit	SP-4			SP-5			Average		
		Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth	M	0.5	7.8	14.6	0.5	7.8	14.6	-	-	-
Temperature	°C	18.0	18.0	18.0	18.0	18.0	18.0	18.2	18.2	18.2
Salinity	-	34.4	35.4	34.3	34.4	34.7	34.8	35.3	35.6	35.0
pH	-	7.95	8.02	7.84	7.85	7.86	8.01	7.94	7.92	7.93
DO	mg/L	6.4	6.1	5.8	6.2	6.0	5.7	6.2	6.0	5.6
BOD	mg/L	0.2	0.3	0.5	0.3	0.4	0.6	0.2	0.4	0.5
COD	mg/L	205	211	223	203	212	235	205	210	229
Oil&Grease	mg/L	4.2	3.1	0.5	4.0	3.0	0.5	4.2	3.0	0.5
SS	mg/L	48	79	312	46	81	329	49	80	305
T-Cr	mg/L	0.021	0.027	0.057	0.019	0.039	0.055	0.043	0.045	0.050
Cu	mg/L	0.1	0.17	0.38	0.1	0.28	0.12	0.10	0.29	0.33
Fe	mg/L	3.25	3.88	45.2	2.97	32.1	25.0	10.82	20.24	28.32
Zn	mg/L	0.05	0.08	0.18	0.05	0.21	0.12	0.05	0.13	0.15
Pb	mg/L	0.01	0.01	0.02	0.01	0.018	0.01	0.010	0.018	0.025
Cd	mg/L	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Hg	mg/L	0.008	0.007	0.011	0.005	0.007	0.007	0.013	0.017	0.012
As	mg/L	0.005	0.005	0.012	0.005	0.009	0.007	0.006	0.007	0.008

(Source: JICA Study Team)

b) Surface water

a. Sampling point

The river water quality of the river (Koheli River) near the power plant site was surveyed. The survey was conducted in the rainy season (7 of October 2012) and in the dry season (30 of January 2013) to reflect the seasonal changes of surface water, as is the case for sea water quality.



Sampling Point	Latitude (North)	Longitude (East)
Surface water	21°41'35"	91°53'17"

(Source: JICA Study Team)

Figure 4.2.2.22 Sampling point of the surface water quality survey

b. Results

The results of the surface water quality survey are shown in Table 4.2.2.15. The value of salinity suggests that the surveyed area has brackish water that is under the influence of sea water in the rainy season. SS (only in the rainy season) and COD showed high concentration levels similar to the sea water quality survey results.

Environmental standards for surface water quality are determined by 6 criteria in Bangladesh, and the survey results satisfied even the highest criteria except DO.

Table 4.2.2.15 Results of the surface water quality survey

Parameter	Unit	Results		Standards for Inland Surface Water					
		Rainy season: 7/Oct/2012	Dry season: 30/Jan/2013	A	B	C	D	E	F
Depth	M	0.5	0.5	-	-	-	-	-	-
Temperature	°C	30.6	18.0	-	-	-	-	-	-
Salinity	-	9.8	35.8	-	-	-	-	-	-
pH	-	7.82	8.00	6.5-8.5	6.5-8.6	6.5-8.7	6.5-8.8	6.5-8.9	6.5-8.9
DO	mg/	5.5	5.8	6 or	5 or	6 or	5 or	5 or	5 or

Parameter	Unit	Results		Standards for Inland Surface Water					
		Rainy season: 7/Oct/2012	Dry season: 30/Jan/2013	A	B	C	D	E	F
	L			above	above	above	above	above	above
BOD	mg/ L	0.8	0.4	2 or less	3 or less	3 or less	6 or less	10 or less	10 or less
COD	mg/ L	97	241	-	-	-	-	-	-
Oil&Grease	mg/ L	4.2	-	-	-	-	-	-	-
SS	mg/ L	613	-	-	-	-	-	-	-

Notes: Category of water body is as below.

- A: Potable water source supply after bacteria freeing only
- B: Water used for recreational purposes
- C: Potable water source supply after conventional processing
- D: Water used for pisciculture
- E: Industrial use water including chilling and other processes
- F: Water used for irrigation

(Source: JICA Study Team)

- c) Ground water
 - a. Sampling point

The water quality of well water around the power plant site was surveyed. The river water quality of the rivers near the power plant site was also surveyed. The survey was conducted in the rainy season (7 of October 2012) and in the dry season (30 of January 2013) to reflect the seasonal change of well water quality, as in the case of sea water quality.



Sampling Point	Latitude (North)	Longitude (East)
Ground water	21°42'42"	91°52'50"

(Source: JICA Study Team)

Figure 4.2.2.23 Sampling point of the ground water quality survey

b. Results

The results of the ground water quality survey are shown in Table 4.2.2.16. The results of both the rainy and dry seasons satisfied the drinking water standards of Bangladesh.

Table 4.2.2.16 Results of the ground water quality survey

Parameter	Unit	Results		Standards for Drinking Water
		Rainy season 7/October/2012	Dry season 30/January/2013	
Temperature	°C	29.7	20.1	20 – 30
pH	-	7.48	7.20	6.5 8.5
Chloride	mg/L	167	167	150 – 600
NH ₃	mg/L	0.04	0.04	0.5
Iron (Fe)	mg/L	0.92	0.92	0.3 1.0
Hardne	mg/L	164	164	200 – 500
Arsenic (As)	mg/L	0.01	0.01	0.05
DO	mg/L	3.5	4.7	6.0
BOD	mg/L	0.4	0.2	0.2
COD	mg/L	0	0	4.0
SS	mg/L	0.2	-	10
Coliform	N/100mL	0	-	0
Salinity	-	0.3	0.7	-

(Source: JICA Study Team)

(12) Noise

a) Sampling points

The residential areas within the site and in the north and south of the site were selected as the sampling points for the noise survey, as is in the case of air quality. The survey was conducted in the rainy season (19 and 20 of October 2012) and in the dry season (29 to 30 of January 2013) to reflect the seasonal changes of noise levels.

b) Results

The noise measurement results indicated that the day time noise level was above the environmental standards for residential areas at one sampling point. Matarbari Island is, as cited above, not an industrial area and therefore vehicles used for local transportation were the noise source. These vehicles are not used during the night.

Table 4.2.2.17 Results of the noise measurement survey

(Unit: dBA)

Survey phase	Results			Standards for Noise				
	St.1	St.2	St.3	A	B	C	D	E
Rainy season 19 20/October/2012	57.0	57.3	49.5	Day (6AM-9PM): 45 Night (9PM-6AM): 35	Day: 50 Night: 40	Day: 60 Night: 50	Day: 70 Night: 60	Day: 70 Night: 70
Dry Season 29 30/January/2013	56.0	57.0	45.3					

Notes: Category of areas is as below.

A: Silent zone

B: Residential area

C: Mixed area (mainly residential area, and also simultaneously used for commercial and industrial purposes)

D: Commercial area

E: Industrial area

(Source: JICA Study Team)

Reference: IFC/EHS guidelines

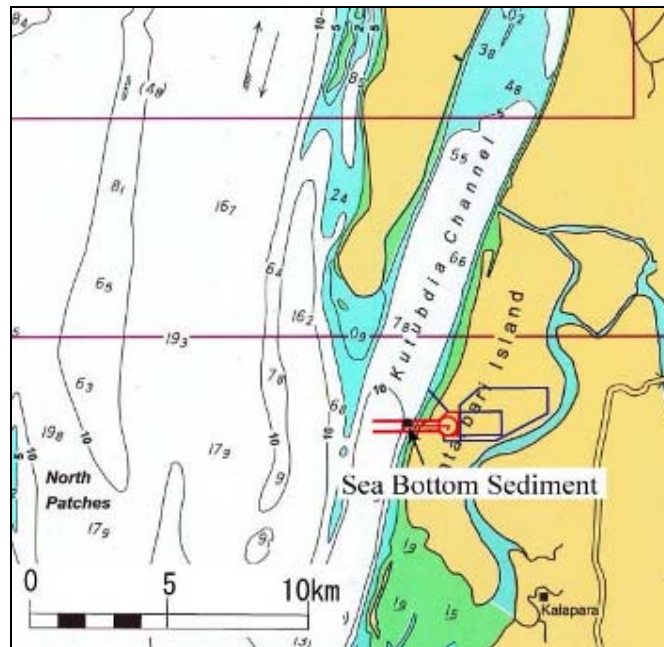
Receptor	Day 07:00-22:00	Night 22:00-07:00
Residential, institutional, educational area	55	45
Industrial, commercial area	70	70

(Source: IFC/EHS General Guidelines, 2007)

(13) Sea bottom sediment (heavy metals)

a) Sampling point

The sampling point for the sea bottom sediment survey was established on the coastal side of SP-1 for the water quality survey, in consideration of sediment contamination resulting from dredging of the canal.



Sampling Point	Latitude (North)	Longitude (East)
Sea bottom sediment	21°41'59.00"	91°51'20.52"

(Source: JICA Study Team)

Figure 4.2.2.24 Sampling point of the sea bottom sediment survey

b) Results

There are no standard values for heavy metals contained in sea bottom sediment in Bangladesh. Globally, ERL (Effects Range-Low) and ERM (Effects Range-Median) are proposed by the NOAA (National Oceanic and Atmospheric Administration, U.S.) as the guidelines to help categorize the range of concentrations of heavy metals and organic chloride compounds in sediment which affect benthic organisms.

In a series of data of ascending levels of contaminants and their toxicity effects, the 10th percentile and the 50th percentile (median) of the effects database were identified for each substance. The 10th percentile values were named the “Effects Range-Low” (ERL), indicative of concentrations below which adverse effects rarely occur. The 50th percentile values were named the “Effects Range-Median” (ERM) values, representative of concentrations above which various effects frequently occur.

The measurement results indicated that ERL was not exceeded in any of the parameters except for mercury (Hg), and even then it did not exceed ERM.

Table 4.2.2.18 Results of the sea bottom sediment survey (Heavy metals)

Parameter	Unit	Results		Guideline of NOAA	
		15/October /2012	28/January /2013	ERL	ERM
Hg	mg/kg	0.142	0.456	0.15	0.71
Cd	mg/kg	0.032	0.05	1.2	9.6
Pb	mg/kg	11.6	3.39	46.7	218
As	mg/kg	4.45	2.91	8.2	70
Cu	mg/kg	23.8	3.75	34	270
Zn	mg/kg	63.7	20.2	410	410
Fe	mg/kg	27,400	11,183	-	-

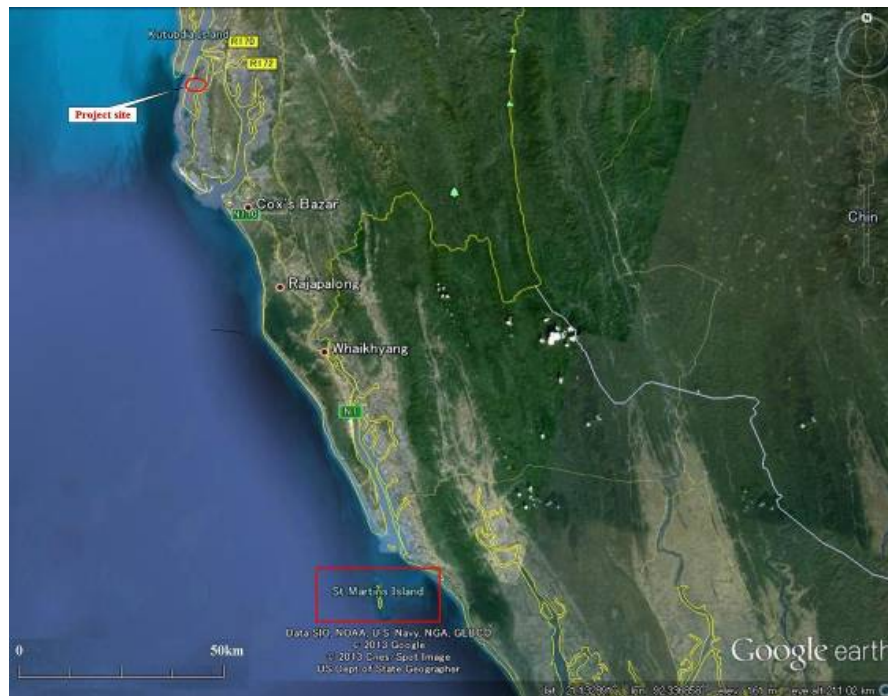
(Source; JICA Study Team)

4.2.3 Natural Biological Resources (including Forests)

(1) Ecologically valuable habitats

a) Coral reef

According to the Chief Scientific Officer of the Bangladesh Fisheries Research Institute in Cox's Bazar, there is no coral reef habitat around the project site, and the closest coral reef to the project site is St. Martins Island located approximately 120km from the project site (Figure 4.2.3.1).



(Source: Google earth)

Figure 4.2.3.1 Project Site and St. Martins Island

b) Seaweed

According to the Chief Scientific Officer of the Bangladesh Fisheries Research Institute in Cox's Bazar, seaweed does not grow around the project site because the transparency of the sea water is low.

c) Mangrove forest

There are no mangrove forests around the proposed port facility site or along the coastline where the outlets for thermal effluents will be constructed. They are only scattered at the riverside of the Kohalia River, which flows between Matarbari and Maheshkhali Islands. There is a mangrove forest, which is large scale and artificially established, at the south side of Matarbari Island and its opposite bank is Maheshkhali Island.

d) Mud flats

The coastline of Matarbari Island is a long sandy beach, and the sea side of the project site, where a port facility and outlets for thermal effluents will be constructed, is also part of the beach. The slope of the sandy beach is steep, and the area of its inter-tidal zone is relatively small.

On the other hand, a sand bar and shallow sea area lie in the estuary of the Kohalia River located south of Matarbari Island due to sedimentation.

(2) Marine organisms

a) Phyto-plankton

a. Sampling points

The phyto-plankton survey was conducted at five sampling points similar to the water quality survey (Figure 4.2.2-23), at three water layers, Surface (0.5m), Middle (1/2 depth), and Bottom (1m up from the bottom), as in the case of the sea water quality survey.

b. Method

Water samples from different depths (pre-selected) were collected by using Nenson bottles and were immediately transferred to 15 commercially available plastic bottles as is the recommended method by Sournia (1978) to obtain an accurate depiction of the quantitative composition of phyto-plankton.

The collected samples were preserved with 3% neutralized formalin. Immediately after collection, the bottles were labeled and transferred to a laboratory for further analysis.

c. Results

<Rainy season>

Fifteen species of phyto-plankton were observed, and Diatom was the largest in number of species (Table 4.2.3.1(1)). *Thalassiothrix* sp. was the species that emerged most frequently, followed by *Biddulphia* sp. The emergence of *Pleurosigma* sp., which is a freshwater species, indicates the strong influence of river water inflow in the sea front area of the power plant site, as described above in the results of the sea water quality survey.

Table 4.2.3.1(1) Results of the phyto-plankton survey

(Rainy season: 6 7/October/2012)

(Unit: cells/L)

Species	SP.1			SP.2			SP.3		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth (m)	0.5	4.5	8.0	0.5	6.5	12.0	0.5	6.5	12.0
CYANOPHYTA									
1 <i>Nostoc</i> sp.	200								
DINOPHYTA									
2 <i>Ceratium</i> sp.		25			100				
HETEROKONTOPHYTA									
3 <i>Diatoma</i> sp.									
4 <i>Skeletonema</i> sp.								50	
5 <i>Coscinodiscus</i> sp.		50	75			50	125		1,400
6 <i>Rhizosolenia</i> sp.				750	1,075			25	600
7 <i>Biddulphia</i> sp.	1,725	300	300	200	950	625	400	625	2,050
8 <i>Ditylum</i> sp.									
9 <i>Thalassiothrix</i> sp.	1,675	1,475	3,000	2,550	6,100	1,875	1,725	1,300	5,650
10 <i>Flagillaria</i> sp.			300	150		350	50		500
11 <i>Thalassionema</i> sp.				300	225				
12 <i>Nitzschia</i> sp.			500	200	125	250		125	500
13 <i>Pleurosigma</i> sp.							50		
HAPTOPHYTA									
14 <i>Coccolith</i> sp.		50					100		
PROCHLOROPHYTA									
15 <i>Tetraedron</i> sp.		25					50		
N. of species	3	6	5	6	6	5	7	5	6
Total	3,600	1,925	4,175	4,150	8,575	3,150	2,500	2,125	10,700

Species	SP.4			SP.5			Average		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth (m)	0.5	8.5	16.0	0.5	6.5	12.0	-	-	-
CYANOPHYTA									
1 <i>Nostoc</i> sp.							40		
DINOPHYTA									
2 <i>Ceratium</i> sp.								25	
HETEROKONTOPHYTA									

Species	SP.4			SP.5			Average		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
3 <i>Diatoma</i> sp.						50			10
4 <i>Skeletonema</i> sp.						100		10	20
5 <i>Coscinodiscus</i> sp.	175	100	250	50	3,200		70	670	355
6 <i>Rhizosolenia</i> sp.	1,800	650	500				510	350	220
7 <i>Biddulphia</i> sp.	1,825	750	2,400	4,175	450	1,900	1,665	615	1,455
8 <i>Ditylum</i> sp.	50						10		
9 <i>Thalassiothrix</i> sp.	1,650	4,200	2,750	4,250	200	1,625	2,370	2,655	2,980
10 <i>Flagillaria</i> sp.	200	200	100	325			145	40	250
11 <i>Thalassionema</i> sp.		200					60	85	
12 <i>Nitzchia</i> sp.		100	475		325	225	40	135	390
13 <i>Pleurosigma</i> sp.	150						40		
HAPTOPHYTA									
14 <i>Coccolith</i> sp.					50		20	20	
PROCHLOROPHYTA									
15 <i>Tetraedron</i> sp.							10	5	
N. of species	7	7	6	4	5	5	12	11	8
Total	5,850	6,200	6,475	8,800	4,225	3,900	4,980	4,610	5,680

(Source: JICA Study Team)

<Dry Season>

Eight species of phyto-plankton were observed, and Diatom was the largest in number of species (Table 4.2.3.1(2)). *Biddulphia* sp. and *Thalassiothrix* sp. were the species that emerged most frequently, followed by *Coscinodiscus* sp. and *Rhizosolenia* sp.

Table 4.2.3.1(2) Results of the phyto-plankton survey

(Dry season: 29/January/2013)

(Unit: cells/L)

Species	SP.1			SP.2			SP.3		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth (m)	0.5	5.0	9.0	0.5	5.0	9.0	0.5	4.5	8.0
CHLOROPHYTA									
1 <i>Cosmarium</i> sp.									
CYANOPHYTA									
2 <i>Nostoc</i> sp.	50								
HETEROKONTOPHYTA									
3 <i>Coscinodiscus</i> sp.	250	150	225	50		100	200	175	225
4 <i>Rhizosolenia</i> sp.	150	650	675		125	150	675	575	475
5 <i>Biddulphia</i> sp.	700	2,725	8,375	775	650	450	6,475	3,875	425
6 <i>Thalassiothrix</i> sp.	1,100	1,575	825	400	950	1,425	1,575	875	1,250
7 <i>Nitzchia</i> sp.		325	350						
8 <i>Surirella</i> sp.							100		
N. of species	5	5	5	3	3	4	5	4	4
Total	2,250	5,425	10,450	1,225	1,725	2,125	9,025	5,500	2,375

Species	SP.4			SP.5			Average		
	Surface	Middle	Bottom	Surface	Middle	Bottom	Surface	Middle	Bottom
Depth (m)	0.5	7.8	14.6	0.5	7.8	14.6	-	-	-
CHLOROPHYTA									
1 <i>Cosmarium</i> sp.						25			5
CYANOPHYTA									
2 <i>Nostoc</i> sp.							10		
HETEROKONTOPHYTA									
3 <i>Coscinodiscus</i> sp.	50	125	225	300	125	150	155	150	165
4 <i>Rhizosolenia</i> sp.	175	75	925	175	75	325	385	320	340
5 <i>Biddulphia</i> sp.	600	1800	2025	1925	700	1350	2,115	2,195	2,260
6 <i>Thalassiothrix</i> sp.	1175	4400	1550	1575	1025	1975	1,160	1,875	1,300
7 <i>Nitzschia</i> sp.								65	70
8 <i>Surirella</i> sp.							20		
N. of species	4	4	5	4	4	4	6	5	6
Total	2,000	6,400	4,725	3,975	1,925	3,825	3,845	4,605	4,140

(Source: JICA Study Team)

b) Zoo-plankton

a. Sampling points

The zoo-plankton survey was conducted at five sampling points similar to the water quality survey (Figure 4.2.2.23), at two water layers, between 5m depth and the Surface (0.5m), and between the Bottom (1m up from the bottom) and 5m depth.

b. Method

Zoo-plankton samples were collected from the subsurface water using a Zooplankton net with mesh size 300µm and metallic circular frame with a 25cm mouth opening. A flow meter (FMC-0.3) was used at the mouth of the net to record the quantity of the water filtered through the net. Precaution was taken for clearing the net and bucket before every sampling to avoid any possible contamination. After collecting the samples, they were put into 200ml plastic jars and preserved with 5% formalin.

c. Results

<Rainy season>

Eleven species of zoo-plankton were observed, and ARTHROPODA was the largest in number of species (Table 4.2.3.2(1)). Copepoda was the species that emerged most frequently, followed by *Sagitta* sp.

Table 4.2.3.2(1) Results of the zoo-plankton survey

(Rainy season: 6 7/October/2012))

(Unit: Individual/m³)

Species	SP.1		SP.2		SP.3	
	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1
COELENTERATA						
1 <i>Pleurobrachia</i> sp.	1		4	2	1	
MOLLUSCA						
2 Bivalve larvae		1			40	
ANNELIDA						
3 <i>Sagitta</i> sp.	57	153	160	282	42	14
ARTHROPODA						
4 Copepoda	120	600	560	520	140	154
5 Caridea	30					
6 <i>Acetes</i> sp.		38				
7 Lucifer	5		12			
8 Shrimp larvae			7	28	2	5
9 Crab Zoa		1	1	5	4	
10 Mysidae						3
VERTEBRATA						
11 Fish larvae			12		3	
N. of species	5	5	7	5	7	4
Total	213	793	756	837	232	176

Species	SP.4		SP.5		Average	
	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1
COELENTERATA						
1 <i>Pleurobrachia</i> sp.	2	2	2	1	2	1
MOLLUSCA						
2 Bivalve larvae					8	
ANNELIDA						
3 <i>Sagitta</i> sp.	27	68	48	96	67	123
ARTHROPODA						
4 Copepoda	320	308	1,060		440	316
5 Caridea					6	
6 <i>Acetes</i> sp.	4	18	17	20	4	15
7 Lucifer	6		6	1	6	
8 Shrimp larvae	3		34		9	7
9 Crab Zoa	1	2	1	326	1	67
10 Mysidae		21		15		8
VERTEBRATA						
11 Fish larvae					3	
N. of species	7	6	7	6	10	7
Total	363	419	1,168	459	546	537

(Source: JICA Study Team)

<Dry season>

Twelve species of zoo-plankton were observed, and ARTHROPODA was the largest in number of species (Table 4.2.3.2(2)). Copepoda was the species that emerged most frequently, followed by *Sagitta* sp.

Table 4.2.3.3.2(2) Results of the zoo-plankton survey
(Dry season: 29/January/2013) (Unit: Individual/m³)

Species		SP.1		SP.2		SP.3	
		0 <- 5	5 <- B+1	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1
MOLLUSCA							
1	Gastropod					1	
2	Sepia Larvae						
ANNELIDA							
3	<i>Sagitta</i> sp.	36	120	124	135	8	85
ARTHROPODA							
4	Copepoda	406	683	1,216	760	934	458
5	<i>Acetes</i> sp.	1		5		17	
6	Daphnia	124	17	44		3	8
7	Lucifer			10	2	11	
8	Shrimp larvae		37	25	32	22	39
9	Lobster larvae						
10	Crab zoea		9	3	3	7	4
VERTEBRATA							
11	<i>Cynoglossus</i> larvae						4
12	Fish larvae		7	2			4
N. of species		4	6	8	5	8	7
Total		567	898	1,429	994	1,003	602

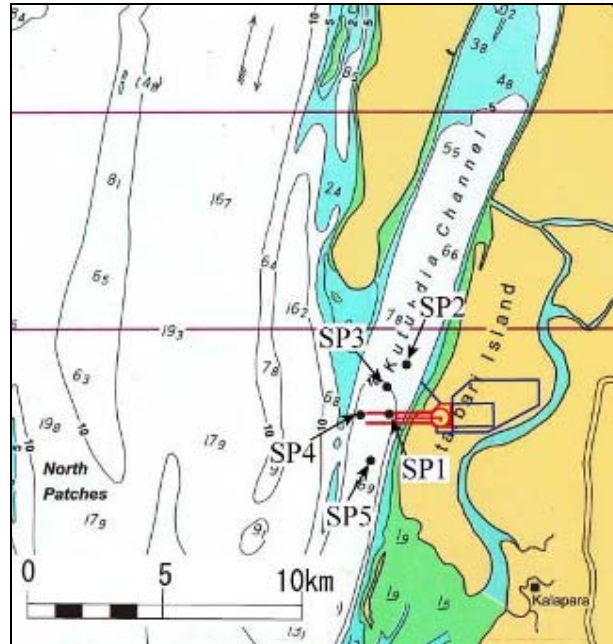
Species		SP.4		SP.5		Average	
		0 <- 5	5 <- B+1	0 <- 5	5 <- B+1	0 <- 5	5 <- B+1
MOLLUSCA							
1	Gastropod						
2	Sepia Larvae	1				0	
ANNELIDA							
3	<i>Sagitta</i> sp.		87	312	210	96	127
ARTHROPODA							
4	Copepoda		927	4,976	248	1,506	615
5	<i>Acetes</i> sp.					5	
6	Daphnia		13	82	28	51	13
7	Lucifer			37	2	12	1
8	Shrimp larvae	6	8	6	10	12	25
9	Lobster larvae	3				1	
10	Crab zoea		6	7	2	3	5
VERTEBRATA							
11	<i>Cynoglossus</i> larvae						1
12	Fish larvae		3	5	2	1	3
N. of species		3	6	7	7	6	6
Total		12	1,058	5,425	507	1,687	812

(Source: JICA Study Team)

c) Benthos (Sea bottom)

a. Sampling points

The macros-benthos survey was conducted at one sampling point similar to the sea bottom sediment survey and at four other sampling points similar to the sea water quality survey (Figure 4.2.3.2).



Sampling Point	Latitude (North)	Longitude (East)
SP-1	21°41'59.00"	91°51'20.52"
SP-2	21°43'00.57"	91°51'32.44"
SP-3	21°42'33.74"	91°51'08.55"
SP-4	21°41'56.99"	91°50'29.11"
SP-5	21°40'56.65"	91°50'43.90"

(Source: JICA Study Team)

Figure 4.2.3.2 Sampling points of macro-benthos on the sea bottom

b. Method

For macro-benthos, samplings were collected at the selected points for bottom sediments. Samples for macro benthos for bottom sediments were collected randomly using a grab sampler of 20cm × 20cm with 10cm depth.

The collected sediments were then placed in plastic buckets and washed through a sieve of mesh size 0.5mm and 0.25 mm to retain all benthic fauna. The fauna from the sieves were preserved in a pre-labeled plastic container containing 5% formaline.

c. Results

<Rainy season>

The population was scarce with only 3 individuals/m² in SP-1, and 16 to 18 individuals/m² in SP-2 to SP-4. On the other hand, 306 individuals/m² of Bivalvia and 30 individuals/m² of Gastropod were observed in SP-5 (Table 4.2.3.3(1)).

Table 4.2.3.3(1) Results of the macro-benthos survey on the sea bottom

(Rainy season: 15/October/2012)

(Unit: Individuals/m²)

Group		SP-1	SP-2	SP-3	SP-4	SP-5	Total
1	Gastropoda		2			30	6
2	Bivalvia	2	5	14	2	306	66
3	Polychaeta		10	2	14		5
4	Crustacea	1		2		2	1
Total		3	17	18	16	338	78

(Source: JICA Study Team)

<Dry season>

A lot of Bivalvia was observed in SP-5 during the rainy season, but was not observed in the dry season (Table 4.2.3.3(2)).

Table 4.2.3.3(2) Results of the macro-benthos survey on the sea bottom

(Dry season: 28/January/2013)

(Unit: Individuals/m²)

Species		SP-1	SP-2	SP-3	SP-4	SP-5	Total
Gastropoda							
1	<i>Macra</i> sp.				2	1	1
Polychete							
2	<i>Duplex</i> sp.	5					1
3	<i>Nematode</i> sp.	1				89	18
4	<i>Lumbrineris</i> sp.		14	22	43		16
Total		6	14	22	45	90	35

(Source: JICA Study Team)

d) Benthos (Mudflat)

a. Sampling point

The sampling of benthos of the intertidal mudflats was conducted at Sonadia Island, in the sea front area of the power plant site and the surrounding sea (Figure 4.2.3.3).



(Source: JICA Study Team)

Figure 4.2.3.3 Sampling point of macro-benthos of the intertidal mudflats

b. Method

For macro-benthos, samplings were carried out at the selected study stations for intertidal mudflats. A permanent plot with an area of 50m × 50m was selected at the two sampling

stations for the collection of macro benthos. During the visit, samples for macro benthos were collected randomly from the permanent plot using a quadrat with an area of 20cm × 20cm with 10cm. For macro benthos of intertidal mudflats, one square meter quadrat was used with 25cm depth. Macro benthos was collected manually from 10cm depth of sediment.

The collected sediments were then placed in plastic buckets and washed through a sieve of mesh size 0.5mm and 0.25 mm to retain all benthic fauna. The fauna from the sieve were preserved in a pre-labeled plastic container containing 5% formaline.

c. Results

<Rainy season>

The bottom sediment of each sampling points was sand and only a small population was observed. Twenty eight individuals per m² were observed in Dhalghata, which is 2/3 of Sonadia, in the sea front area of the power plant site. The dominant species were different in Sonadia and Dhalghata, and no dominant species was observed in Kutubdia (Table 4.2.3.4(1)).

Table 4.2.3.4(1) Results of the macro-benthos survey of the intertidal mudflats

(Rainy season: November/2012)

(Unit: Individuals/m²)

Group	Species	Area		
		Kutubdia	Dhalghata	Sonadia
Nematoda	Nematoda	1		
Gastropoda	<i>Umbonium vestiarium</i>		3	
	<i>Batillaria angulifera</i>	1		
	<i>Batillaria</i> sp.			1
	<i>Cerithidea cingulata</i>	1		23
	<i>Cerithidea quadrata</i>	1		
	<i>Nodilittorina thocchridos</i>			1
	<i>Polinices</i> sp.		1	
	<i>Oliva carneola</i>		1	
	<i>Heliacus areola</i>			1
	<i>Atrina</i> sp.		13	
Bivalve	<i>Macra</i> sp.		2	1
	<i>Barbatia bistrigata</i>	1		
	<i>Anadara antiquate</i>		1	
	<i>Anadara nodifera</i>	1		
	<i>Scapharca pilula</i>	1		
	<i>Anadara scapha</i>		1	
	<i>Atrina vexillum</i>	1		
	<i>Apolymetis edentula</i>	1		
	<i>Apolymetis identula</i>		1	
	<i>Donax carinatus</i>		1	

Group	Species	Area		
		Kutubdia	Dhalghata	Sonadia
	<i>Tellina tenuis</i>		1	
	<i>Sanguinolaria acuminata</i>			1
	<i>Dosivia variegata</i>	1		
	Unidentified			4
Polycheta	<i>Lumbrinereis</i> sp.	1		
	Unidentified		3	10
Number of species		11	11	8
Total		11	28	42

(Source: JICA Study Team)

<Dry season: January/2013>

In the dry season, 115 individuals/m² of Benthos was observed in Dhalghata in the sea front area of the power plant, which was more than the number of individuals observed in Kutubdia and Sonadia. Many kinds of Mollusk species such as Gastropoda and Bivalve were observed in Dhalghata, but only a few or even none of Mollusk was observed in Kutubdia and Sonadia (Table 4.2.3.4 (2)).

Table 4.2.3.4(2) Results of the macro-benthos survey of the intertidal mudflats

(Dry season: January/2013)

(Unit: Individuals/m²)

Group	Species	Area		
		Kutubdia	Dhalghata	Sonadia
Gastropoda	<i>Umbonium vestiarium</i>		16	
	<i>Pythia</i> sp.		2	
	<i>Cerithium</i> sp.		22	
	<i>Thais</i> sp.		1	
	<i>Bullia</i> sp.		6	
	<i>Telescopium</i> sp.		4	
Bivalve	<i>Cerithudea cingulata</i>	9		
	<i>Donax carinatus</i>		23	
	<i>Macra</i> sp.		28	
	<i>Tellina tenuis</i>		10	
	<i>Barbatia bistrigata</i>		2	
	<i>Pholas</i> sp.		1	
Polychaete	<i>Nematode</i> sp.	14		37
Number of species		2	11	1
Total		23	115	37

(Source: JICA Study Team)

<Dry season: March/2013>

During the surveyed period, 452 individuals/m² of Benthos were observed in Sonadia, which was more than the number of individuals observed in Kutubdia and Dhalghata. Species of

Gastropod and Bivalve were observed most often in Dhalgata, on the other hand, species of Polychete was observed at most in Sonadia. Larva of cuttlefish was also observed in Sonadia (Table 4.2.3.4 (3)).

Table 4.2.3.4(3) Results of the macro-benthos survey of the intertidal mudflats

(Dry season: March/2013)

(Unit: Individuals/m²)

Group	Species	Area		
		Kutubdia	Dhalghata	Sonadia
Gastropod	<i>Rhinoclavis</i> sp.		45	
	<i>Batillaria</i> sp.		1	
	<i>Umbonium vestiarium</i>	3	8	
	Unidentified gastropod larvae			2
Bivalve	<i>Dosinia</i> sp.		2	
	<i>Trachycardium</i> sp.	8	1	
	<i>Scapharsa</i> sp.		2	
	<i>Macra</i> sp.	6	1	
	<i>Tellina</i> sp.		15	
	<i>Donax</i> sp.	5	2	
Polychete	<i>Lycasteroneries indica</i>			32
	<i>Nereis</i> sp			66
	<i>Lumbrineris</i> sp.	68		284
	Unidentified species			31
Sipuncula	Unidentified species			62
Arthropoda	<i>Sepia</i> larvae			6
Number of species		5	9	7
Total		90	77	452

(Source: JICA Study Team)

e) Fish and Nekton

a. Sampling points

The fish samples for assessment were collected from set bag nets of the Kutubdia channel, Sonadia Island and Dhalghata Union of Matarbari Island. One sample was collected from a local fish farm (Ghona) of Matarbari Island. A brief introduction of the sampling areas is as below (Figure 4.2.3.4):

Kutubdia Channel: The Kutubdia Channel is situated in the south eastern part of the Bay of Bengal. It lies between 21°45' N to 21°55' N latitude and 91°53' E to 91°55' E longitude. Kutubdia Channel is an important spawning and nursery ground for several species of fin fish and shrimps.

Project site: Matarbari Island is situated in the north western part of Maheshkhali Island. Many parts of this island are at stake because of unplanned shrimp farming and

natural disasters. This island is rich in shrimp farming and solar salt pans. There are also many fish farms (local name: *ghona*) scattered on this island. The island lies between 21°41' N to 21°44' N latitude and 91°46' E to 91°52' E longitude. The survey in front of the project site was conducted at 2 sampling points (Matarbari and Dhalghata).

Sonadia Island: Sonadia Island is an island situated in the northern part of Maheshkhali Island. It lies between 21°23' N to 21°28' N latitude and 91°48' E to 91°52' E longitude. Sonadia Island is a biodiversity hotspot and a proposed area for a future deep sea port of Bangladesh.

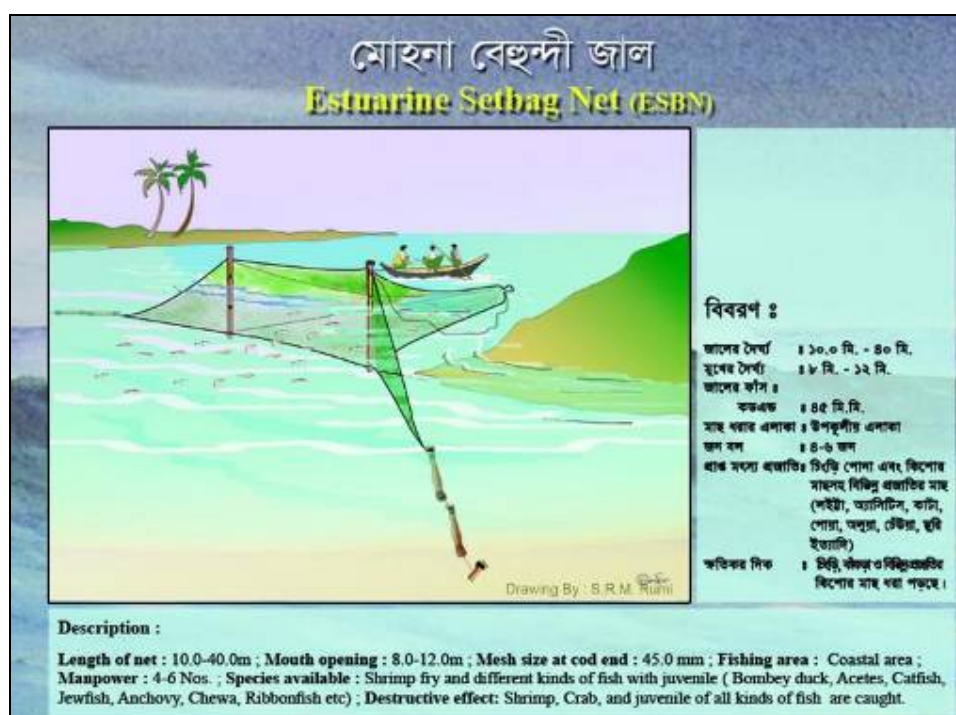


(Source: JICA Study Team)

Figure 4.2.3.4 Sampling points of fish and nekton

b. Method

The sampling gear of fish was an estuarine set bag net, locally known as “Behundi Jal” (Figure 4.2.3.5). The set bag net is a fixed tapering net, resembling a trawl net, set in the tidal stream by attaching it to hold-fasts. It has a rectangular mouth kept open by two vertical bamboo poles. The net is held in a fishing position against the current by linking the extended sides of the net (wing tips) to hold-fasts by means of long bamboo poles and steel wires. The hold-fasts are two wooden stakes embedded some distance apart in the sea bed, so that the net is parallel to the direction of the current. The set bag net catches species of fish which drift with the current or do not swim fast enough to stem the current and maintain a fixed position in relation to the sea bed. At each slack water period, the net comes to the surface (by means of the bamboo poles used for opening of the net, the bamboos serving as sweep lines) when it is emptied; it is then reversed in the opposite direction ready for fishing. The survey was conducted from high tide in one evening up to high tide in the morning of the following day. Set bag nets at every sampling point were set up at depths of 8 to 12 meters.



(Source: http://www.fisheries.gov.bd/album_details/507)

Figure 4.2.3.5 Estuarine set bag net

c. Results

<Rainy season>

For fish and nekton, the highest number of species was observed at the sampling point in Sonadia, which had 22 species, followed by 21 species in Dhalghata and 20 species in Matarbari where the proposed power plant will be located and 14 species in Kutubdia. The only common species observed in all of the 4 sampling points was “*Loligo sp.*” under DECAPODIFORMES.

The dominate species in the 2 sampling points near the power plant site were different from the dominate species in Sonadia and Kutubdia; the dominate species near the power plant site were “*Metapenaeus monoceros*” and “*Exopalaemon styliferus*” under DECAPODA, “*Stolephorus tri*” under Engraulidae, “*Glossogobius giuris*” and “*Odontamblyopus rubicundus*” under Gobiidae and “*Terapon jarbua*” under Terapontidae; whereas, in Sonadia and Kutubdia, “*Squilla sp.*” under STOMATOPODA, “*Acetes sp.*” under DECAPODA, “*Charybdis natator*” under BRACHYURA and “*Harpadon nehereus*” under Synodontidae were the dominate species.

Table 4.2.3.5 (1) Results of the fish and nekton survey

(Rainy season: 16/November/2012)

(Unit: N=Individuals/haul, W=g/haul)

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
DECAPODIFORMES									
1	<i>Sepia sp.</i>	2	24.96			8	99.84		
2	<i>Loligo sp.</i>	5	16.35	2	3.27	65	212.55	1	3.27
STOMATOPODA									
3	<i>Squilla sp.</i>	17	13.09			357	274.89	148	113.96
DECAPODA									
4	<i>Solenocera sp.</i>					68	992.80		
5	<i>Metapenaeus lysianassa</i>			30	42.60	65	95.36	10	14.20
6	<i>Metapenaeus monoceros</i>	61	100.65	68	112.20				
7	<i>Parapenaeopsis sculptilis</i>							98	230.30
8	<i>Acetes sp.</i>					424	42.01	616	141.68
9	<i>Exopalaemon peliferus</i>							61	59.78
10	<i>Exopalaemon styliferus</i>	187	287.98	213	328.02	14	9.55		
BRACHYURA									
11	<i>Matuta planipes</i>					8	3.04		
12	<i>Charybdis natator</i>					166	141.10	14	11.90
13	<i>Scylla sp.</i>			1	14.55				
14	<i>Acanthopotamon martensi</i>	7	28.08	11	55.88				
OSTEICHTHYES									
15	<i>Pisodonophis boro</i>	1	7.97	1	7.97	1	7.97		
16	<i>Harpadon nehereus</i>					785	2,001.75	362	923.10
17	<i>Coilia dussumieri</i>					10	10.21		

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
18	<i>Coilia peliferus</i>							5	17.00
19	<i>Setipinna phasa</i>							1	26.04
20	<i>Stolephorus tri</i>	100	150.00	3	4.50	30	16.62		
21	<i>Liza</i> sp.	4	29.96	7	52.43				
22	<i>Valamugil speigleri</i>	1	10.70	2	21.40				
23	<i>Strongylura strongylura</i>			6	11.52				
24	<i>Ambassis</i> sp.			1	3.98				
25	<i>Boleophthalmus viridis</i>	2	6.26						
26	<i>Eleutheronema tetradactylum</i>	1	7.61						
27	<i>Glossogobius giuris</i>	24	96.48	15	60.30				
28	<i>Lates calcarifer</i>			2	110.06				
29	<i>Lepturacanthus savala</i>					17	242.25	2	28.50
30	<i>Lutjanus johnii</i>	1	0.86	1	0.86	26	22.36		
31	<i>Odontamblyopus rubicundus</i>	14	78.96	1	5.64	2	1.44		
32	<i>Pampus argenteus</i>					1	1.50		
33	<i>Polynemus paradiseus</i>							3	45.42
34	<i>Scatophagus argus</i>			1	23.66				
35	<i>Sillago domina</i>							1	17.69
36	<i>Trypauchen vagina</i>	7	19.32	9	24.84	1	2.70		
37	<i>Pseudapocryptes elongates</i>	1	9.12	2	18.24				
38	<i>Terapon jarbua</i>	35	573.65	11	180.29				
39	<i>Cynoglossus cynoglossus</i>	1	3.32						
40	<i>Cynoglossus lingua</i>					1	1.88		
41	<i>Paraplagusia bilineata</i>	1	8.48			4	54.20		
42	<i>Arius</i> sp.					1	2.70	3	40.72
43	<i>Syngnathoides</i> sp.	4	5.72						
44	<i>Chelonodon patoca</i>					6	13.58		
Total		476	1,479.52	387	1,082.21	2,060	4,250.30	1,325	1,673.56
Number of species		21		20		22		14	

(Source: JICA Study Team)

<Dry season: January/2013>

The highest number of species was observed at the sampling point in Matarbari, which had 29 species, followed by 26 species in Dhalghata, 25 species in Kutubdia, and 17 species in Sonadia. The only common species observed in all of the 4 sampling points was “*Acetes* sp.” under DECAPODA and “*Cynoglossus cynoglossus*” under Cynoglossidae.

The dominate species near the power plant site were “*Metapenaeus monoceros*” under DECAPODA, “*Harpadon nehereus*” under Synodontidae, “*Coilia dussumier*” under Engraulidae, “*Johnius argentatu*” under Sciaenidae, and “*Otolithoides pama*” under Sciaenidae; whereas, in Sonadia and Kutubdia, “*Metapenaeus brevicornis*” and “*Metapenaeus lysianassa*” under DECAPODA were the dominate species.

Table 4.2.3-5 (2) Results of the fish and nekton survey

(Dry season: 17/January/2013)

(Unit: N=Individuals/haul, W=g/haul)

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
DECAPODIFORMES									
1	<i>Sepia</i> sp.	10	152.77	2	7.85			4	61.11
2	<i>Histioteuthis celalaria pacifica</i>					14	30.73		
3	<i>Loligo</i> sp.	3	25.45	17	168.42	2	13.96		
OCTOPODIFORMES									
4	<i>Octopus</i> sp.	3	25.22						
STOMATOPODA									
5	<i>Orantokuilla inornata</i>	6	20.87	112	371.99				
6	<i>Squilla</i> sp.							42	292.22
DECAPODA									
7	<i>Solenocera melantho</i>			61	87.84				
8	<i>Solenocera</i> sp.					10	3.83		
9	<i>Penaeus affinis</i>	2	0.29	11	1.97				
10	<i>Penaeus merguensis</i>	1	11.46						
11	<i>Penaeus semisulcatus</i>			10	13.10				
12	<i>Penulirus</i> sp.							17	3.58
13	<i>Metapenaeus brevicornis</i>					2	0.98	14	56.70
14	<i>Metapenaeus lysianassa</i>					24	8.65	70	72.10
15	<i>Metapenaeus monoceros</i>	103	232.75					51	23.29
16	<i>Metapenaeus tenuipes</i>	11	25.80	12	5.48				
17	<i>Trachypenaeus</i> sp.					43	28.02		
18	<i>Acetes</i> sp.	243	27.86	5,020	379.85	254	19.22	3,720	281.48
19	<i>Panulirus ornatus</i>	1	0.44	3	2.01				
BRACHYURA									
20	<i>Matuta planipes</i>			117	226.55	15	11.15	16	11.89
21	<i>Scylla olivacea</i>			56	10.64			29	5.51
22	<i>Portunus sanguinolentus</i>	28	213.83						
OSTEICHTHYES									
22	<i>Gymnothorax punctatus</i>							1	357.00
23	<i>Congresox talabonoides</i>							1	0.39
24	<i>Muraenesox bagio</i>							1	1.24
25	<i>Thyrsoidea macruna</i>			6	3.01				
26	<i>Harpadon nehereus</i>	7	48.51	71	272.78			9	13.96
27	<i>Pellona dichella</i>	20	107.79						
28	<i>Sardinella fimbriata</i>							6	12.68
29	<i>Sardinella melanura</i>			19	9.69			1	0.49
30	<i>Tenualosa megaloptera</i>			1	1.60	5	11.71		
31	<i>Coilia dussumieri</i>	74	295.65	14	13.55			4	8.78
32	<i>Ilisha filigera</i>					9	15.88		
33	<i>Setipinna taty</i>	2	24.09					1	4.79
34	<i>Tenualosa ilisha</i>							1	3.79
35	<i>Thryssa purava</i>			153	96.90			25	15.83
36	<i>Mugil cephalus</i>	1	1.86						
37	<i>Johnius argentatus</i>	57	65.45	7	9.76			2	1.83
38	<i>Butis butis</i>			2	0.76	2	0.51		
39	<i>Drepane punctata</i>	1	3.85	2	2.35				

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
40	<i>Lates calcarifer</i>			1	2.42	1	1.28		
41	<i>Odontamblyopus rubicundus</i>	1	7.21	13	12.39			5	4.77
42	<i>Apocryptes dantatus</i>			16	32.20				
43	<i>Otolithoides pama</i>	25	58.80	72	44.78				
44	<i>Pampus argenteus</i>	2	11.63			6	26.56	1	2.56
45	<i>Pampus chinensiss</i>			1	0.45				
46	<i>Secutor ruconius</i>	8	16.04	3	4.94	14	23.04		
47	<i>Sillago domina</i>	1	6.00	1	0.39				
48	<i>Lepturacanthus savala</i>			52	576.59	4	13.45	18	60.53
49	<i>Trichiurus haumela</i>	12	91.70						
50	<i>Cynoglossus cynoglossus</i>	11	82.56	22	169.76	2	1.38	5	37.53
51	<i>Torquigener oblongus</i>	7	11.20			2	0.85	1	1.60
Total		640	1,569.08	5,877	2,530.02	409	211.20	4,045	1,335.65
Number of species		26		29		17		25	

(Source: JICA Study Team)

<Dry season: March/2013>

The highest number of species was observed at the sampling point in Matarbari, which had 24 species, followed by 23 species in Dhalghata, 21 species in Sonadia, and 16 species in Kutubdia. The common species observed in all of the 4 sampling points were “Squilla sp.” under STOMATOPODA, “Acetes sp.” under DECAPODA, “Stelopherus tri” under Engraulidae, and ”Lepturacanthus savala” under Trichiuridae.

“Acetes sp.” was the dominate species in all the 4 sampling points. Other than “Acetes sp.”, the dominant species near the power plant site were “Coilia desumeri” under Engraulida and “Harpadon nehereus” under Synodontidae, whereas, in Sonadia, “Squilla sp.” and “Thryssa hamiltoni” under Engraulidae were the dominate species (Table 4.2.3.5(3)).

Table 4.2.3.5 (3) Results of the fish and nekton survey

(Dry season: March/2013)

(Unit: N=Individuals/haul, W=g/haul)

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
DECAPODIFORMES									
1	<i>Sepia</i> sp.	3	9.84	1	67.62				
2	<i>Loligo</i> sp.	2	22.73	2	4.67	11	44.40		
OCTOPODIFORMES									
3	<i>Octopus</i> sp.	2	7.38			1	1.97	1	6.16
STOMATOPODA									
4	<i>Squilla</i> sp.	9	58.67	9	64.83	228	4.70	4	4.65
DECAPODA									
5	<i>Solenocera</i> sp.	2	5.35	14	24.59				
6	<i>Penaeus monodon</i>			9	51.67				
7	<i>Metapenaeus affinis</i>	5	43.31			3	2.29		

Species		Dhalghata		Matarbari		Sonadia		Kutubdia	
		N	W	N	W	N	W	N	W
8	<i>Metapenaeus lysianassa</i>					13	4.98	5	1.17
9	<i>Parapenaeopsis hardwickii</i>			14	24.58			7	28.43
10	<i>Acetes</i> sp.	55	21.49	347	95.08	234	77.41	457	178.53
11	<i>Alpheus</i> sp.	2	0.68	3	2.59			1	3.71
BRACHYURA									
12	<i>Matuta planipes</i>	14	163.41	3	15.00			2	6.99
13	<i>Scylla olivacea</i>					21	22.01	99	18.03
14	<i>Acthopotamon</i> sp.			55	9.00				
OSTEICHTHYES									
15	<i>Gymnothorax punctatus</i>			5	28.07				
16	<i>Lamnostoma orientalis</i>	1	10.79	2	13.63				
17	<i>Coilia desumeri</i>	16	35.83	23	75.34			7	30.57
18	<i>Thryssa hamiltoni</i>					34	61.71		
19	<i>Setipinna phasa</i>			2	16.77				
20	<i>Setipinna taty</i>	1	22.63			2	10.58	1	17.54
21	<i>Stelopherus tri</i>	2	9.94	15	26.90	2	2.59	9	14.78
22	<i>Surdinella gibbosa</i>					12	47.96		
23	<i>Securicola gora</i>					10	12.22		
24	<i>Harpodon neherus</i>	47	79.64	4	15.94			53	22.88
25	<i>Valamugil</i> sp.	1	4.18						
26	<i>Sillago domina</i>	1	3.34	1	4.91				
27	<i>Atropus atropas</i>			3	18.48	8	39.38		
28	<i>Lutjanus johnii</i>					3	2.11		
29	<i>Johnius argentatus</i>	2	3.01					6	18.60
30	<i>Otolithoides pama</i>			30	41.78			68	94.69
31	<i>Drepane punctata</i>							6	1.03
32	<i>Boleophthalmus boddarti</i>					1	1.06		
33	<i>Glossogobius</i> sp.					2	3.17		
34	<i>Odontamblyopus rubicundus</i>	4	6.59						
35	<i>Parapocryptes batoides</i>	6	6.70						
36	<i>Lepturacanthus savala</i>	7	34.54	3	22.30	10	98.38	2	10.43
37	<i>Scambaromor</i> <i>guttatus</i>			1	2.64				
38	<i>Rastrelliger</i> sp.			1	5.10				
39	<i>Cynoglossus cynoglossus</i>	2	11.26			3	17.71		
40	<i>Cynoglossus lingua</i>	3	11.96	1	3.74				
41	<i>Chilondon patoca</i>	1	6.45	2	12.08	7	47.27		
42	Unidentified sp.1					46	45.03		
43	Unidentified sp.2					1	1.34		
Total		188	579.70	550	647.31	652	548.27	728	458.18
N.of species		23		24		21		16	

(Source: JICA Study Team)

(3) Terrestrial wildlife

The aim of the survey is to provide information on fauna and flora for the preparation of the EIA report in connection with the Coal-Fired Thermal Power Plant Construction Project and its transmission (power) line extension areas (PLA). The information should cover the issues of threatened species including critically endangered (CR), endangered (EN), and

vulnerable species (VU) listed in the Red list. Every potential impact on and risk to those species has to be mentioned in the report. If the impacts are seriously negative, and the risks are quite high, appropriate countermeasures should be taken to minimize those impacts and risks.

The survey was conducted twice during different seasons of the rainy season (September to October, 2012) and the dry season (middle of January, 2-13)

a) Location of Power Plant

The power plant site will be located at the middle part of Matarbari Island. The site is a low lying area with facilities of salt cultivation in the winter season and shrimp cultivation in the rainy season. There is the Bay of Bengal on the West of the site, Kohelia River on the East, Dhalghata Union on the South, and Sairiar Dail fishermen village on the North of the site.

b) Location of Survey Points

Four survey points were identified by the JICA Study Team to survey the flora and fauna of the area. The survey points are as follows (Figure 4.2.3.6):

1. Southern part of Kutubdia Island
2. Inside the power plant area
3. Mouth of Matarbari Channel (Kohelia River)
4. Sonadia Island

.



(Source: JICA Study Team)

Figure 4.2.3.6 Map showing the location of the survey points

c) List of Flora and Fauna identified by the survey

A list of flora and fauna identified during the rainy and dry seasons at the 4 survey points is provided in the Annex-2.

d) Results

a. Flora

Humans have impacted much of the land area of the Power Plant site, particularly by shifting shrimp farming and salt pans to the area over several generations. The project area

now has species generally associated with secondary and pioneer communities, secondary scrubs, grasslands, poor vegetation cover, and little cash crop in its fringe areas.

In all, 77 species in the rainy season and 71 species in the dry season were recorded at the power plant site, the majority of which are angiosperms. No threatened species, as designated by IUCN status declaration of 2012, were recorded. Three species (*Calamus guruba* Buch-Ham, *Trihosanthes cordata* Roxb, and *Lepisanthes rubiginosa*) which are considered as threatened species under local status by scientist groups in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

b. Fauna

<Insects>

A total of 23 species of 22 families under 10 orders in the rainy season and 32 species of -27 families under 13 orders in the dry season were recorded in the proposed project area. All of these species have Not Threatened (NO) status as per the IUCN status declaration of 2012.

<Amphibians>

A total of 4 species of 2 families under 1 order in the rainy season and 5 species of 2 families under 1 order in the dry season were recorded in the proposed project area, all of which are Not Threatened (NO) status by IUCN.

<Reptiles>

A total of 13 species of 7 families under 2 orders in the rainy season and 10 species of 5 families under 2 orders in the dry season were recorded in the study area.

Among these reptiles, 1 Turtle species (*Eretmochelys imbricate*) was identified as being designated as Critically Endangered (CR) as per the IUCN Red list category.

Three Turtles species (*Geoclemys hamiltonii*, *Chelonia mydas*, and *Caretta caretta*) were identified as being designated as Endangered (EN) and another Turtle species (*Lepidochelys olivacea*) was identified as being designated as Vulnerable (VU) as per the IUCN Red list category.

Five species (*Calotes versicolor*, *Mabuya mabuya*, *Gekko gekko*, *Panghura tentoria*, and *Naja naja*) which are considered as threatened species under local status by scientist groups

in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

<Birds>

A total of 77 species of birds in the rainy season and ~~103-147~~ species of birds in the dry season were recorded in the proposed project area. Among these birds, 1 species (*Eurynorhynchus pygmeus*, Spoon-billed Sandpiper) was identified as being designated as Critically Endangered (CR) by the IUCN status declaration of 2012. No threatened species, as designated by the IUCN status declaration of 2012, were recorded. Two species (*Arachnothera magna*, *Ketupa zeylonensis*) which are considered as threatened species under local status by scientist groups in Bangladesh were recorded, but these species have wide distributions and are common in the region (Biologist-group's views of Chittagong University).

<Mammals>

A total of 11 species of 8 families under 4 orders in the rainy season and 8 species of 6 families under ~~4-5~~ orders in the dry season were recorded in the proposed project area. All of these species have Not Threatened (NO) status as per the IUCN status declaration of 2012. ~~(The results of the dry season will be added to the Final Report)~~

c. Threatened Species

<Threatened Species listed on the IUCN List>

From the results of the survey on flora and fauna which was carried out during the rainy and dry seasons, a total of 6 species of 1 bird and 5 reptiles were identified as designated threatened species as CR, EN and VU on the IUCN Red List of 2012.

Except for these 6 species of reptiles, there were no other threatened species of flora and fauna observed in both project sites.

Table 4.2.3.6 Threatened species observed in project areas

Taxa	No.	Scientific Name	Season		Conservation Status	Remarks
			Rainy	Dry	IUCN (2012)	
Bird	1	<i>Eurynorhynchus pygmeus</i> (Spoon-billed sandpiper)		O	CR	During the weekly survey in the month of December 7 to March 30, 2013, only 3 days in project site and at most 2 individuals in one day were identified in project site.

Taxa	No.	Scientific Name	Season		Conservation Status	Remarks
			Rainy	Dry	IUCN (2012)	
Reptile	1	<i>Geoclemys hamiltonii</i> (Spotted Pond Turtle)	O		VU	One individual found. It may have strayed into the salt pan as its main habitat is in fresh water ponds, rivers, and marshlands beside salt pans.
	2	<i>Lepidochelys olivacea</i> (Olive Ridley Turtle)	-	O	VU	One strayed individual (<i>Lepidochelys olivacea</i>) found at a salt pan far from the sea coast. All other 3 species were observed at the adjoining sandy coast of the power plant project site. The numbers of these turtles landing at this coast for laying eggs was 15 individuals over 18 days, approximately one turtle landing per night. A more detailed survey to understand these turtles' nesting distributions has been carried out beginning March, 2013. Effective measures to mitigate for these turtles will be confirmed in the Final Report based on the current detailed survey.
	3	<i>Caretta caretta</i> (Logger head turtle)	-	O	EN	
	4	<i>Chelonia mydas</i> (Green turtle)	-	O	EN	
	5	<i>Eretmochelys Imbricate</i> (Hawksbill turtle)	-	O	CR	
Total	5		↖ 1 ↗	↖ 4 ↗		

Notes: CR - Critically Endangered, EN - Endangered, VU - Vulnerable

(Source: JICA Study Team)

Spoon-billed Sandpiper (*Eurynorhynchus pygmeus*)

According to the survey conducted for the month of December 7 till March 30' 2013 it can be confirmed that migration behavior somehow controls the study area to be the wintering ground, that is during winter the Spoon billed Sandpiper come to ashore of the sandy beach of the project front site but it is extremely small compared to nearby coastal offshore, Sonadia Island which is also supported by other's finding in different sites.

During the weekly survey in the month of December 7 to March 30, 2013, only 3 days in project site and 11 days in the southern front of Sonadia were observed flying there respectively, and at most 2 individuals in one day were identified in project site which is about 15% whereas 13 individuals were identified in the southern front of Sonadia in one day (Annex-2).

So, the availability frequency of Spoon billed Sandpiper as a wintering ground to the Matabari Peninsula is comparatively very poor in comparison with that in the nearby offshore island, Sonadia. According to all those previous survey results point out that Matabari Peninsula beach is not main migratory habitat for the migratory bird especially for

Spoon billed Sandpiper in Bangladesh which was also supported by other experts and reports (eminent-ornithology-group's views of Bangladesh) (Annex-2).

Sea Turtle

The survey which aims to grasp the numbers of landing sea turtle for laying eggs at sandy beaches of Matarbari Island and its adjacent beach and one nearby offshore island is to be carried out and following items will be cleared and provided by present survey:

- The numbers of landing sea turtles.
- The name of species of landing sea turtles.
- The nesting behaviors of landing sea turtles.
- The record of hearing results on landing sea turtles from concerned people or authorities
- * The ecological document data on landing sea turtles from scientists

The survey results for 40 days of March 5th to 24 and April 1 to 20' 2013 have been tabulated and Turtles landed confirmed by the survey for the duration aforesaid in the total study area were 34 individuals of 4 species of Olive ridley turtle (*Lepidochelys olivacea*), Loggerhead turtle (*Caretta caretta*), Green turtle (*Chelonia mydas*), and Hawksbill turtle (*Eretmochelys imbricate*).

According to the survey results it be confirmed that tidal behavior somehow controls the spawning of both species that is during neap tide the turtles come to ashore to spawn on to the sandy beach is extremely small compared to spring tide which is also supported by other's finding in different sites.

The landing frequency has been decreasing in almost all sites from March to April. These results agreed with the findings of different papers published in MTN (Marine Turtles Network) by Marine Life Alliance survey for Saint Martin's island and Sonadia Island of the sane coast.

In 2011, a study of 2009-2010, 192 individuals per year was confirmed landing in the Sonadia island. Additionally, landing of 19 individuals was confirmed in one day and night in the same investigation (Islam et al 2011) conducted by the MarineLife Alliance survey. On the other hand, only 34 individuals in 40 days of observation have been confirmed to land in and Matabari Peninsula. The frequency of nesting is very poor in comparison with their nesting frequency in the nearby offshore island, Sonadia (eminent-reptile-group's views of Bangladesh) (Annex-2).

For the sea turtles, available mitigation measures such as controlling levels of lighting, noise and vibrations caused by construction work may be needed as the sandy coast adjacent to the project site appears to be their nesting and egg-laying sites.

Spotted Pond Turtle (*Geoclemys hamiltonii*)

This species was observed at the salt pans in the project site, although it did not appear to use these salt pans for its displacement and access to feeding, breeding and reproduction in view of its ecological features, so that there is no need to take special countermeasures to protect it besides capturing and replacing it into its original environment.

<Threatened Species that may be treated as rare species by Bangladesh scientist groups in the project areas and effective measures to mitigate the impacts on them>

During the site survey on fauna and flora in both project sites of the Power Plant and transmission line, 11 rare species which are not yet listed in the IUCN Red List of 2012 as threatened species, but are being evaluated as threatened species by Bangladesh scientist groups have been recorded.

Table 4.2.3.7 Threatened Species proposed by Bangladesh scientist groups

Taxa	No.	Scientific name	English name
Flora	1	<i>Calamus guruba</i> <i>Buch.-Ham.</i>	Cane
	2	<i>Trichosanthes cordata</i> <i>Roxb.</i>	Snake guard
	3	<i>Lepisanthes</i> <i>rubiginosa</i>	Rusty sapindus
	3		
Reptile	1	<i>Calotes versicolor</i>	Garden lizard
	2	<i>Mabuya mabuya</i>	Skink
	3	<i>Gekko gekko</i>	Tokay Gecko
	4	<i>Pangshura tentoria</i>	Median Roofed Turtle
	5	<i>Naja naja</i>	Bicled Cobra
	5		
Bird	1	<i>Arachnothera magna</i>	Streaked Spiderhunter
	2	<i>Ketupa zeylonensis</i>	Brown Fish Owl
	3	<i>Vanellus duvaucelii</i>	River Lapwing
	3		
Total	11		

(Source: JICA Study Team)

<Other>

According to “Data collection survey on coal power master plan follow-up in the People's Republic of Bangladesh: final report”, there are some endangered species in and around Sonadia Island. Therefore, an investigation of endangered species was conducted.

- Spotted green shanks (*Tringa guttifer*) (EN the IUCN Red List of 2012)

From the results of the survey on birds which was carried out during the rainy and dry seasons in the Power plant site and the Transmission line, none of this species was recorded.

- Great knotd (*Calidris tenuirostris*) (VU the IUCN Red List of 2012)

From the results of the survey on birds which was carried out during the rainy and dry seasons in the Power plant site and the Transmission line, none of this species was recorded.

- Indo-Pacific Finless Porpoised (*Neophocaena phocaenoides*) (VU the IUCN Red List of 2012)

From the results of the survey on dolphin which was carried out during the rainy and dry seasons in the canals, shores and offshore areas of the Power plant site and Sonadia Island, none of this species was recorded.

- Irrawaddy Dolphins (*Orcaella brevirostris*) (VU the IUCN Red List of 2012)

From the results of the survey on dolphins which was carried out during the rainy and dry seasons in the canals, shores and offshore areas of the Power plant site and Sonadia Island, none of this species was recorded.

4.2.4 Socio-Economic Status

(1) Social environment

A household survey targeting over 300 household heads as well as focus group discussions targeting women, children, salt workers and shrimp workers were conducted in December 2012 for comprehensive apprehension of the socio-economic profile of the project affected people. The project site is home to the local residents over generations. The maximum length of time found among them reached 300 years. The household size typically found at the site is 6 people, and over 70% of the interviewed household heads were illiterate or could only write their own names. 35% of the interviewed households received between 10,000 and 20,000 taka, and the average household monthly income was approximately 26,500 taka, 45.5% of the households spent between 10,000 and 20,000 taka per month, and the average household monthly expenditure was approximately 18,000 taka. Based on the incidence of poverty by the cost of basic needs (CBN) method defined by the Bangladesh

Bureau of Statistics, 9% of them were categorized as poor households on income basis, and 13% on expenditure basis.

Most of the land in the power plant site is used for salt cultivation during the dry season (November to April), and shrimp cultivation during the rainy season (May to October). Shrimp laborers often come from Matarbari Island: Saliari Dail, Mogdai Bazar, Sardar Para, Honsho Meage Para, and Nasir Mohammaddhil villages. Salt laborers are mainly collected at the labor market in Santair Bazar, and also come from Natur Bazar, Puran Bazar, Rajghat, Matarbari, Saliari Dail, Mogdai Bazar, Nutur Para, Sardar Para, Honsho Meage Para, Nasir Mohammaddhil, and Uttar Hohoraghora.



(Source: Taken by the JICA Study Team)

Figure 4.2.4.1 Power plant and Port facility site

There are mainly four kinds of people involved in salt and shrimp cultivations: cultivator, laborer, mazi, and businessman. Among the households interviewed at the project site in December 2012, cultivators were comprised of over 30% among them, are the owners of salt field of shrimp field (by owning or leasing the land). They invest money for cultivation. Laborers are those people who sell their labor under the instruction given by the cultivators. They prepare and make the salt bed, for instance. They receive wages from cultivators. Due to the fact that their households have not been financially privileged, they do not have sufficient opportunities for education. Many of them have to drop out of school while they were children even before they completed primary education. They have fewer job opportunities because of their low education and literacy levels. They also shared around 30% in the interview survey. Maziz, comprised of 10 % among the interviewed households, coordinate between cultivators and laborers. They find laborers and allocate them at salt/shrimp fields that belong to the owners or lessees who need laborers. Businessmen, around 10 % as well, are those who are involved in purchasing salt (or shrimp) from the field and local market, and sell them at markets in Chittagong, Dhaka or Narayanganj.

One of the salt factories located within the site has 70 to 80 workers throughout the year, 20 to 30 of whom live together in a terrace house. Laborers come from other districts for shrimp cultivation during the rainy season. All salt taken at the site is sent to Chittagong as there is no salt market in Cox's Bazar.



(Source: Taken by the JICA Study Team)

Figure 4.2.4.2 Power plant and Port facility site (East edge)

Almost all the interviewed households used firewood for cooking, and majority of them used kerosene for lighting. All of them depended on tube wells for water. Local residents used alum (phitkari) for purifying water instead of boiling water. They have to travel to the nearest market to see quack doctors and other sources for medical and health treatment. They often suffer from general fever, respiratory infection (such as cold), diarrhea and stomachache.

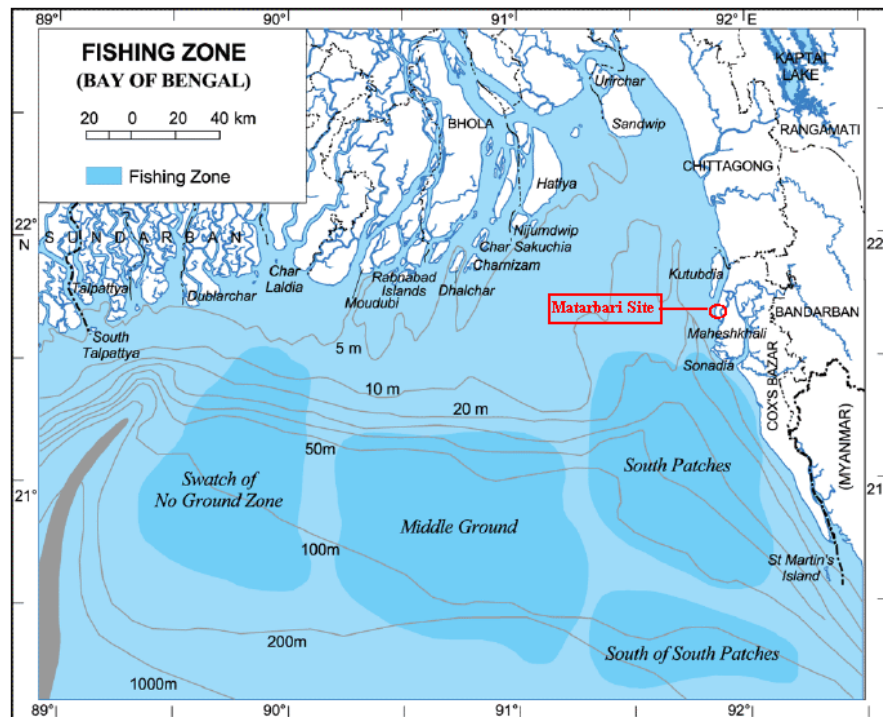
Not many of them collect information from TV or radio as they do not have these items at home. They often listen to radio or watch TV at tea stands or in the local markets for collecting information, apart from which they hear news from neighbors and friends.

The survey details and results are found in the Land Acquisition and Resettlement Action Plan as attached in the Annex-5.

(2) Fishery

Information on fishery was collected and confirmed at Maheshkhali Upazila Office. Fisherman's village in Maheshkhali Upazila is located along the coast line and Kohalia River, and the number of fisherman's households is estimated to be 3000 to 4000. The average annual income by fishing activities is about 10,000 to 15,000 per household. There are four main fishing zones in the Bay of Bengal as described in Figure 4.4.4.3. The nearest fishing zone from the proposed power plant site is South Patches, located at south of

Sonadia Island. Therefore, it can be noted that the sea side of the proposed power plant site is not the main fishing ground.



(Source: http://www.banglapedia.org/httpdocs/HT/B_0361.HTM (accessed August 2012))

Figure 4.2.4.3 Main fishing zone in Bengal Bay

4.2.5 Environmentally Sensitive Areas of Special or Unique Scientific, Socio-economic or Cultural Value

Under the Environmental Conservation Act (ECA), ecologically sensitive and precious areas are designated as ECAs (Ecologically Critical Areas) by Department of Environment in Bangladesh in cases where an ecosystem or biodiversity area is considered to be threatened to reach a critical state. On the other hand, protected areas such as national parks and protected forests are designated by Department of Forest under the Wildlife Order and Forest Act as shown on Table 4.2.5.1.

Table 4.2.5.1 Protected Areas in Bangladesh

Classification		Competent Authority	Governing Law
A	National Parks	Department of Forest	Wildlife (Preservation) Order
B	Wildlife Sanctuaries		
C	Game Reserves		
D	Botanical Gardens, Eco-parks		
E	Reserved Forests, Protected Forests		Forest Act
F	Ecologically Critical Areas	Department of Environment	Environmental Conservation Act

ECAs focus more on the importance and diversity of species and ecosystem and target any ecologically sensitive areas except for the protected areas designated by Department of Forest.

Along with the ECAs declaration, each ECAs has notifications declared by Department of Environment in which specific activities to be restricted in that ECA are specified.

ECAs are actually a new category of Protected Area in Bangladesh and not formally acknowledged in Bangladesh law, in reality all the ECA management enforcement could become ineffective³. According to Department of Environment, enforcement of laws and regulations regarding ECAs are not clearly scheduled at this moment.

The closest ECA to the project site is Sonadia ECA located 15km from the project site (Figure 4.2.5.1). The area of Sonadia ECA is 49.2km². The following is a list of restricted activities specified in the notification of Sonadia ECA⁴:

- Natural forest and tree felling and harvesting
- Wildlife or game killing
- Catching or collecting corals, bivalves, turtles and other wild life
- Destruction or alteration of habitats for flora and fauna
- Any activities that relate to the destruction of the natural characteristics of land and water
- Establishment of industries that might pollute the land, water, air and make sound pollution
- Any activity that might harm fish and other aquatic lives

³ Sonadia Island ECA Conservation Management Plan -DRAFT-, 2006.

⁴ Ibid



(Source: Sonadia Island ECA Conservation Management Plan -DRAFT-, 2006.)

Figure 4.2.5.1 Project Site and Sonadia ECA boundary

Chapter 5

Primary Fuel Sources and Transportation

Chapter 5

Primary Fuel Source and Transportation

Table of Contents

5.1	Amount of Coal Resources	1
5.2	Demand and Supply of Imported Coal	2
5.3	Global Coal Production	4
5.4	Thermal Coal Export Countries	5
5.5	Thermal Coal Import Countries	5
5.6	Possibility of Coal Supply to Matarbari	6
5.7	Coal Supply Plan	14
5.8	Transportation and Loading Port	17

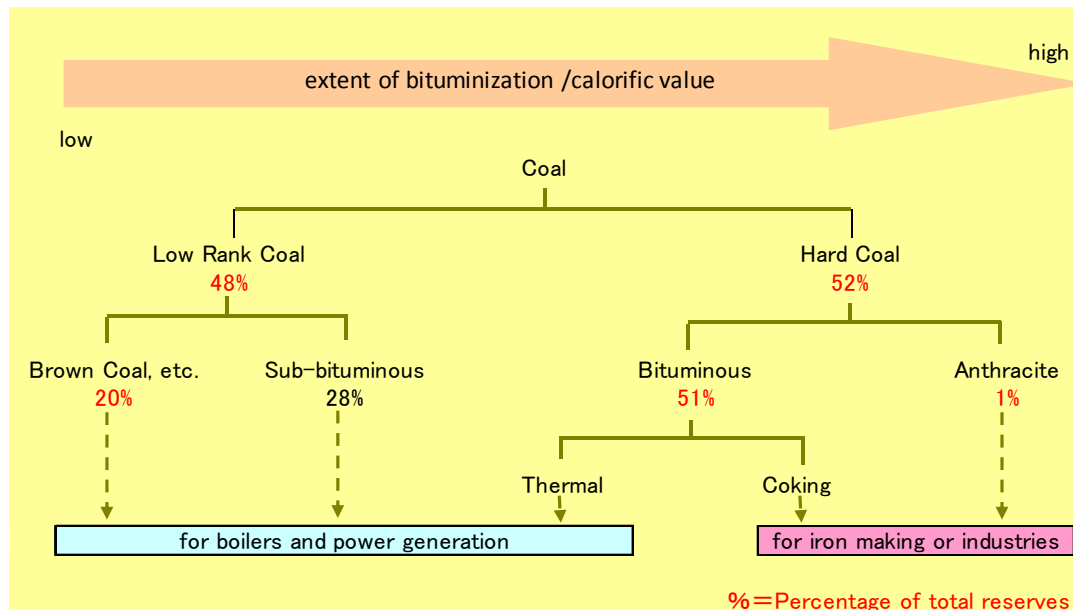
5 Fuel Supply Plan

5.1 Amount of coal resources

5.1.1 Classification of coal

Coal is roughly divided into three types according to the progress of coalification shown in Figure 5.1.1. They are brown coal including peat and lignite, bituminous coal, and anthracite in ascending order according to coalification. Because coalification is the process of the increasing carbon content, the quality of coal rises from brown coal to anthracite. At each intermediate stage in the coalification process, there is matter called peat (the lower grade of lignite), sub-bituminous coal (the lower grade of bituminous) and semi-anthracite etc. Young coal which has high oxygen content requires careful handling due to the likelihood of spontaneous combustion.

In addition, depending on how it is used, coal can be classified as coking coal for iron making and thermal coal for power generation.



Source: The Study Team

Figure 5.1.1 Classification of coal

5.1.2 Proven reserves of coal in the world

According to BP statistics, the world's proven reserves of coal are 861 billion tones as shown in Table 5.1.1. The reserve-production ratio is about 118 years. Coal has the longer R/P ratio than oil or gas, and has a wider global dispersion rate. The United States has the biggest reserves,

Russia the second, and China the third, followed by Australia, India and so on.

Table 5.1.1 Proven reserves of coal in the world

(million tonnes)

	Anthracite/ Bituminous	Sub-bituminous/ Brown Coal	Total
USA	108,501	128,794	237,295
Russia	49,088	107,922	157,010
China	62,200	52,300	114,500
Australia	37,100	39,300	76,400
India	56,100	4,500	60,600
Germany	99	40,600	40,699
Ukraine	15,351	18,522	33,873
Kazakhstan	21,500	12,100	33,600
South Africa	30,100	–	30,100
Columbia	6,366	380	6,746
Canada	3,474	3,108	6,582
Indonesia	1,520	4,009	5,529

Source: BP Statistical Review of World Enrgy 2011

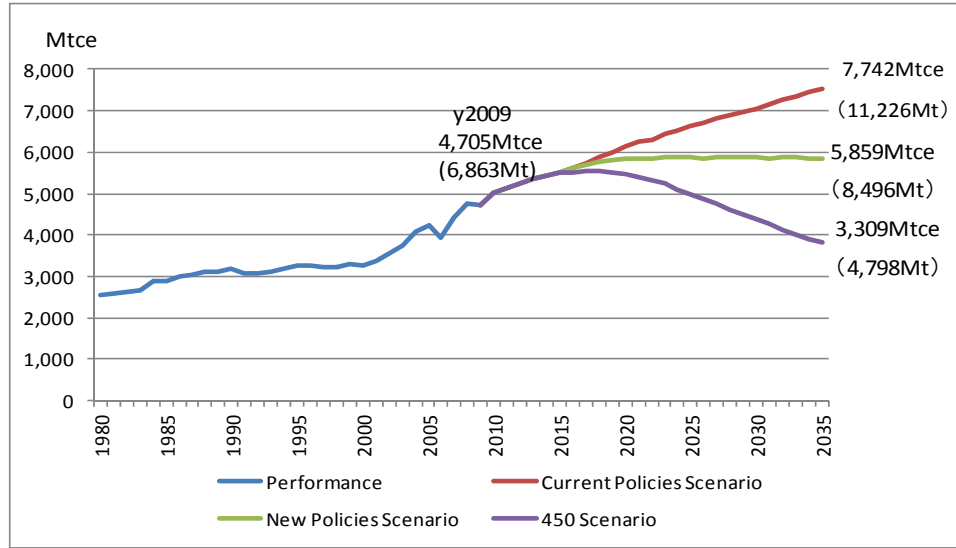
5.2 Demand and supply situation of imported coal in the international market

5.2.1 Global coal demand

Figure 5.2.1 shows the result of world coal demand through 2010 and the IEA's prediction until 2035. The predicted scenario shows three via a national approach towards climate change, which are the Current Policies Scenario, New Polices Scenario and the 450 Scenario¹. World coal production in 2009 was 6.8 billion tons and the demand for coal should continue the current policy remains will reach 11.2 billion tons in 2035. However, it is said that it is possible to reduce the consumption of coal by 8.5 billion tons per the New Polices Scenario and 4.8 billion tons per the 450 Scenario.

Coal demand has been increasing rapidly since 2002 and coal prices have been rising as a result. The period of stable demand applied not only to stable coal prices but also to situations where rapidly increasing coal demand in Non-OECD countries in recent years. The tight supply has caused a coal price increase and uncompetitive coal resources will allow the mining of coal and an increase in coal supply as a result. Therefore, the future price of coal is expected to rise until the balance between supply and demand is stabilized.

¹ 450 scenario is the scenario to hold down CO₂ density to 450ppm



(Sources: IEA World Energy Outlook11)

Figure 5.2.1 World Coal Demand Forecast

About 90 ↓ of the world’s coal consumption is thermal coal, so global coal demand trends can basically be considered to be global thermal coal demand trends.

According to the “World Energy Outlook 2011” by IEA, global coal demand in 2009 was 4.7 billion tons and occupied a 27% share of primary energy demand. From 2000 to 2010, the estimated global coal demand growth was 4.4% per annum, and that figure was far more than the 1.1 ↓ growth in oil demand and 2.7% growth in natural gas demand. As a result, coal contributed to a little less than half the level of primary energy demand growth over the 10- year period. The main use of coal is for power generation. About two-thirds of the demand for coal is for power generation, and 20% is for industrial purposes. During power generation, the proportion of coal is about less than half, so coal can be the main fuel.

In terms of future demand trends, the global coal demand is expected to increase by 1.9% per the annum growth rate from 4.7 billion tones in 2009 to 7.7 billion tones in 2035 under the current policy scenario. Even under the new policy scenario² the demand is expected to remain unchanged from 2020, but reach 5.9 billion tones in 2035.

Concerning regional demand growth, whereas OECD countries are almost flat, non-OECD

² New policy scenario is a scenario which is considered the planning and pledge released by the countries for energy security or no environment problems, and it is not a forecast.

countries especially China and India are expected to experience large demand growth as shown in Table 5.2.1. Under the current policy scenario, the growth in coal demand in China and India is expected to account for three quarters of global coal demand growth by 2035. So the growth of coal imports of both countries is projected to have a major impact on the coal trade.

Table 5.2.1 Coal demand by region and scenario

【Coal demand by region and scenario】

	(Mtce)					
	1980	2009	Current Policies Scenario		New Policies Scenario	
			2020	2035	2020	2035
OECD	1,380	1,476	1,609	1,588	1,494	1,146
<i>United States</i>	<i>537</i>	<i>693</i>	<i>751</i>	<i>773</i>	<i>705</i>	<i>599</i>
<i>Europe</i>	<i>663</i>	<i>415</i>	<i>431</i>	<i>400</i>	<i>383</i>	<i>264</i>
<i>Japan</i>	<i>85</i>	<i>145</i>	<i>165</i>	<i>156</i>	<i>158</i>	<i>115</i>
Non-OECD	1,179	3,229	4,699	6,154	4,339	4,713
<i>China</i>	<i>446</i>	<i>2,179</i>	<i>3,069</i>	<i>3,709</i>	<i>2,863</i>	<i>2,820</i>
<i>India</i>	<i>75</i>	<i>399</i>	<i>699</i>	<i>1,148</i>	<i>619</i>	<i>883</i>
<i>Russia</i>	<i>NA</i>	<i>136</i>	<i>173</i>	<i>203</i>	<i>166</i>	<i>168</i>
World	2,560	4,705	6,308	7,742	5,833	5,859

Source: IEA "World Energy Outlook 2011"

5.3 Global coal production

According to BP statistics, global coal production in 2010 was 7.3 billion tons, an increase of 6.3 percent. Per country, production in China is overwhelming in comparison to other countries and its volume accounts for more than 40% of the total world coal production followed by the United States, India, and Australia as shown in Table 5.3.

Table 5.3 Global coal production

(million tonnes)	
China	3,240
USA	985
India	570
Australia	424
Russia	317
Indonesia	306
South Africa	254
Germany	182
Poland	133
Kazakhstan	111

Source: BP Statistical Review of World Enrgy 2011

5.4 Thermal coal export countries

Countries with a higher export volume of coal are Indonesia, Australia, and then Russia as shown in Table 5.4. In high-volume production countries such as China, the United States and India, coal is essentially devoted to domestic consumption and exports are minimal. China has recently become a net importer.

Table 5.4 Countries with a higher export volume of coal

(million tonnes)	
Indonesia	285
Australia	143
Russia	95
Columbia	68
South Africa	68
Kazakhstan	33
USA	23
China	19

Source: IEA "Coal Information 2011"

5.5 Thermal coal import countries

Top coal importers are mainly East Asian Countries such as Japan, China, Korea, India, and Taiwan as shown in Table 6.2-4. In addition, European countries are also importers. Although China occupies only about 4 % of the imports in domestic coal production, China is already ranks as one of the top importing counties. Given the significant increase in coal demand in India and China in the future, Chinese and Indian influence is expected to increase in the area of seaborne trade of coal.

Table 5.5 Top coal importers

(million tonnes)	
Japan	135
China	129
Korea	91
India	60
Taiwan	58
Germany	38
Russia	23

Source: IEA "Coal Information 2011"

5.6 Possibility of coal supply to the Matarbari CFPP

For coal supply and demand forecasts of countries that can export to Bangladesh, coal production was examined country by country. In order to study the coal supply and demand forecast for 2030, Indonesia, Australia, South Africa and Mozambique will be considered as possible coal-producing countries for the sea transport distances to Bangladesh. Table 5.6 shows freight rate and navigation days in 2012.

Table 5.6 Freight Rate and Navigation Day

Shipping Country! to Chittagong	Loading Port	Freight Rate (US\$/t)	Navigation mile	Navigation Days (port to port, 13 knot/hr)
Indonesia (South Sumatra)	Palembang	\$13	1,842	6
Indonesia (South Kalimantan)	Taboneo	\$14	2,268	8
Indonesia (East Kalimantan)	Bontang	\$15	2,963	9
South Africa	Richards Bay	\$18	4,979	16
Australia (NSW)	Newcastle	\$22	5,767	19
Canada (West coast)	Westshore	\$28	8,584	28
USA (West coast)	Long Beach	\$31	9,190	30
Colombia (Atlantic coast)	Puerto Bolivar	\$33	11,726	38
USA (Gulf)	New Orleans	\$38	13,223	42

In addition, in terms of coal reserves and future production possibilities, the neighboring countries of Bangladesh, Myanmar and Laos are being considered. But stable exports would still take time. Thailand has also been producing coal but it cannot be expected that their coal has a high sulfur content, considering the fact that domestic consumption is limited. And, since China becomes an import coal country, China is out of all those countries.

The coal production situation in Australia, Indonesia, South Africa, and Mozambique are described here.

5.6.1 Australia

According to the “Australian energy projections to 2034–35” released by BREE³ in December, 2011, production of black coal⁴ is expected to increase at an annual rate of 2.8% from 300 million tons (9,004 petajoules) in FY2008/09 to 623 million tons in FY2034/35 (18,676 petajoules) as shown in Table5.6.1 and Figure 5.6.1. Since domestic coal demand is expected to become lower than present levels, the export volume should increase along with the expansion of production. Construction of infrastructure for coal development and coal exports is promoted

³ The Bureau of Resources and Energy Economics, a research body of the commonwealth of Australia,

⁴ Bituminous coal of both steam and coking coal, etc.

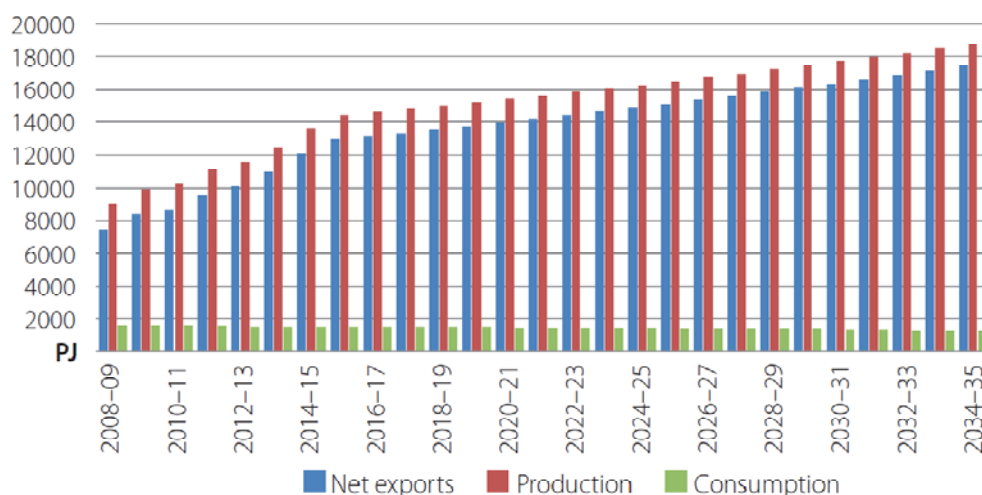
in the State of New South Wales and the State of Queensland, and it is expected that the volume of coal exports will continue to expand at an annual rate of 3.3% towards FY2034/35 from 247 million tons (7,411 petajoules) to 581 million tons (17,415 petajoules) (black coal alone).

Table 5.6.1 Australian Coal Supply and Demand Outlook

		2008/09		2019/20		2034/35	
		(million tons)	(PJ)	(million tons)	(PJ)	(million tons)	(PJ)
Production	Black Coal	300	(9,004)	506	(15,185)	623	(18,676)
	Brown Coal	66	(647)	66	(647)	29	(281)
		366	(9,651)	572	(15,832)	651	(18,957)
Domestic Consumption	Black Coal	53	(1,593)	49	(1,460)	42	(1,260)
	Brown Coal	66	(647)	66	(647)	29	(281)
		119	(2,240)	115	(2,107)	71	(1,541)
Exports	Black Coal	247	(7,411)	458	(13,725)	581	(17,415)
	Brown Coal	0	(0)	0	(0)	0	(0)
		247	(7,411)	458	(13,725)	581	(17,415)

Source: Prepared by JICA study team based on the “Australian energy projections to 2034–35, December 2011” of BERR

In the “BREE’s list of major minerals and energy projects, April 2012” made public by BREE on its own Web site in April, 2012, 46 projects to expand existing coal mines (16 under construction) and 48 new development projects (5 under construction), totaling 94 projects (21 under construction), are listed in Table 6.3-3.



Source: The “Australian energy projections to 2034–35, December 2011” of BERR

Figure 5.6.1 Australian Black Coal Supply and Demand Outlook

If the coal supply capacity that can be added by such coal production increase projects listed

here in and after 2012 is accumulated, Australia can will be able to add a total of 570 million tons of coal supply capacity in 2017, of which steam coal is 400 million tons and 170 million tons is coking coal as shown in Table 5.6.3. BREE says that 348 million tons of coal (coal products minus lignite) was actually produced in 2011 and the simple addition of this value to added coal supply capacity yields 920 million tons as of 2017. BREE expects coal production (coal products minus lignite) in 2019/20 to be 506 million tons and, if the production increase projects shown in the “BREE’s list of major minerals and energy projects, April 2012” are implemented smoothly, it seems that the supply capacity will be sufficient enough to satisfy the expected value even if some of the existing mines are closed due to coal reserve depletion. Since coal production can be expanded as mentioned above, it is assumed to be quite possible to achieve the outlook for 2019/20 coal exports. According to BREE, Australia exported 281 million tons of coal in 2011, of which 133 million tons 47% of this amount was steam coal and 148 million tons or 53% of this amount was coking coal.⁵ This means that, if the above ratio is applied, as shown in Table 5.6.4, the volume of steam coal exports will swell to 241 million tons in 2019/20 and to 305 million tons in 2034/35, while the volume of coking coal exports will increase to 217 million tons in 2019/20 and to 275 million tons in 2034/35.

Table 5.6.2 Number of Australian Coal Projects

	NSW	QLD	West Australia	Total
Expansion	25 (9)	21 (7)	0 (0)	46 (16)
New Project	8 (1)	39 (4)	1 (0)	48 (5)
Total	33 (10)	60 (11)	1 (0)	94 (21)

Source: Prepared by JICA study team based on the “BREE’s list of major minerals and energy projects, April 2012” of BERR

⁵ BREE’s Web site-contained information “Resources and Energy Statistics—December Quarter 2011—Commodity Historical Data Tables”

Table 5.6.3 Australian Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015	2016	2017-
NSW		12.0	33.3	23.6	15.5	14.0	44.4
	Steam Coal	9.0	20.7	16.1	15.5	3.5	41.7
	Coking Coal	3.0	12.7	7.5	0.0	10.5	2.8
QLD		13.2	54.3	146.6	72.6	18.0	120.9
	Steam Coal	3.2	19.2	101.9	70.6	5.0	92.5
	Coking Coal	10.0	35.1	44.7	2.0	13.0	28.5
West Australia		0.0	0.0	2.5	0.0	0.0	0.0
	Steam Coal	0.0	0.0	2.5	0.0	0.0	0.0
	Coking Coal	-	-	-	-	-	-
Total		25.2	87.6	172.7	88.1	32.0	165.3
	Steam Coal	12.2	39.9	120.5	86.1	8.5	134.1
	Coking Coal	13.0	47.8	52.2	2.0	23.5	31.2
Cumulative Total		25.2	112.8	285.5	373.6	405.6	570.9
	Steam Coal	12.2	52.1	172.6	258.7	267.2	401.3
	Coking Coal	13.0	60.8	113.0	115.0	138.5	169.7

(Source: Prepared by JICA study team based on the “BREE’s list of major minerals and energy projects, April 2012” of BERR)

Table 5.6.4 Australia’s By-Coal Type Coal Exports Outlook

(million tons)

		2011 Actual	2019/20	2034/35
Exports	Steam Coal	148	241	305
	Coking Coal	133	217	275
		281	458	581

Note: Actual values are based on BERR statistics.

(Source: Prepared by JICA study team)

5.6.2 Indonesia

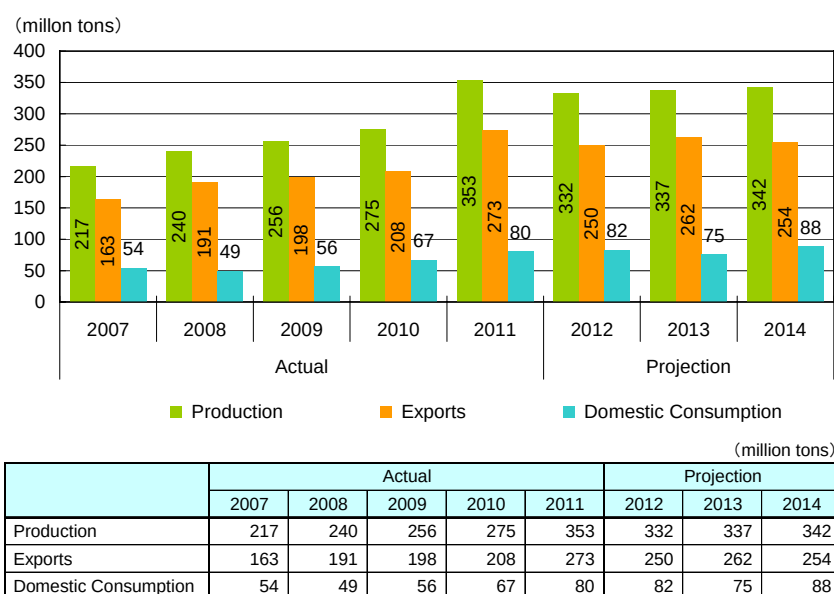
According to the presentation⁶ made by Mr. Wibowo, Directorate General of Mineral and Coal, the Ministry of Energy and Mineral Resources as shown in Figure 5.6.2.1, in the medium runs both production volume and export volume of coal fail to maintain such expansion as was achieved before and hit their ceilings. Furthermore, according to the presentation⁷ made by Mr. Kamandanu from the Indonesian Coal Mining Association as shown in Figure. 5.6.2.2, it is expected that, in the long term, coal production will continue to expand. It is, however, assumed that since domestic coal demand is expected to increase, exports will remain in the range from

⁶ The “Coal Policy and The New Mining Law No. 4/2009 in Indonesia” at the “Clean Coal Day in Japan 2012 International Symposium” held on September 4 and 5, 2012,

⁷ The “Indonesian Coal Mining Outlook” at the IEA workshop “Coal Market’s Outlook” held in China on April 14, 2011,

240 million tons to 260 million tons and fail to maintain such expansion as was achieved before.

Table 5.6.2.1 shows a compilation⁸ of projects for the production increase at existing coal mines and new coal mine development cited in an information magazine⁹ between last year and this year, indicating that the supply capacity that can be added between 2012 and 2014 reaches 121 million tons (107 million tons of steam coal and 14 million tons of coking coal). As shown in Figure. 5.6.2.1, in the medium run, since no increase in coal production is expected between 2011 and 2014, 121 million tons of supply capacity to be added becomes the reserve supply capacity as is. In other words, Indonesia ends up having some 100 million tons-worth reserve coal export capacity.



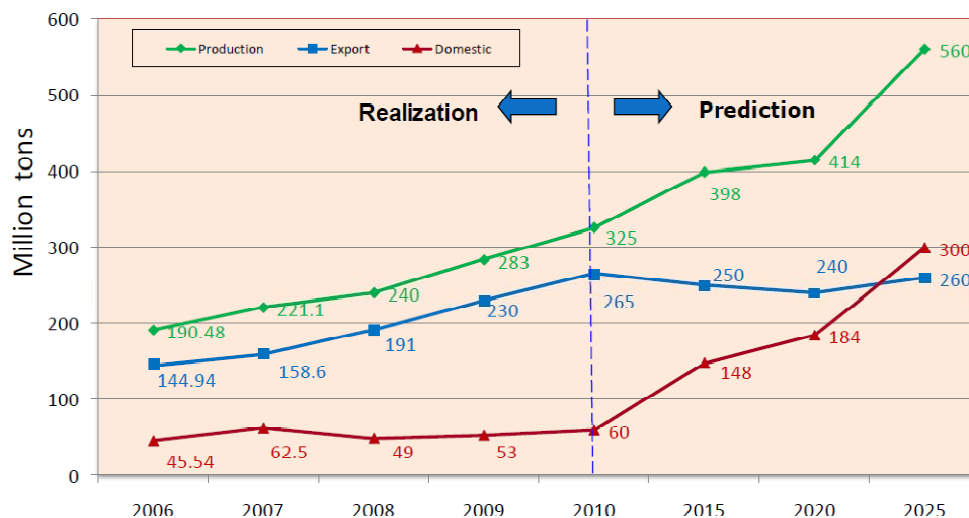
(Source: Prepared by JICA study team based on lecture materials of the “Clean Coal Day in Japan 2012 International Symposium” held on September 4, 2012)

Figure 5.6.2.1 Indonesian Medium-Term Coal Supply and Demand Outlook

⁸ Does not cover all of Indonesia’s projects for production increase and new development.

⁹ TEX Report (released by The TEX Report Ltd., <http://www.texreport.co.jp/xenglish/index.html>)

**THE DEVELOPMENT OF COAL PRODUCTION, EXPORT AND DOMESTIC
SALES, AND ESTIMATION UP TO 2025**
(based on the existing infrastructure capability)



Note:

*Calculated based on Government target on Primary Energy Mix (Pres. Decree No.5/2006)

10

(Source: Lecture materials of IEA workshop “Coal Market’s Outlook” held on April 14, 2011)

Figure 5.6.2.2 Indonesian Long-Term Coal Supply and Demand Outlook

Table 5.6.2.1 Indonesia’s Coal Production Increase Plan

		(million tons)					
		2012	2013	2014	2015	2016	2017-
Total		33.8	45.0	42.0	13.5	3.0	6.0
	Steam Coal	29.3	35.5	42.0	0.0	0.0	6.0
	Coking Coal	4.5	9.5	0.0	13.5	3.0	0.0
Cumulative Total		33.8	78.8	120.8	134.3	137.3	143.3
	Steam Coal	29.3	64.8	106.8	106.8	106.8	112.8
	Coking Coal	4.5	14.0	14.0	27.5	30.5	30.5

Note: Does not cover all of Indonesia’s projects for production increase at existing coal mines and new coal mine development.

(Source: Prepared by JICA study team)

With regards to the outlook breakdown for coal exports, in Indonesia, the coking coal demand for domestic usage is scarce and it is assumed that the coking coal supply capacity to be added will be all applied to exports. Therefore, although Indonesia exported about 1 to 2 million tons of coking coal in the 2000s¹⁰, it becomes possible to expand this to around 20 million tons in 2015. Assuming that the coking coal supply capacity to be added is entirely applied to exports,

¹⁰ The “Coal Information 2012” of IEA

the by-coal type outlook for coal exports prepared in line with long-term coal supply and demand outlook (Figure. 5.6.2.2) will be as shown in Table 6.3-7.

Table 5.6.2.2 Indonesia's By-Coal Type Coal Exports Outlook

		(million tons)			
		2011 Actual	2015	2020	2025
Exports	Steam Coal	272	230	220	240
	Coking Coal	1	20	20	20
		273	250	240	260

(Source: Prepared by JICA study team)

5.6.3 South Africa

Regarding South Africa and Mozambique describing later, nothing like the above-given coal supply-demand outlook released such as by a government agency is available but the coal supply capacity that can be added is identified from the projects for production increase at existing coal mines and the new coal mine development contained in an information magazine to infer the volume of coal that can be exported.

First, with regards to South Africa, a compilation¹¹ of 6 new coal mine development projects placed in an information magazine¹² between last year and this year is shown in Table 5.6.3.1. During and after 2012, the supply capacity that can be added by 2015 is 36 million tons (18 million tons of steam coal and 18 million tons of coking coal). Since the coal production in 2011 is 253 million tons¹³, the supply capacity expands to as much as about 290 million tons in 2015, assuming that the production will not drop due to coal mine closure etc. As for the added coal supply capacity, it is assumed that the coking coal will be entirely applied to exports and, 80% of the steam coal will be applied to the exports. However, the steam coal supply capacity of 10 million tons to be added in 2014 is excluded because it is for domestic use. Table 5.6.3.2 shows the coal export volume outlook based on this assumption.

Table 5.6.3.1 South Africa's Coal Production Increase Plan

		(million tons)			
		2012	2013	2014	2015
Total		0.8	6.2	12.1	0.0
	Steam Coal	0.8	5.2	12.1	0.0
	Coking Coal	0.0	1.0	0.0	0.0
Cumulative Total		0.8	6.9	19.0	19.0
	Steam Coal	0.8	5.9	18.0	18.0
	Coking Coal	0.0	1.0	1.0	1.0

¹¹ Does not cover all of South Africa's projects for production increase and new development.

¹² TEX Report (released by The TEX Report Ltd.)

¹³ The "Coal Information 2012" of IEA

Note: Does not cover all of South Africa's projects for production increase at existing coal mines and new coal mine development.

(Source: Prepared by JICA study team)

Table 5.6.3.2 South Africa's By-Coal Type Coal Exports Outlook

(million tons)

		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	66.1	56.6	51.4	65.6	71.6	72.2	76.3	78.0	78.0
	Coking Coal	0.9	1.3	0.6	0.8	0.2	0.2	1.2	1.2	1.2
		67.0	57.9	52.0	66.4	71.7	72.3	77.4	79.1	79.1

Note: Actual values are based on "Coal Information 2012" of IEA and 2011 values are prospective.

(Source: Prepared by JICA study team)

5.6.4 Mozambique

As for Mozambique, a compilation¹⁴ of 5 new coal mine development projects placed in an information magazine¹⁵ between last year and this year is shown in Table 5.6.4.1. The supply capacity that can be added between 2012 and 2015 is 44 million tons (14 million tons of steam coal and 30 million tons of coking coal). Since, according to the "Coal Information 2012" released by IEA, the coal production in 2011 is below 0.1 million tons, the supply capacity of 44 million tons that can be added by 2015 remains as is the amount that can be produced. Assuming that the added coal supply capacity will be entirely applied to coking coal and 70% of steam coal will be applied to exports, the coal exports outlook will be as shown in Table 5.6.4.2.

Table 5.6.4.1 Mozambique's Coal Production Increase Plan

(million tons)

		2012	2013	2014	2015
Total		6.3	10.5	17.4	9.6
	Steam Coal	1.9	3.1	3.4	5.2
	Coking Coal	4.3	7.5	13.9	4.4
Cumulative Total		6.3	16.8	34.1	43.7
	Steam Coal	1.9	5.0	8.4	13.6
	Coking Coal	4.3	11.8	25.7	30.1

Note: Does not cover all of Mozambique's projects for production increase at existing coal mines and new coal mine development.

(Source: Prepared by JICA study team)

Table 5.6.4.2 Mozambique's By-Coal Type Coal Exports Outlook

(million tons)

		Actual					Projection			
		2007	2008	2009	2010	2011*	2012	2013	2014	2015
Exports	Steam Coal	0.02	0.03	0.03	0.03	0.01	1.3	3.5	5.9	9.5
	Coking Coal	0.00	0.00	0.00	0.00	0.00	4.3	11.8	25.7	30.1
		0.02	0.03	0.03	0.03	0.01	5.7	15.3	31.6	39.7

¹⁴ Does not cover all of Mozambique's projects for production increase and new development.

¹⁵ TEX Report (released by The TEX Report Ltd.)

Note: Actual values are based on the “Coal Information 2012” of IEA and 2011 values are prospective.
(Source: Prepared by JICA study team)

5.7 Coal Supply Plan to Matarbari CFPP

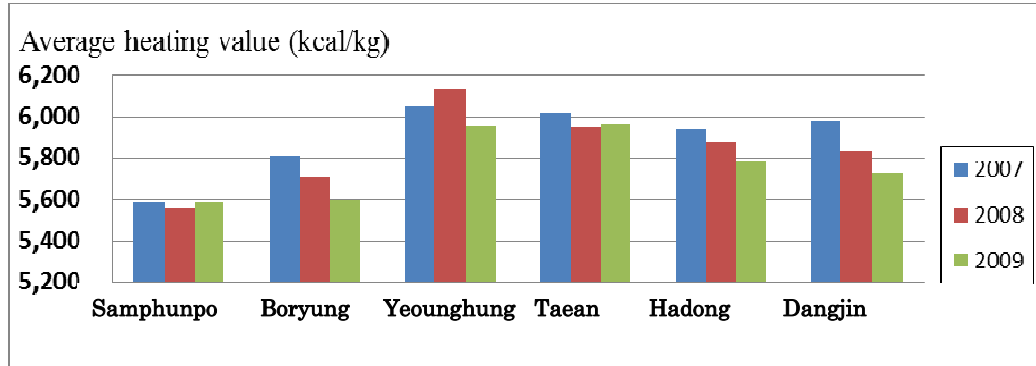
5.7.1 The calorific value of import coal and summary of imported coal

(1) Determination of the calorific value

When the calorific value of coal imported by Bangladesh is considered from the viewpoint of the importation of coal available in terms of future stability, the circumstances described below are examined.

- An extra 6,000 kcal/kg for the average demand has already been decided in developed countries and it is difficult to import this high calorie coal to the new market of Bangladesh.
- In terms of the boiler design, to use the higher calorific value becomes a smaller investment amount and better efficient combustion but when calorific value is below the design specifications of the imported coal from the supply problems in the future, it will cause significant operational problems. It is often seen in cases of new power plants in developing countries. Conversely, if the calorific value is greater than the design specifications, it is a minor problem.
- As an example of the current power plant in Korea in Figure. 6.4-1, the existing power station also tends to degrade the calorific value of coal in terms of securing a stable supply of coal.

From the above situation, the information of Japanese trading companies and the site investigations conducted in Indonesia and Australia, the range and amount of heat from 4,200 kcal/kg to 5,200 kcal/kg and the average calorific value of 4,700 kcal/kg of imported coal is reasonable and determined. It has been confirmed that the quantity of coal in this calorific value necessary for 600Mw x two units is sufficient for long-term stable supply through an investigation as from 3.5 to 4 million tons. In addition, more information about the details of the design coal is described later.



(Source: JICA study team)

Figure 5.7.1 Actual Use of Low-grade Coal at Coal-fired Power Stations in South Korea

(2) Summary of import coal

As a result of this study, Indonesia will be main country of import coal for Matarbari CFPP and 70% of the entire amount of import coal will be from Indonesia. And the rest will be imported from Australia. South Africa and Mozambique will be in addition to Australia in the future. The summary of these coals is as followings.

1) Indonesian coal

- Ⓔ Though Indonesian coal has normally low ash content at around 2% -15%, the range of the total moisture is wide at around 11% - 40%.
- Ⓔ There is much coal with a sulfur content of less than 1%, but, sometimes, there may be much available coal of high calorific value with high sulfur levels.
- Ⓔ In general, the high moisture coal can easily self-ignite. The examination of spontaneous combustion and the adjustment of the coal reserve period in the coal stock pile are necessary.
- Ⓔ Due to insufficient quality controls at some coal mines, special attention is particularly necessary for the coal from coal mines of small and medium size scale.

2) Australian coal

- Ⓔ! Generally, Australian coal has a stable coal quality, and their coal quality control management is thorough.
- Ⓔ! Australian coal is available for blend use with Indonesian low grade coal, when high quality coal of Australian coal appears in spot market.

3) South African and Mozambican coal

- Ⓔ! South African coal is high-grade coal and can be used for blends like Australian coal.
- Ⓔ! The Mozambican coal will be expected in the near future, too, but the economic

infrastructure situation involving such factors as the port facilities and transportation becomes a problem.

5.7.2 Coal quality of design coal

(1) Candidate for design coal

Based on a determination of the calorific value of imported coal in 6.4.1, the main factor of coal quality of the candidate for design coal that can be supplied stably for the long term in Matarbari CFPP is shown in Table 6.4-1. The coal data painted in blue shows for single brand and coal data painted in yellow shows for blending use in the table.

Table 5.7.2.1 Candidate for design coal

No	Country	Sample No.	total moisture (AR)	Inherent moisture (AD)	Ash (AD)	Sulfur (AD)	GAR (Kcal/kg)
1	South Africa	18	9.0	4.1	15.6	0.82	6,010
2	Indonesia	9	19.0	11.5	8.0	1.00	5,860
3	Australia	13	12.5	7.0	11.5	0.40	5,830
4	Australia	16	17.0	8.0	9.5	0.60	5,800
5	Australia	15	10.5	3.5	21.0	1.00	5,750
6	Indonesia	8	19.0	14.0	5.2	1.60	5,630
7	Australia	14	10.0	2.5	22.0	0.60	5,630
8	South Africa	19	8.0	3.5	23.1	0.74	5,400
9	Indonesia	10	26.0	15.5	7.0	1.00	5,200
10	Indonesia	1	26.0	12.0	6.0	0.60	5,100
11	Indonesia	6	26.0	18.0	4.5	0.99	4,960
12	Indonesia	4	31.0	16.0	6.0	1.00	4,600
13	Indonesia	11	35.0	15.0	6.0	0.80	4,440
14	Indonesia	2	38.0	25.0	7.0	0.60	4,200
15	Indonesia	5	35.0	22.0	4.5	0.10	4,200
16	Indonesia	25	35.0	22.0	3.5	0.10	4,200
17	Indonesia	26	35.0	21.0	4.0	0.15	4,200
18	Indonesia	28	34.0	18.4	7.0	0.60	4,140
19	Indonesia	24	38.0	25.0	3.0	0.15	4,100
20	Indonesia	3	40.0	27.0	2.0	0.15	4,000
21	Indonesia	12	39.0	14.1	4.9	0.13	3,800

(Source: JICA study team)

(2) Summary of single brand

The summary of single brand that is used as only one brand of coal for Matarbari CFPP is shown in table 6.4-2.

Table 5.7.2.2 Summary of single brand

Country	Total moisture (Ar.%)	Inherent moisture (Ad.%)	Ash (Ad.%)	Sulfur (Ad.%)	GAR (Ar.%)
Indonesia	26.0 - 38	12 - 25	3.5 – 7.0	0.1 – 1.0	4,200-5,200

(Source: JICA study team)

(2) Summary of blending coal

When securing of coal of single brand is difficult, use of blending coal is necessary for stabilization of the fueling, the efficiency driving of the boiler, reduction of the fuel cost. In the blend coal, a combination of Australian and South African high calorific coal and Indonesian low calorific coal is examined. They show the coal painted by yellow color in Table 5.7.2.1. In this case, the calorific value after the blend aims 4,900kcal/kg from 4,500kcal/kg in consideration of fluctuation of the coal quality and Table 5.7.2.3 shows coal quality of blending coal.

Table 5.7.2.3 Summary of blending coal

Country	Total moisture (Ar.%)	Inherent moisture (Ad.%)	Ash (Ad.%)	Sulfur (Ad.%)	GAR (Ar.%)
Indonesia Australia South Africa	18.3 – 33.7	10.2 – 23.1	3.0 – 15.1	0.23 – 1.0	4,500-4,900

(Source: JICA study team)

5.8 Transportation and Loading Port for the Coal

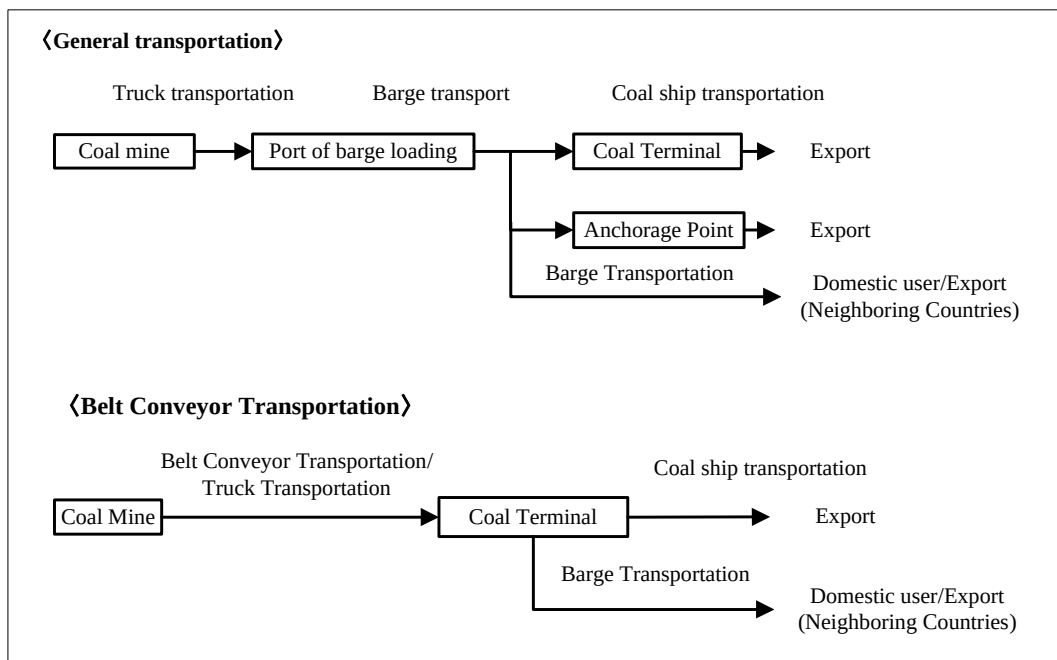
This Study shows that from the perspective of transportation and production prospects, Indonesia, Australia, South Africa and Mozambique have the potential to export coal to Bangladesh. Among the countries, Indonesia and Australia have the most potential.

(2) Indonesia: Kalimantan Island

Regarding the amount of coal mines in Indonesia in 2010, accessible coal reserves are 104,900 million tons and the estimated amount of coal reserves are 19,000 million tons. The specifications of the Indonesian coal are that most of the coal is thermal coal, not coking coal. The ash content and sulfur content of the Indonesian coal is low so that the calorific value of most of the coal in Indonesia is comparatively low. In Indonesia, there is abundant coal in Sumatra Island and Kalimantan Island, and a small amount of coal in the Java Island, Sulawesi Island, Maluku Islands and the Papua area. Coal production in Indonesia was 376 million tons in 2011 (IEA Coal information 2012). Of particular mention is that the proven reserves of coal in Kalimantan Island are approximately 460 million tons. Currently, coal production is conducted primarily in Kalimantan Island.

1) Coal Transportation

In Indonesia, coal production is implemented mainly in Sumatra Island and Kalimantan Island. Given that there are no train facilities in Sumatra Island and Kalimantan Island and a large river runs nearby the coal mine, two measures for coal transportation are used; one is the truck delivery from the coal mine to the ship, the other is a river barge.

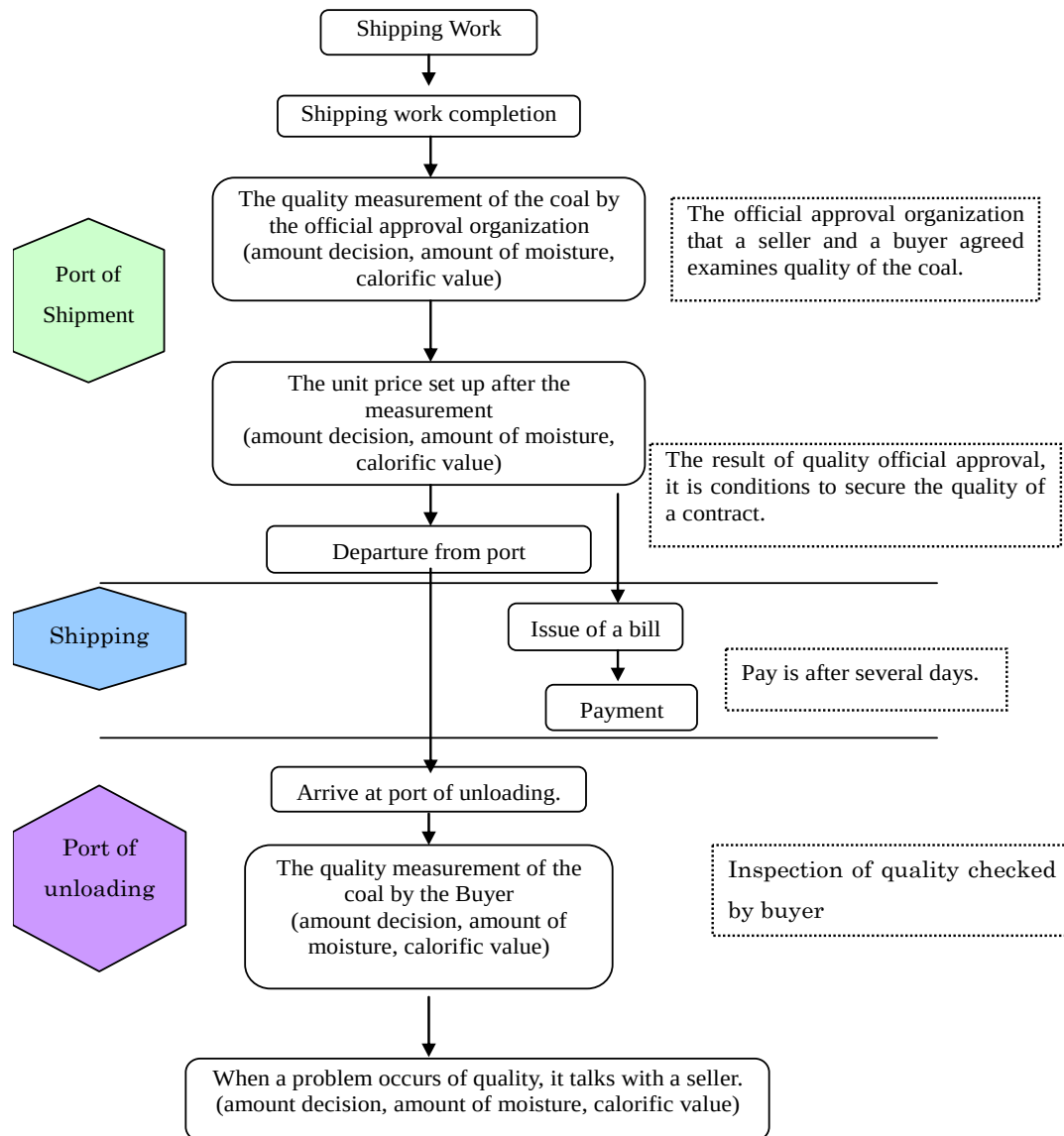


(Source: JICA Study Team)

Figure 5.8.1 Coal Transportation in Indonesia

5.8.1 Coal quality management at coal mine

The general workflow from coal shipping to coal loading in Australia is shown in the following figure.



(Source: JICA Study Team)

Figure 5.8.1 Work Flow of Coal Shipping

5.8.2 Type of transport ships

In Japan, power utilities for coal transportation enter into a special shipping vessel contract with the shipping companies.

In consideration of the coal procurement risks and quantity change, it is necessary to decide a proper transportation mode and contract amongst the long/short-term contracts or spot chartering.

Most of the steel manufacturing companies use special shipping vessels. For example, 60-70% of steel factories in China consign their special vessels to Japanese shipping companies, and the others enter into spot contracts.

5.8.3 Type of ships

1) Types of ships by cargo

The following figure shows the types of ships by cargo.

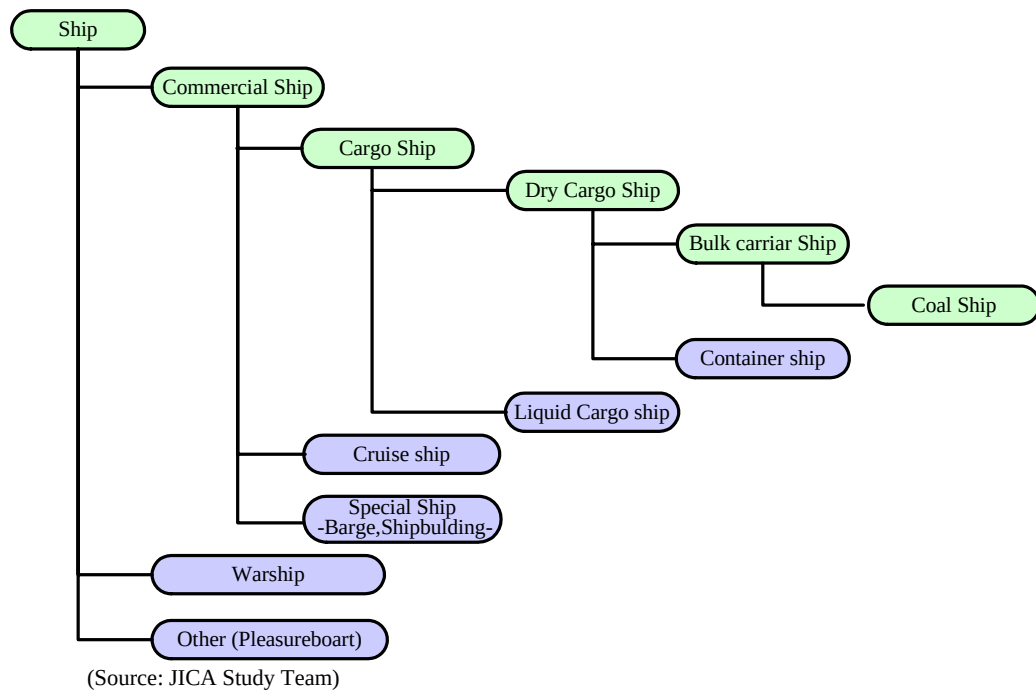


Figure 5.8.3.1 Types of Ships by Cargo

The types of ships by cargo are divided into three types: Dry Cargo, Liquid Cargo and the others. Dry Cargo can be classified into bulk carriers and container ships.

The bulk carrier ships deal with general merchandise, machineries and steel materials. The container ships carry the container freight 20 feet by 40.

The bulk carrier ships are classified into standard bulk carrier and special bulk carrier. The distinguishing characteristics of standard bulk carrier ships are their handy size, panamax size and cape size.

The various special ships are bulk coal carriers, ore coal carriers, chip carriers, car carriers and reefer carriers.

Liquid cargo ships are divided into oil tankers, product carriers, chemical tankers, and liquefied natural gas carriers.

The oil tankers are for oil, product carriers are for petroleum products (naphtha, diesel oil, heavy oil, kerosene, gasoline), chemical tankers are for liquid chemical products(benzene, toluene, wine, milk and others), and liquefied natural gas carriers are for LNG and LPG.

In the above figure, the “Others (Pleasure boat)” refer to passenger boats, cruise passenger boats, ferry boats, fishing boats, tugboats and naval escort ships.

2) Size of bulk carriers

The size of carriers depends on the weight of the freight such as the fuel, lubricating oil, passengers and food items.

The loading capacity of a carrier is shown in tons. The unit of the “DWT (deadweight)” is used as tonnages in explanation of the number of cargo ships and tankers. The size of the bulk carriers are specified into 4 types such as a (i) Small Handy, (ii) Supramax Handy, (iii) Panamax and (iv) Cape Size. The typical size of the bulk carriers is described in the following table.

Table 5.8.3.1 Typical Size of Bulk Carriers

Item	Small Handy	Supermax Handy	Panamax	Cape size
DWT(Dead weight)	32,000	55,000	70,000	170,000
LOA(Length over all)	170	190	225	280
Beam(m)	27	32.2	32.2	47
Full draft(m)	12.5	12.5	13.7	17.8
Number of Hold	5	5	7	9
Hold Capacity (m ³)	41,000	69,000	102,000	195,000

(Source: NYK Presentation material)

The Handy size vessels are those bulk carriers whose loading capacity is 18,000-55,000DWT.

Their fairly compact size allows for easy entry and departure at most of the world's ports.

Among the various Handy sizes, the Small Handy are those bulk carriers whose loading capacity is less than 28,000DWT, and the Super Max are those bulk carriers whose loading capacity is 45,000DWT-55,000DWT.

The word "Panamax" is a compound word combining "Panama" and "maximum". The size of the ship is the maximum size that would allow for passage through the Panama Canal. The length is 900 feet (approximately 274m) or less, and the width is 106 feet (approximately 32.31m) or less. The loading capacity is a 70,000DWT-75,000DWT class. The Panamax is utilized for not only tankers, but also bulk carriers, or carriers and container ships.

For the coal transportation at the Matarbari coal-fired power station it is recommended that Panamax-size ships be used. These Panamax size ships will raise the efficiency of coal procurement. The Cape size is larger than the Panamax size. The Cape size ships whose loading capacity is 150,000DWT-170,000DWT class are too large to allow for easy passage through the Panama Canal, so they need to go around the Cape of Good Hope in the African Continent.

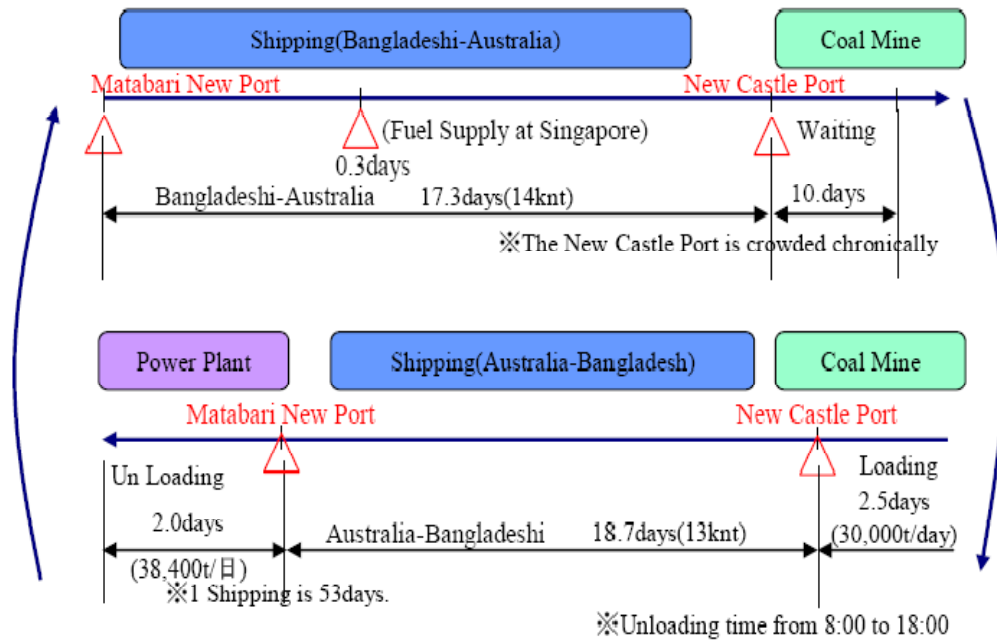
3) Transportation from Australia to Matarbari in Bangladesh

The navigation period from New Castle Port in Australia to the newly developed Matarbari Port in Bangladesh is estimated in Figure 5.8.3.2.

The transportation route from Australia to Matarbari is shown in Figure 5.8.3.2.

The conditions of the transportation are the estimated loading capacity of 75,000 tons, an estimated distance of 5,824 miles, a transportation speed of 13knt(25.3km/h). In the route via Australia, refueling is planned to take place at the Singapore Port due to passage through the Strait of Malacca.

The navigation period from New Castle Port in Australia to Matarbari Port in Bangladesh is 53 days. According to past data, if 20 days are to be regarded as non-operation days due to bad weather, the remaining days in the year for operation will be 345 days, and coal transportation can be conducted 7 times a year.



(Source: JICA Study Team)

Figure 5.8.3.2 Transportation Route of Australia to Matarbari in Bangladesh

4) Transportation from Indonesia to Matarbari Port in Bangladesh

The navigation period from Tarakan Port of East Kalimantan Island in Indonesia to the newly developed Matarbari Port in Bangladesh is estimated in Figure 5.8.3.3.

The transportation route is shown in Figure 5.8.3.3.

The conditions of the transportation is the estimated loading capacity of 75,000 tons, an estimated distance of 2,837 miles, a transportation speed of 13knt (25.3km/h). In the route via Australia, refueling is planned to take place at the Singapore Port due to passage through the Strait of Malacca.

The navigation period from Tarakan Port in Indonesia(Anchored type port) to Matarbari Port in Bangladesh is 32 days, and coal transportation can be conducted 11 times a year.

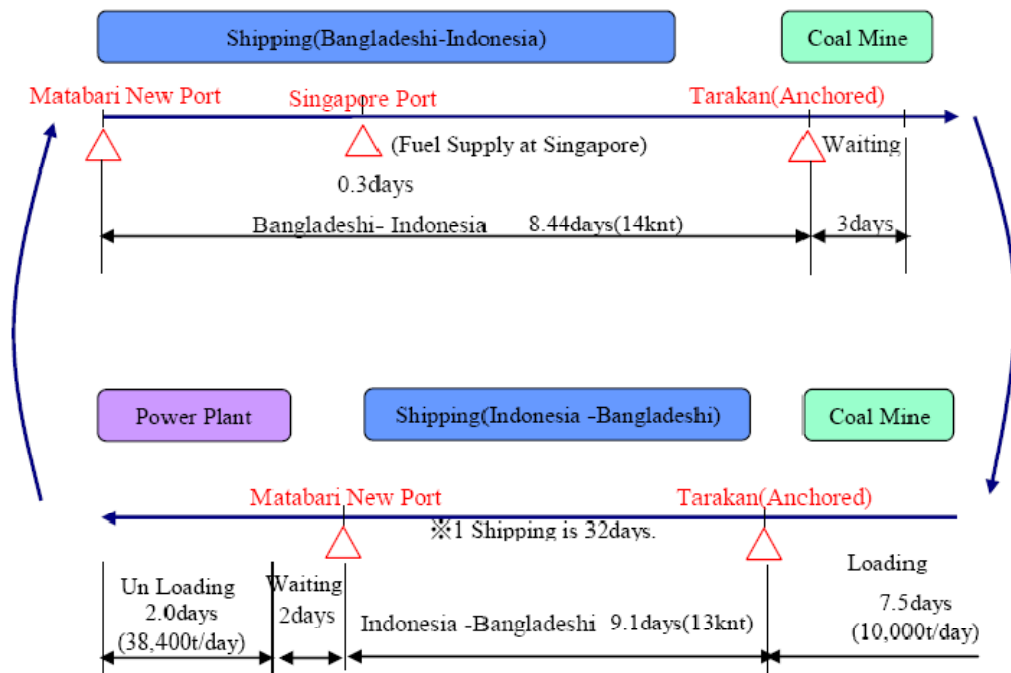


Figure 5.8.3.3 Transportation Route from Tarakan in Indonesia to Matarbari Port in Bangladesh

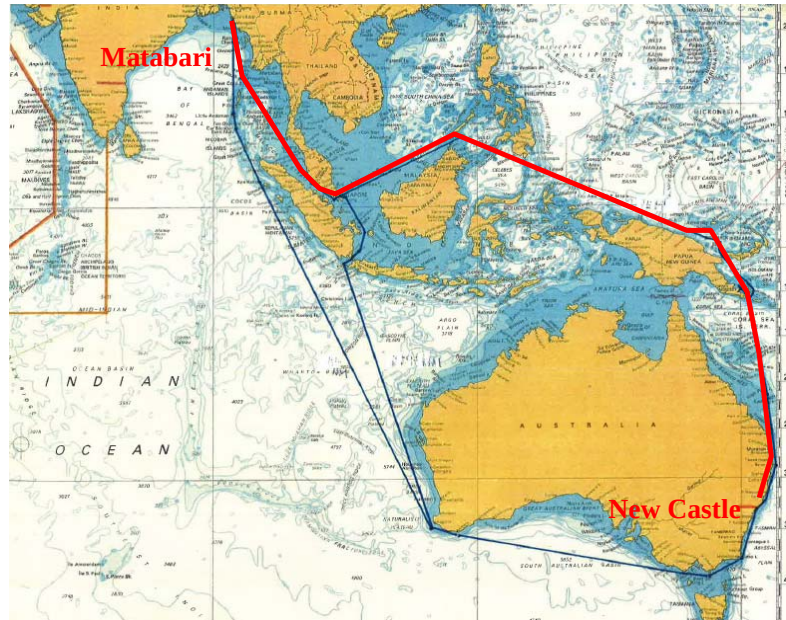
Table 5.8.3.2 Navigation Days from the Main Port in Australia and Indonesia

Estimation of navigation days from the main port in Australia and Indonesia to Matarbari in Bangladesh ⚡ Review Conditions ⚡ ⚡ Target vessel: PANAMAX type (DWT76,000) ⚡ Precondition of sailing speed ⌚ Outward: 14knt, (27.2km/h) ⌚ Homeward: 13knt, (25.3km/h) ! ⚡ Shipping port ! ! ! ⌚ Australia: New Castle Port in NSW ! ! ! ⌚ Indonesia: East Kalimantan Island				
Item	Representative Port			
Loading Port	Australia	Indonesia		
	NEWCASTLE (Jetty)	TARAKAN (Anchored)	SAMARINDA (Anchored)	TANJUNG BARA(Jetty)
Expectation of cargo Weight (t)	75,000	74,500	75,000	75,000
⚡ Bound ⚡	!	!	!	!
Distance of Shipping (Mile)Via Singapore	5,824	2,837	2,647	2,716
Navigation Days↖ day↗	17.33	8.44	7.88	8.08
Time of Fuel Supply at Singapore (day)	0.3	0.3	0.3	0.3
Waiting days of Loading on offing(day)	10	3	3	3
Loading Capacity of one day (t/day)	30,000	10,000	17,000	35,000
	!	!	!	!
The total number of loading days (day)	2.5	7.5	4.4	2.1
⚡ Return ⚡	!	!	!	!
Distance of Shipping (Mile)Via Singapore	5,824	2,837	2,647	2,716
Navigation Days↖ day↗	18.67	9.09	8.48	8.71
Waiting days of Unloading(day)	2	2	2	2
Unloading Capacity of One day (t/day)	38,400	38,400	38,400	38,400
The total number of Unloading days (day)	2.0	2.0	2.0	2.0
The total number of navigation days(day↗)	52.8	32.2	28.0	26.2
The number the annual shipping (Shipping/year)	7	11	12	13
⚡ Annual Operation Days:345days ⚡ It is 20 th non-operation days by bad weather				
⚡ Reference ⚡ Quantity of annual procurement coal (t/year)	490,500	797,895	923,250	998,600

Source: JICA Study Team

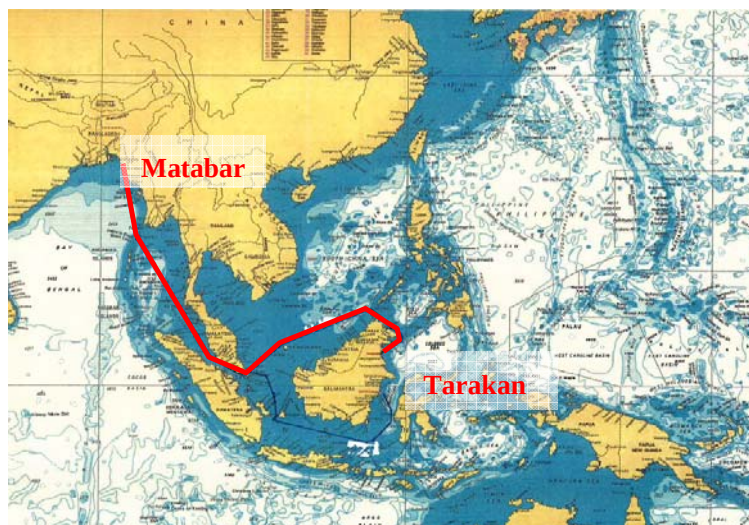
5) Marine Transportation Route

The marine transportation route between Matarbari area in Bangladesh and New Castle Port in Australia is shown in Figure 5.8.3.4, and the route between the Matarbari area and Tarakan Port in Kalimantan Island, Indonesia is shown in Figure 5.8.3.5.



(Source: JICA Study Team)

Figure 5.8.3.4 Transportation Route from Australia



(Source: JICA Study Team)

Figure 5.8.3.5 Transportation Route from East Kalimantan Island, Indonesia

Chapter 6

Environmental Impact Assessment

Chapter 6

Environmental Impact Assessment

Table of Contents

6.1	Results of Environmental Impact Assessment for the Power Plant.....	1
6.2	Results of Environmental Impact Assessment for the Port Facility	9

6 Summary of Environmental and Social Impact Assessment

The results of environmental impact assessment are summarized in Table 6.1 to 6.2.

Table 6.1: Results of Environmental Impact Assessment for the Power Plant

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	A-	B-	B-	Construction phase: - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. Operation phase: - Concentration of pollutants in emission gas will meet emission gas standards by adopting low-NO_x combustion methods, electrostatic precipitators (around 99.8% efficiency: 7,707 mg/m³ -> 50 mg/m³) and flue gas desulphurization equipment (around 70% efficiency: 2,526 mg/m³ -> 820 mg/m³). - Ground concentration of pollutants caused by emission gas will meet ambient air quality standards. - Prevention measures for dust dispersion will be taken at coal storage and ash disposal sites.
	2	Water Quality	A-	A-	B-	B-	Construction phase: - Turbid water, such as rainwater run off, will be treated with precipitation processes. - Wastewater containing oil will be treated with oil-water separator. Operation phase: - Plant wastewater will be treated at a wastewater treatment facility in order for pollutants in the water to meet wastewater quality standards. - The outlet for intake of cooling water and the outlet for discharge of thermal effluent are designed to be located far away from each other. The diffusion of the increase of water temperature will occur only in the surface layer. - Wastewater discharged from coal storage and ash disposal sites will be treated at the wastewater treatment facility.
	3	Waste	B-	B-	B-	B-	Construction phase: - Construction waste and general waste will be re-used, recycled or disposed following relevant laws and regulations. Operation phase:

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Sludge from the wastewater treatment facility, waste oil from machine inspections and general waste will be re-used, recycled or disposed following relevant laws and regulations. - All fly ash and bottom ash will be disposed of inside the power plant site.
	4	Noise and Vibration	B-	A-	B-	B-	Construction phase: - Construction machinery and vehicles will be regularly maintained. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area (Max 114dB -> 70.3dB). Operation phase: - Construction machinery and vehicles will be regularly maintained. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area (Max 108dB -> 43.3dB).
	5	Subsidence	C-	C-	D	D	Construction and Operation phases: - Ground water will not be used during construction and operation phases.
	6	Odor	B-	B-	B-	B-	Construction and Operation phases: - General waste will be re-used, recycled or disposed following relevant laws and regulations.
	7	Soil	B-	B-	B-	B-	Construction phase: - Wastewater containing oil will be treated with oil-water separator. - Oil and chemical substances will be appropriately stored. Operation phase: - Ash disposal site will be designed to prevent seepage. - Storage for oil and chemical substances will be designed to prevent seepage.
	8	Sediment	B-	B-	B-	B-	Construction and Operation phases: - Wastewater and waste will be appropriately treated and disposed.
Natural Environ-ment	9	Protected Areas	C-	C-	D	D	Construction and Operation phases: - Sonadia ECA has been designated pursuant to the Environmental Protection Law in Bangladesh, located 15km south of the proposed project site. - Air quality, water quality and noise levels during both

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							construction and operation phases will meet environmental standards, and the impacts will not reach Sonadia ECA.
	10	Ecosystem	A-	A-	A-	B-	Construction phase: - Impact of air pollution, water turbidity and noise, etc., during the operation phase will be mitigated through appropriate countermeasures, as described above. - The Spoon billed Sandpiper, listed in the IUCN Red list, was observed at the beach in front of the power plant. However, Matabari Peninsula beach is not the main migratory habitat for migratory birds, particularly the Spoon billed Sandpiper in Bangladesh. For the purpose of protecting the species, construction workers will be instructed to strictly comply with hunting and capturing restrictions prescribed by law. - Four species of sea turtle species listed in the IUCN Red list, spawn at the sea front area of the power plant. Mitigation measures will be taken, especially night-time lighting and lowering noise levels. Monitoring will also be conducted. - Other fauna species designated as valuable by biologists of Bangladesh have been observed, but these species are generally observed widely around the area. Operation phase: - Impact of air pollution, water turbidity and noise, etc., during the operation phase will be mitigated through appropriate countermeasures, as described above, and the results of simulation also indicate that environmental standards are met. - The frequency with which this species uses the Matabari Peninsula as a wintering ground is relatively very low in comparison with the nearby offshore island of Sonadia. Many previous survey results point out that Matabari Peninsula beach is not a main migratory habitat for migratory birds, especially the Spoon billed Sandpiper in Bangladesh; this is also supported by other experts and reports. However, for the purpose of protecting the species, construction workers will be instructed to strictly comply with hunting and capturing restrictions prescribed by law. - Four kinds of sea turtle species listed in the IUCN Red list spawn at the sea front area of the power plant. Mitigation measures will be taken, especially night-time lighting and lowering noise levels. Monitoring will also be conducted.

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Other fauna species designated as valuable by biologists of Bangladesh have been observed, but these species are generally observed widely around the area.
Social Environ- ment	11	Land Resettlement	A-	D	A-	D	Pre-construction phase: - 343 households and 2,031 people will be affected by the construction of the power plant and the port facility. LARAP (Land Acquisition and Resettlement Action Plan), that includes not only a compensation plan but also a livelihood restoration program for affected people, shall be established.
	12	Disturbance to Poor People	A-/B+	A-/B+	A-/B+	A-/B+	Pre-construction and Construction phases: - The employment of local people will be promoted for increased employment opportunities for various subcontract work resulting from the power plant construction activity. - Livelihood restoration measures will be established including job training for those who want it. Operation phase: - Poor people who currently have deteriorated living standards without proper facilities will have better access to social services throughout the year if roads are improved along with the construction of the power plant, especially access during the rainy season.
	13	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	D	D	- There were no ethnic and indigenous people found on or around the project site.
	14	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	A-	A-/B+	A-	A-/B+	Pre-construction and Construction phases: - The employment of local people will be promoted for increased employment opportunities for various subcontract work resulting from the power plant construction activity. - Livelihood restoration measures will be established including job training for those who want it. Operation phase: - The employment of local people will be promoted for increased employment opportunities for various subcontract work resulting from the power plant construction activity. - Livelihood restoration measures will be established including job training for those who want it.

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- Services, such as laundry and catering services, and products provided by the local community will be preferentially used to the extent possible.
	15	Land Use and Utilization of Local Resources	A-	A-	A-	A-	Pre-construction, Construction, and Operation phases: - The employment of local people will be promoted for increased employment opportunities for various subcontract work resulting from the power plant construction activity. - Livelihood restoration measures will be established including job training for those who want it.
	16	Disturbance to Water Usage, Water Rights, etc.	A-	B-	B-	B-	Construction phase: - Wastewater will be treated, and monitoring of groundwater will be conducted. Operation phase: - Plant water used during the operation phase will be taken from sea water through a desalinating process, so that no impact to river and ground water is anticipated.
	17	Disturbance to the Existing Social Infrastructure and Services	B-	B-/B+	B-	B-/B+	Construction phase: - For vessels, a water route will be determined after consultation with related authorities. - For vehicles, bus use will be promoted to reduce increasing the number of vehicles used. - Bus schedules will be managed in consultation with related organizations. Operation phase: - Bus use will be promoted - An access road, community road and road around the power plant boundary will be built. - A school and medical facility constructed within the power plant site will be open to all local people for the improvement of their lives.
	18	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	B-	D	Pre-construction phase: - Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process. In the resettlement process, personnel responsible for responding to complaints or suggestions from local residents will work at the power plant office.
	19	Misdistribution of Benefits and Compensation	B-	B+	B-	B-/B+	Pre-construction phase: - Equality of compensation shall be assured as there is a possibility of unequal compensation between local residents. Operation phase:

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							- The access road, school and medical facility constructed within the power plant site will be open to all local people.
	20	Local Conflicts of Interest	B-	B-/B+	B-	B-/B+	Preconstruction phase: - Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process. In the resettlement process, personnel responsible for responding to complaints or suggestions from local residents will work at the power plant office. Construction phase: - Local people will be employed to the maximum extent possible, and foreign workers will be taught to respect local customs in order to facilitate good relationships with local people. Lodgings of project workers will be equipped with sufficient living facilities keeping order that workers remain at the project site as much as possible. Operation phase: - Lodgings of project workers will be equipped with sufficient living facilities keeping order that workers remain at the project site as much as possible. - The access road, school and medical facility constructed within the power plant site will be open to all local people.
	21	Cultural Heritage	D	D	D	D	- There are no historical, cultural and archaeological properties or heritage sites in or around the site.
	22	Landscape	D	D	D	D	- There is no picturesque scenery in or around the site.
	23	Gender	B-/B+	B+	B-/B+	B+	Pre-construction and Construction phases: - There are women among those to be resettled and/or lose their livelihood means. They currently have low living standards and lack proper facilities; they will have better access to social services throughout the year. However, wives of those men who lose their land or jobs may suffer from adverse effects on their household economy. - Livelihood restoration measures will be established for improving life quality. Operation phase: - The access road, school and medical facility constructed within the power plant site shall be open to all local people to the maximum extent possible for the improvement of their lives. - Job opportunities will be open to them according to their qualification.
	24	Children's Rights	B-	B-/B+	B-	B-/B+	Pre-construction and Construction phases: - Labor contracts between the construction industry and

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							children shall be prohibited. Regular patrols to check for child workers will be conducted. Operation phase: - Labor contracts between the construction industry and children shall be prohibited. Regular patrols to check for child workers will be conducted.
	25	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	Construction phase: - Local people will be recruited for simple work as much as possible and there is a low risk of infectious diseases transmitted from external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).
	26	Work Environment (Including Work Safety)	B-	B-	B-	B-	Construction and Operation phases: - The construction company shall establish a work safety plan and submit it to CPGCBL to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc.) and on hard aspects (provide workers with appropriate protective equipment, etc).
Other	27	Accidents	B-	B-	B-	B-	Construction phase: - For land traffic, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be conducted. - For marine traffic, marking buoys will be set up around the construction area for marine safety. - Schedule of vessels will be announced to fishermen, etc. Operation phase: - Observation of traffic regulations, installation of traffic signs, and training will be conducted. - Education on driving safety shall be carried out for land traffic vehicles. - For ocean navigation, water routes will be determined after consultation with related authorities, and course buoys shall be set on navigation channel for marine safety. - For fire prevention, regular watering of the coal storage site, installation of fire protection equipment in the power plant, and organization of fire-fighting teams and fire-fighting training shall be carried out.
	28	Cross-boundary Impact and Climate Change	B-	B-	B-	B-	Construction phase: - Periodic maintenance and management of all construction machinery and vehicles will be conducted. Operation phase: - CO ₂ will be produced by plant operation. Ultra supercritical

Item	No.	Impact	Assessment of Scoping		Assessment of survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							(USC) technology will be adopted at the power plant, which compared to a sub critical coal-fired power plant will produce less CO ₂ of approximately 555,400 tons /year.

Notes: A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)

D: No impact is expected.

(Source: JICA Study Team)

Table 6.2: Results of Environmental Impact Assessment for the Port Facility

Item	No.	Impact	Assessment based Scoping		Assessment based survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
Pollution Control	1	Air Quality	B-	B-	B-	B-	Construction phase: - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. Operation phase: - Air pollution caused by exhaust gas generated from the vessels using the port is predicted. - Dust dispersion, generated from loading-unloading of coal, is also predicted.
	2	Water Quality	A-	A-	B-	B-	Construction phase: - Grab dredgers or pump dredgers will be used and anti-diffusion membrane will be installed to prevent diffusion of turbidity. - When excavating the land area, steel sheet piles will be installed for enclosure on the marine side before any excavation work. - Turbid water from the land will be treated with a precipitation system. Operation phase: - Dredging method and equipment will be selected to minimize turbidity. - The number of days that coal vessels enter and leave the port is about 50 days per year, which is relatively few.
	3	Waste	A-	A-	B-	B-	Construction phase: - Sand and silt from dredging work of the navigation channel and the port will be re-used for land preparation of the plant and disposed of into the ash pond. Operation phase: - Dredged materials generated by maintenance of the port will be reused to the maximum extent around the project and residual material will be disposed of within the project site.
	4	Noise and Vibration	B-	B-	B-	B-	Construction phase: - Construction machinery and vehicles will be maintained regularly. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area

Item	No.	Impact	Assessment based Scoping		Assessment based survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							(Max 119dB -> 73.2dB). Operation phase: - Construction machinery and vehicles will be maintained regularly. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area (101dB -> 43.3dB).
	5	Subsidence	C-	C-	D	D	Construction and Operation phases: - Ground water will not be used during construction and operation phases.
	6	Odor	D	D	D	D	Construction and Operation phases: - No expected use of substances that may be a potential source of bad odors.
	7	Sediment	D	D	D	D	Construction and Operation phases: - No hazardous waste will pollute the sediment.
Natural Environ- ment	8	Protected Areas	C-	C-	D	D	Construction and Operation phases: - Sonadia ECA has been designated pursuant to the Environmental Protection Law in Bangladesh, located 15km south of the proposed project site. - Air quality, water quality and noise levels during both the construction and operation phases will meet environmental standards, and the impacts will not reach Sonadia ECA.
	9	Ecosystem	A-	A-	A-	B-	Construction phase: - Impact of air pollution, water turbidity and noise, etc., during the operation phase will be mitigated through appropriate countermeasures, as described above. - The frequency with which this species uses the Matabari Peninsula as a wintering ground is relatively very low in comparison with the nearby offshore island of Sonadia. Many previous survey results point out that Matabari Peninsula beach is not a main migratory habitat for migratory birds, especially the Spoon billed Sandpiper in Bangladesh; this is also supported by other experts and reports. However, for the purpose of protecting the species, construction workers will be instructed to strictly comply with hunting and capturing restrictions prescribed by law. - Four species of sea turtle species listed in the IUCN Red list spawn at the sea front area of the power plant. Mitigation measures will be taken, especially night-time lighting and

Item	No.	Impact	Assessment based Scoping		Assessment based survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
							minimizing noise levels. Monitoring will also be conducted. - Other fauna species designated as valuable by biologists of Bangladesh have been observed, but these species are generally observed widely around the area. Operation phase: - Impact of air pollution, water turbidity and noise, etc. during the operation phase will be mitigated through appropriate countermeasures, as described above, and the results of simulations also indicate that environmental standards will be satisfied. - The frequency with which this species uses the Matabari Peninsula as a wintering ground is relatively very low in comparison with the nearby offshore island of Sonadia. Many previous survey results point out that Matabari Peninsula beach is not a main migratory habitat for migratory birds, especially the Spoon billed Sandpiper in Bangladesh; this is also supported by other experts and reports. However, for the purpose of protecting the species, construction workers will be instructed to strictly comply with hunting and capturing restrictions prescribed by law. - Four kinds of sea turtle species listed in the IUCN Red list spawn at the sea front area of the power plant. Mitigation measures will be taken, especially night-time lighting and minimizing noise levels. Monitoring will also be conducted. - Other fauna species designated as valuable by biologists of Bangladesh have been observed, but these species are generally observed widely around the area.
	10	Hydrology	B-	B-	B-	B-	Construction and Operation phases: - The impact of the port facility on changes in ocean currents will be limited and not considered significant, because the proposed port facility is an excavated type port.
	11	Topography and Geology	B-	B-	B-	B-	Construction and Operation phases: - The impact of the port facility and sedimentation on changes in topography will be limited and not considered significant, because the proposed port facility is an excavated type port.
Social Environ-ment	12	Disturbance to the Existing Social Infrastructure and	B-	B-	B-	B-	Construction and Operation phases: - For vessels, a water route will be determined after consultation with the related authorities.

Item	No.	Impact	Assessment based Scoping		Assessment based survey results		Results
			Pre/ construction Phase	Operation Phase	Pre/ construction Phase	Operation Phase	
		Social Services					
	13	Work Environment (Including Work Safety)	B-	B-	B-	B-	Construction and Operation phases: - The construction company shall establish a work safety plan and submit it to CPGCBL to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc.) and hard aspects (provide workers with appropriate protective equipment, etc).
Other	14	Accidents	B-	B-	B-	B-	Construction phase: - Marking buoys will be set around the construction area for marine safety. - Schedules of vessels will be announced to fishermen, etc. Operation phase: - The water route of large coal transport vessels will be determined after consultation with related authorities. - Course buoys will be set on navigation channel for marine safety.
	15	Cross-boundary Impact and Climate Change	D	D	D	D	Construction phase: - CO ₂ will be produced from construction work, but no impact on climate change is expected. Operation phase: - CO ₂ will be produced by entry and departure of vessels, but no impact on climate change is expected.

Note: A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)

D: No impact is expected.

(Source: JICA Study Team)

Chapter 7
Environmental Management
and Mitigation Plan

Chapter 7

Environmental Management and Mitigation Plan

Table of Contents

7.1	Power Plant and Port Facility.....	1
7.2	Proposed Mitigation or Management Measures for Threatened Species	33

7 Environmental Management and Mitigation Plan

7.1 Power Plant and Port Facility

(1) Power Plant

1) Implementation system

a) Construction phase

At the construction phase, the Project Implementation Unit (PIU) of CPGCBL shall carefully consider all construction activities with the supervision consultant, and encourage the contractor to fully understand the necessary mitigation measures and to implement them.

For this purpose, an environmental management unit (EMU) shall be organized prior to construction activity and an expert environmental management administrator in the EMU shall be employed. The unit will discuss and prepare mitigation measures with the supervision consultant and the contractor prior to the start of construction.

We anticipate a large inflow of workers and vehicles once construction begins. The EMU shall also function as a grievance organization to understand and address any grievances from local people during the construction phase, and conduct appropriate mitigation measures.

The EMU shall improve the understanding of the surrounding community regarding construction details, the schedule and mitigation measures, and shall obtain local input from people and change the mitigation measures as appropriate.

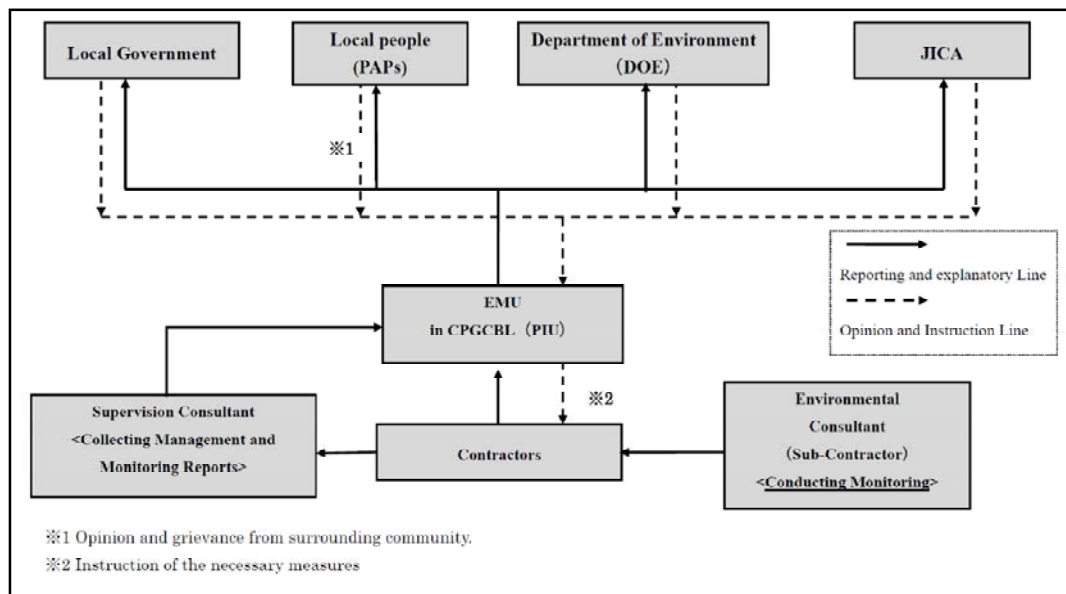
In order to confirm the implementation of environmental management and to consider further mitigation measures, the contractor should submit regular reports to the supervisory consultant and the EMU on the implementation status of the management plan.

The administrator of the EMU shall regularly hold explanation sessions with the local community, continuously listen to their grievances, submit reports to the Department of Environment, JICA and other relevant organizations regarding those grievances, as well as the implementation status of environmental management and environmental monitoring (described hereinafter).

If environmental problems occur due to construction work, the EMU shall confirm the cause with the contractor as soon as possible.

In order to resolve these problems, the administrator of the EMU shall instruct the contractor and consultant regarding necessary measures. If the problem is serious, the PIU may order the contractor to halt construction work until the problem is resolved.

Figure 7.1.1 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the construction phase.



(Source: JICA Study Team)

Figure 7.1.1 Environmental Management and Monitoring Implementation Structure in the Construction Phase for the power plant and port facility

b) Operation phase

The power plant is responsible for organizing the EMU in a manner that allows it to develop and implement an environmental management plan that includes mitigation measures. An expert environmental management administrator at the EMU shall be employed to ensure the environmental management plan is appropriately implemented. The administrator shall encourage the project staff to familiarize themselves with the environmental management plan prior to the start of plant operation, and shall regular educate those regarding ongoing matters during the operation phase.

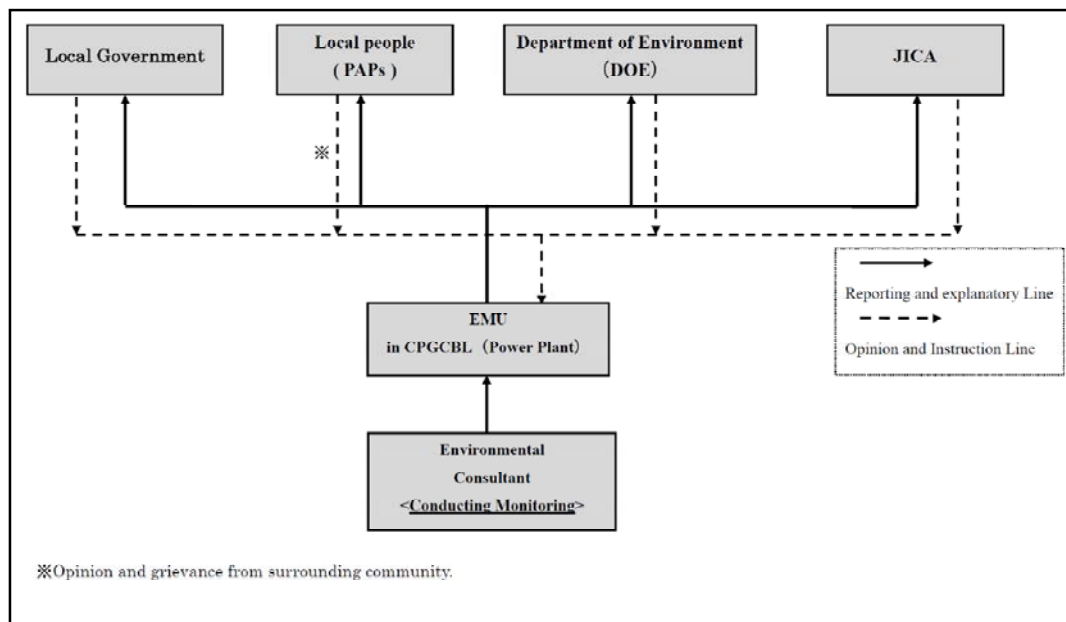
The EMU shall also function as a grievance organization and will strive to understand and address any grievances from the local people during the operation phase, and undertake appropriate mitigation measures.

The basic function of the environmental management plan is to lease with the local community, and to provide them with sufficient explanations based on positive mitigation measures, which is very important.

The administrator shall report on the contents and implementation status of the environmental management plan and environmental monitoring plan described below to the director of the plant, with the director taking final responsibility.

The administrator of the EMU shall regularly hold explanation sessions with the local community, continuously listen to their grievances, submit reports to the Department of Environment, JICA and other relevant organizations regarding those grievances, as well as on the implementation status of environmental management and environmental monitoring activities (described hereinafter).

Figure 7.1.2 describes the environmental management and monitoring implementation structure with the reporting flow during the operation phase.



(Source: JICA Study Team)

Figure 7.1.2 Environmental Management and Monitoring Implementation Structure in Operation Phase for the power plant and port facility

2) Mitigation Measures

The major environmental impact, mitigation measures, responsible organization, and expenses for each environmental item during the construction and operation phases for the power plant and port facility are listed in Table 7.1.1 and Table 7.1.2.

Table 7.1.1 Environmental Management Plan (Power Plant)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	1) Loss of private land 2) Loss of salt fields, shrimp farms and fishing ground for push net 3) Loss of residential/ commercial structures 4) Loss of trees, home gardens, fish ponds and fruit	1) - 4) - The Acquisition and Requisition of Immovable Property Ordinance of 1982 - JICA Guideline (2010)	1) Consideration for land owners 2) Consideration for persons losing their homes 3), 4) Consideration for persons losing their property	1) - 4) - Developing an appropriate “land acquisition and resettlement action plan” - Land acquisition should be conducted in compliance with the relevant laws and regulations - The cost related to relocation will be given to relocated residents - Employ local residents, especially loss of salt fields, shrimp farms, and fishing ground for push net as much as possible	1) - 4) - At the site	1) - 4) - During land acquisition process	- Office of the Deputy Commissioner - CPGCBL	Expenses to be paid by CPGCBL - Total cost relating to land acquisition: 3,864,045,082 Tk.
2	Disturbance to poor people	- Poor households among those who are to be resettled.	- JICA Guideline (2010)	- Consideration for burden on vulnerable groups	- Developing “livelihood restoration program”, including job training programs to persons who want the training.	- At the site	- Prior to start construction	- Office of the Deputy Commissioner - CPGCBL	Expenses to be paid by CPGCBL - Job training programs: 120,000 Tk./ 20person↯20day
3	Social Institutions such as Social Infrastructure and Local Decision-	- Changing peoples’ thinking through interacting with local government officers, local	-----	- Consideration to affected peoples’ emotions	- Developing an appropriate “land acquisition and resettlement action plan”	- At the site	- Prior to start construction	- Office of the Deputy Commissioner - CPGCBL	Expenses to be paid by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
	making Institutions	residents and others in the land acquisition procedure							
4	Misdistribution of Benefits and Compensation	- It can occur among residents, workers, government officers and local politicians	-----	- Consideration for uneven distribution of benefits and losses	- Implement the same mitigation measures as those outlined in "Social infrastructure"	- At the site	- Prior to start construction	- Office of the Deputy Commissioner - CPGCBL	Expenses to be paid by CPGCBL
5	Local Conflicts of Interest	- It can occur among residents, workers, government officers and local politicians	-----	- Consideration to affected peoples' emotions	- Implement the same mitigation measures as those outlined in "Poor people"	- At the site	- Prior to start construction	- Office of the Deputy Commissioner - CPGCBL	Expenses to be paid by CPGCBL
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction	1) - 3) - Ambient Air Quality Standard - IFC guideline value for ambient air quality (General/ 2007)	1) - 3) - Prevention of air pollution in the surrounding area	1) Dust prevention - Watering access road and construction site, especially in the dry season - Using cover sheets on trucks for the transportation of soil 2) Gas emission prevention - Periodic maintenance and management of all the construction machinery and vehicles 3) Waste management - Prohibit open burning	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		materials and waste							
2	Water Quality	1) Run off water from construction area 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakage oil and chemical materials from construction activity	1) - 4) - Wastewater standards	1) - 4) - Prevention of water pollution in the surrounding area	1) Run off water - Excavate channels, ditches and temporary settling pond around construction area - Install oil separator for treatment of oily wastewater - Construct silt basin 2) Domestic wastewater - Install wastewater treatment facility for workers such as septic tanks 3) Waste management - Prohibit illegal dumping 4) Oil and chemical materials leakage - Storage of oil and chemical materials in an appropriate storage site and appropriate method to prevent permeation into ground	1) - 4) - Construction area	1) - 4) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous	1) - 3) - Waste Management Rule	1) - 3) - Prevention of inappropriate waste disposal	1), 2) Construction and domestic waste - Conduct separate waste collection and promote recycling and reuse - Appropriate disposal of non-recyclable waste	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		waste such as dry batteries, etc.			according to rules 3) Hazardous waste - Hazardous waste should be treated under the related regulations				
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1), 2) - Noise level standards - IFC guideline values for noise (General/ 2007)	1), 2) - Reduction of noise levels from construction activities	1) Construction machinery - Optimizing construction schedule - Performing construction work during daytime, especially piling work - Using low-noise/ low vibration equipment as much as possible 2) Mobilization - Transportation of material and equipment for construction by shipping - Determine a traffic control plan including route-setting - Limit truck speed especially around residential areas	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
5	Odor	- Domestic wastewater of workers	- Wastewater standards	- Prevention of generating odor	- Taking appropriate measures for handling general waste - Prohibit illegal waste disposal	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor.
6	Soil	1) Leakages of oil and chemical	1), 2) - Drinking water	1), 2) - Prevention of	1) Leakages of oil and chemical materials	1), 2) - Construction	1), 2) - During	- Implementation: Contractor/	Expenses included in contract cost by

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		materials from construction activity 2) Inappropriate disposal of waste	quality standards	water and soil pollution in the surrounding area	- Storage of oil and chemical materials in an appropriate storage site and method to prevent permeation into the ground 2) Waste management - Prohibit illegal dumping	area	construction phase	Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Contractor
7	Sediment	1) Run off water from construction area 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakages of oil and chemical materials from construction activity	1) - 4) - Wastewater standards	1) - 4) - Prevention of water pollution in the surrounding area	1) - 4) - Implement the same mitigation measures as those addressed in "Water quality"	1) - 4) - Construction area	1) 4) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
8	Ecosystem	1) Existence of endangered species 2) Spawning of sea turtles	1), 2) - Bangladesh Wild Life (Preservation) Act, 1974 - JICA Guideline (2010)	1), 2) - Protection of endangered species	1) Existence of endangered species - Prohibit disturbance, harassment, and hunting, especially of the Spoon billed Sandpiper, by workers - Replace to nearby site, if needed 2) Spawning of sea turtles	1) Construction area 2) Construction site adjoining sand beach	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					- Turning off unnecessary lights during the nesting season - Using a smaller number or lower wattage of lights - Using red, yellow lights (as sea turtles are less affected by these colors) - Using low noise machinery - Planning construction activities to minimize adverse effects during the nesting season				
		- Potential impact due to water pollution caused by construction activities	- Wastewater standards	- Prevention of water pollution in order to reduce negative impact on marine organisms	- Implement the same mitigation measures as those addressed in "Water quality"	- Construction area			
9	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- Increase in employment and business opportunities	- Number of employment opportunities for local residents and number of businesses around the construction area	- Improvement of the local economy - Improvement of living standards of local residents - Consideration to local residents' feelings	- Employ local residents as much as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community. - Developing "livelihood restoration program", including job training programs to persons who want the training.	- Villages near the site	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	- Expense is included in contract cost by Contractor - Hire local residence: 1,000Tk./person-day

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
10	Land Use and Utilization of Local Resources	- Changing the traditional land use patterns and utilization of local resources	-----	- Consideration to local residents' feelings	- Implement the same mitigation measures as those addressed in the "Local economy"	- Villages near the site	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
11	Disturbance to Water Usage, Water Rights, etc.	1) Adverse impact due to water pollution 2) Usage of underground water	1) Water pollution - Same as those addressed in "Water quality" 2) Ground water - Drinking water quality standards	1) Water pollution - Same as those addressed in "Water quality" 2) Ground water - Consideration to local residents' living	1) Water pollution - Implement the same mitigation measures as those addressed in "Water quality" 2) Ground water - Monitoring of water levels and water quality at wells in residential areas	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
12	Disturbance to Existing Social Infrastructure and Services	1) Increased marine traffic may disturb the existing marine traffic including fishing boats 2) Traffic jams caused by increased number of vehicles during construction 3) Closure of the existing road along the	1) - 3) -Traffic volume around the construction site	1) - 3) - Mitigation of traffic jams	1) Marine traffic - Consulting with related authorities on the schedules of vessels - Determining water routes after consultation with related authorities 2), 3) Land traffic - Making inappropriate vehicle schedules - Reducing the number of vehicles used by using buses - Consulting with related authorities on bus	1) Sea area near the site 2), 3) Roads near the construction area	1) - 3) During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		shoreline			schedules				
13	Local Conflicts of Interest	- Conflicts between local residents and external workers	- Change in local customs	- Consideration of the attitudes of local residents to the project	- Employ local residents as much as possible - Promote communication between external workers and local people (e.g., join in local events)	- Villages near the site	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
14	Children's Rights	- Child labor	-----	- Banning child labor	- Prohibit labor contracts between subcontractor and children - Patrolling periodically to check for any child labor	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
15	Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of infection	-----	- Consideration for sanitation for local residents	- Implementation of periodic medical check-ups by temporary medical team - Education and training on health care of workers	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Medical checkups: 22,500Tk./ person (Full Medical Checkup) - Safety education and training: 75,000Tk./ 20 person
16	Work environment (including work safety)	1) Labor accidents 2) Diseases caused by air pollutants, water pollutants, and noise by construction	1) Labor accidents - Handling heavy loads - Working at heights	1), 2) - Prevention of labor accidents and health problems	1) Labor accidents - Prepare a manual for labor accident prevention including safety education and training - Provide workers with	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision	Expenses included in contract cost by Contractor - Protective equipment: 5,000Tk./ person

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		work	- Electric shocks 2) Environment pollution - Ambient Air Quality Standards - Noise level standards - Waste management rules - IFC guideline values for ambient air quality and noise (General/ 2007)		- appropriate protective equipment, such as helmets - Install fire extinguishers in fire handling places - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate during the construction period - Use equipment that protects against electric shocks 2) Environment pollution - Observe related standards and provide workers with appropriate equipment, such as masks, ear plugs, etc.			Consultant	
17	Accidents	- Traffic accidents	1) Marine traffic 2) Land traffic	1), 2) - Traffic accidents	1) Marine traffic - Marking buoys around the construction area for marine safety - Informing vessel schedules to local fishermen, etc. 2), 3) Land traffic - Informing bus schedules to the surrounding villages - Determining a traffic	1) Sea area near the site 2) Roads near the construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Making buoys: 5,000Tk./ unit

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					control plan - Training safe operation of vehicles				
18	Cross-boundary impact and climate change	- CO ₂ will be produced by construction work	-----	- Reduce CO ₂ emissions as much as possible	- Periodic maintenance and management of all construction machinery and vehicles	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
Operational Phase									
1	Air Quality	1) Exhaust gas from the stacks 2) Dust from ash disposal activity 3) Exhaust gas from vehicles used for mobilization of equipment and workers 4) Dust from coal handling activities at jetty and coal yard	1) - 4) - Emission gas standards - Ambient air quality standards - IFC guideline values for ambient air quality (General/ 2007) and gas emission (Thermal power plant/ 2008)	1), 3) - Prevention of air pollution in the surrounding area 2) Appropriate handling of ash 4) Appropriate coal handling during stock and unloading activities	1) Power plant operational activities: - To reduce PM emissions, Electrostatic Precipitator (EP; around 99.8% efficiency) will be installed - To reduce NO ₂ emissions, firing system will use low combust technology - To reduce SO ₂ emissions, sea water FGD equipment (FGD; around 70% efficiency) will be installed - For stack design, the height is 275m - Duct will be provided with CEMS (Continuous Emission Monitoring System) with the supported infrastructure as required under the gas emission	1) Stack 2) Ash pond 3) Villages near the site 4) Coal stock yard	1) - 4) During operation of power plant	CPGCBL	- Flue gas treatment facilities: 319 million US\$ - Flue gas duct and stack: 114 million US\$ - Coal handling and transportation facilities: 182 million US\$ - Re-greening: 100Tk./ m ² (50ha) (Expenses included in contract cost by Contractor)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					standards and IFC guideline 2) Ash handling - Shifting the fly ash and the bottom ash to the ash pond using air sealed conveyer - Watering in ash pond as required for the dry season - Re-greening especially along the boundary of the plant site, surrounding ash pond with domestic plants according to local climate conditions 3) Gas emissions from vehicles - Periodic maintenance and management of vehicles 4) Coal handling - A cover will be installed for the conveyor for coal transportation to coal yard - Unloading of coal will be minimized (e.g., reduce the frequency of activity, etc.) during times of high speed winds - Spraying water in coal yard to keep the surface wet and prevent wind from blowing coal and dust - Installation of a dust				

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					control fence - Re-greening especially along boundary of plant site, surrounding coal yard with domestic plants				
2	Water Quality	1) Thermal effluents from cooling system 2) Wastewater from plant process 3) Rainwater drainage from ash pond and coal yard 4) Leakages of oil and chemical materials	1) - 3) - Wastewater standards - IFC guideline values for wastewater (Thermal power plant/ 2008)	1) - 4) - Prevention of sea water pollution	1) Thermal effluents - Thermal effluents are discharged to north side far from the intake point of cooling water to reduce the impact on surrounding area 2) Wastewater - Installation of wastewater treatment system by neutralization, settling and oil separation so any wastewater produced complies with wastewater standards and IFC guideline 3) Run off water - Run off water is collected in the pond and discharged after appropriate treatment - The bottom of the ash pond shall have an impermeable layer (less than 10^{-6} cm/sec) such as impermeable geo-membrane, sheet and clay 4) Oil and chemical materials leakage - Storage of oil and chemical	1) - 4) - Power plant, especially at discharge of thermal effluents and wastewater treatment system	1) - 4) During the operation of power plant	CPGCBL	- Wastewater treatment system: (Expenses included in contract cost by Contractor)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					materials in an appropriate tank with retaining wall and method to prevent permeation into ground				
3	Waste	1) Fly ash and bottom ash 2) Sludge from wastewater treatment and waste oil from equipment, etc. 3) Sewage and garbage from workers	1) - 3) - Waste management rules	1) Appropriate handling of coal ash 1) 3) - Management of waste, especially hazardous waste - Prevention of inappropriate waste disposal	1) Ash pond is designed with capacity of 25 years operation 2), 3) Waste management - Waste management program consisting of reduction, reuse, and recycling of materials - Systematic collection and protected storage - Waste disposal at appropriate location - Hazardous waste shall be treated under the related regulations - Prohibition of dumping any contaminating materials	1) Ash pond 2), 3) - Power plant	- During the operation of power plant	CPGCBL	- Ash handling facilities: 114 million US\$ (Expenses included in contract cost by Contractor)
4	Noise and vibration	1) Noise and vibration from steam turbines, generators, and pumps, etc. 2) Noise by ash disposal activity 3) Noise caused by vehicles used for mobilization of	1) - 4) - Noise standards - IFC guideline values for noise (General/ 2007)	1) - 4) - Mitigation of noise generated by the power plant	1) - 4) - Maintenance of equipment - Installation of low noise/ low vibration type equipment - Adequate basis of equipment to reduce vibration - Adequate enclosure of equipment to reduce noise	1) - 4) - Power plant	1) - 4) - During the operation of power plant	CPGCBL	- Buildings housing boiler and turbine generator (Expenses included in contract cost by Contractor)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		equipment and workers 4) Noise from coal handling activity at jetty and coal yard							
5	Odor	- Domestic wastewater of workers	- Wastewater standards	- Prevention of generating odors	- Taking appropriate measures for handling general waste - Prohibit illegal waste disposal	- Power plant	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
6	Soil	1) Seepage from ash disposal site 2) Leakages of oil and chemical materials	1), 2) - Ground water (Drinking water quality standards)	1), 2) - Prevention of soil and water pollution in the surrounding area	1) Seepage - The bottom of the ash pond should have an impermeable layer (less than 10^{-6} cm/sec) such as impermeable geo-membrane, sheet and clay 2) Oil and chemical materials leakage - Storage of oil and chemical materials in an appropriate tank with retaining wall and method to prevent permeation into ground	1) Ash pond 2) Power plant	1), 2) - During coal unloading activity	CPGCBL	Expenses by CPGCBL
7	Sediment	1) Wastewater from plant process 2) Run off water from ash disposal site and coal yard 3) Leakages of oil	1) - 3) - Wastewater standards - IFC guideline values for wastewater	1) - 3) - Prevention of sea water pollution	1) Wastewater - Installation of wastewater treatment system by neutralization, settling and oil separation so any wastewater produced	1) - 3) - Power plant, wastewater treatment system	1) - 3) - During the operation of power plant	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		and chemical materials	(Thermal power plant/ 2008)		- complies with wastewater standards and IFC guideline 2) Run off water - Run off water is collected in the pond and discharged after appropriate treatment 3) Oil and chemical materials leakage - Storage of oil and chemical materials in an appropriate tank with retaining wall and method to prevent permeation into ground				
8	Ecosystem	1) Existence of endangered species 2) Spawning of sea turtles	1), 2) - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010)	1), 2) - Protection of endangered species	1) Existence of endangered species - Prohibit disturbance, harassment, and hunting, especially of the Spoon billed Sandpiper, by workers 2) Spawning of sea turtles - Turning off unnecessary lights during the nesting season - Using a smaller number or lower wattage of lights - Using red and yellow lights (as sea turtles are less affected by these colors) - Using low noise machinery	1) Power plant 2) Power plant adjoining sand beach	1), 2) - During the operation of the power plant	CPGCBL	Expenses by CPGCBL
		- Negative impact	- Emission gas	- Prevention of air	- Implement the same	- Power plant			

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		due to air pollutants, noise, and waste management	standards - Ambient air quality standards - Wastewater standards - Noise standards - Waste management rules - IFC guideline values for ambient air quality (General/ 2007) and gas emissions (Thermal power plant/ 2008)	pollution, water pollution, noise, and inappropriate waste treatment	mitigation measures as those addressed in air quality, water quality, noise, and waste				
9	Disturbance to Poor People	- Improved road along with the power plant	-----	- Access to social services	- Construction of the access road, community road, and road around the power plant boundary - These roads will be built with sufficient height that they can be used even in the rainy season	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
10	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- Increase in employment and business opportunities	- Number of employment opportunities for local residents and number of businesses around the	- Improvement of the local economy - Improvement of living standards of local residents - Consideration of	- Employment of local residents as much as possible - Use of services (i.e., laundry and catering services, etc.) and products offered by the local	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
			power plant	local residents' feelings	community				
11	Land Use and Utilization of Local Resources	- Changing traditional land use patterns and utilization of local resources	-----	- Consideration of local residents' feelings	- Implement the same mitigation measures as those addressed in "Local economy"	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
12	Disturbance to Water Usage, Water Rights, etc.	- Adverse impact due to water pollution	- Same as those addressed in "Water quality"	- Same as those addressed in "Water quality"	- Implement the same mitigation measures as those addressed in "Water quality"	- Power plant	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
13	Disturbance to the Existing Social Infrastructure and Services	1) Traffic jams caused by increased vehicles 2) Improved roads along with the power plant 3) Improved social infrastructure along with the power plant	-----	1) Traffic volume will increase 2) Access to social services 3) Improvement of living standards of local residents	1) Traffic volume - Minimizing traffic volume by using buses for employees 2) Access to social services - Construction of the access road, community road, and road around the power plant boundary - These roads can be used even in the rainy season. 3) Improvement of living - New service facilities, such as school and medical center, are made available to local residents, as required - Electrification of surrounding area will be examined	1), 2) Villages near the site 3) Power plant	1) 3) During the operation of power plant	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
14	Misdistribution of Benefits and Compensation	- It can occur among residents, workers, government officers and local politicians	-----	- Consideration to affected peoples' emotions	- Developing an employment plan that is fair to every affected person	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
15	Local Conflicts of Interest	- Conflict between local residents and workers	- Change in local customs	- Consideration of the attitudes of local residents to the project	- Employ local residents as much as possible - Promote communication between workers and local people (e.g., join in local events)	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL - Hire local residence: 1,000Tk./person-day
16	Gender	- Improved road along with the power plant	-----	- Access to social services and markets	- Implement the same mitigation measures as those outlined in "Poor people"	- Villages near the site	- During the operation of power plant	CPGCBL	Expenses by CPGCBL
17	Children's Rights	1) Child labor 2) Improved road along with the power plant	-----	1) Banning child labor 2) Access to schools	1) Child labor - Prohibit labor contracts between subcontractor and children - Patrolling periodically to check for any child labor 2) Improved roads - Construction of the access road, community road, and road around the power plant boundary - These roads will be built with sufficient height so that they can be used even in the rainy season	1), 2) - Power plant	1), 2) - During the operation of power plant	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
18	Work environment (including work safety)	1) Labor accidents 2) Diseases caused by air pollutants, water pollutants, and noise from the operation of the power plant	1) Labor accidents - Handling heavy loads - Working at heights - Electric shocks 2) Environment pollution - Ambient air quality standards - Noise standards - Waste management rules - IFC guideline values for ambient air quality and noise (General/ 2007)	1), 2) - Prevention measures against labor accidents and health problems	1) Labor accidents - Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate - Use equipment that protects against electric shock 3) Environment pollution - Observe related standards and provide workers with appropriate facilities	1), 2) - Power plant	1), 2) - During the operation of power plant	CPGCBL	Expenses by CPGCBL - Safety education and training: 75,000Tk./ 20person - Protective equipment: 5,000Tk./ person
19	Accidents	1) Traffic accidents 2) Fire 3) Cyclones and tidal surge	1) Traffic accidents - Marine traffic - Land traffic 2) Fire 3) Cyclones and tidal surge	1) Prevention of traffic accidents 2) Prevention of fire 3) Prevent floods caused by cyclones	1) Traffic accidents - Determining water routes and setting course buoys on navigation channel for safety - Informing vessel schedules to local fishermen, etc. - Observation of traffic regulations, installation of	1) Villages near the site 2) Power plant	1), 2) During the operation of power plant	CPGCBL	Expenses by CPGCBL - Course buoys: 5,000Tk./ unit - Fire extinguisher: 60,000Tk./ set (Consist of 6 pcs)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					traffic signs, and education on safe driving - Informing bus schedules to the surrounding villages 2) Fire - Installing fire extinguishers in fire handling places - Installing fire fighting system - Spraying water in coal yard - Developing fire fighting organization and implementing fire drills 3) Cyclones and tidal surges - Construction of embankment along navigation channels and revetment in the port to prevent floods caused by cyclones.				
20	Cross-boundary impact and climate change	- CO ₂ emission	- Amount of CO ₂ emission	- Reduce CO ₂ emissions per electric generate (kW)	- Use of USC of high efficiency for power generation	- Power plant	- During the operation of power plant	CPGCBL	Expenses by CPGCBL - Boiler and auxiliaries: 433million US\$

(Source: JICA Study Team)

Table 7.1.2 Environmental Management Plan (Port Facility)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) - Ambient Air Quality Standard - IFC guideline values for ambient air quality (General/ 2007)	1) - 3) - Prevention of air pollution in the surrounding area	1) Dust prevention - Watering access road and construction site, especially in the dry season - Using cover sheets on trucks for the transportation of soil 2) Gas emission prevention - Periodic maintenance and management of all the construction machinery and vehicles 3) Waste management - Prohibit open burning and illegal dumping	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality	1) Dredging 2) Landfill for land preparation	1), 2) - Wastewater standards for industrial activity	1), 2) - Prevention of water pollution in the surrounding coastal area	1) Dredging - Conducting dredging at sea area with pump dredger or grab dredger and setting film preventing the diffusion of contamination - When dredging terrestrial area, firstly driving steel sheet pile at the sea side	1) Dredging area 2) Power plant site	1) During the dredging activities 2) During landfill activities	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					and dredging with pump or grab after sea water penetrates the land 2) Landfill - Treating turbid water from land, such as rainwater run off, with precipitation process and discharging the remaining water into the excavated part of the port				
3	Waste	- Dredging material for the channel	- Waste Management Rules	- Prevention of inappropriate waste disposal	1) Dredging material - Sand: Use for leveling the site - Silt: Dispose in the ash pond (7,500,000m ³)	1) Dredging area 2) Power plant site	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
4	Noise and Vibration	- Noise and vibration caused by construction machinery	- Noise level standards - IFC guideline values for noise (General/ 2007)	- Reduction of noise levels from construction activities	- Optimizing construction schedule - Perform construction work during daytime, especially piling work - Using low-noise/ low vibration equipment as much as possible	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
5	Ecosystem	1) Existence of endangered species 2) Spawning of sea turtles	1), 2) - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline	1), 2) - Protection of endangered species	1) Existence of endangered species - Prohibit disturbance, harassment, and hunting, especially the Spoon billed Sandpiper, by workers - Replace to nearby sites if	1) Construction area 2) Construction site adjoining sand beach	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
			(2010)		needed. 2) Spawning of sea turtles - Turning off unnecessary lights during the nesting season - Using a smaller number or lower wattage of lights - Using red and yellow lights (as sea turtles are less affected by these colors) - Using low noise machinery - Planning construction activities to minimize adverse effects during the nesting season				
6	Disturbance to the Existing Social Infrastructure and Social Services	- Increase the number of construction vessels	- Interference to other tankers, barges, and fishing boats	-----	- Consulting with related authorities on vessel schedules - Determining water routes after consultation with related authorities	- Sea area around construction area for port facility	-During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
7	Work environment (including work safety)	1) Labor accidents 2) Diseases caused by air pollutants, water pollutants, and noise by construction	1) Labor accidents - Handling heavy loads - Working at heights - Electric shocks 2) Environment pollution	1), 2) - Prevention of labor accidents, traffic accidents, and health problems	1) Labor accidents - Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		work	- Ambient Air Quality Standards - Noise level standards - Waste management rule - IFC guideline values for ambient air quality and noise (General/ 2007)		- lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate during the period of construction - Use equipment that protects against electric shock 2) Environment pollution - Observe related standards and provide workers with appropriate facilities				
8	Accidents	- Traffic accidents	- Marine traffic accidents	- Prevention of traffic accidents	- Setting marking buoys around the construction area for marine safety - Informing vessel schedules to local fishermen, etc.	- Sea area around construction area for port facility	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
Operational Phase									
1	Air Quality	1) Dust from coal handling activity at port 2) Exhaust gas from vessels	1) Coal handling - Ambient air quality (No.41/199) - IFC guideline for ambient air quality (General/ 2007) 2) MALPOL 73/78 treaty	1) Appropriate coal handling during coal unloading activity 2) Prevention of air pollution caused by vessels	1) Coal handling - A cover will be installed on the conveyor for coal transportation to coal yard - Unloading of coal will be minimized (e.g., reduce the frequency of activity, etc.) during times of high speed winds - Spraying water in coal	1), 2) - Port facility	1), 2) - During coal unloading activity	CPGCBL/ Environmental Consultant	Expenses by CPGCBL/ Vessel owners

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
			(Annex VI)		handling area to keep the surface wet and prevent wind from blowing coal and dust 2) Gas emission from vessels - Hire vessels compliant to MARPOL 73/78 treaty - Stop engines in the port				
2	Water Quality	- Dredging material for the maintenance of the navigation channel	- Regulations relating to dredging	- Minimization of water pollution by dredging	- To choose dredging method and equipment that will minimize turbidity	- Dredging area	- During the dredging activities	CPGCBL/ Environmental Consultant	Expenses by CPGCBL
		1) Operation of the port may cause a coal spillage, and as a result, water pollution will occur 2) Leakages of oil from oil tankers 3) Wastewater from vessels will cause water pollution	1) ---- 2), 3) - MALPOL 73/78 treaty (Annex I-V) 3) Wastewater from vessels - International Convention for the control and management of Ships' Ballast Water and Sediments (BWM), 2004	1) Appropriate coal handling during coal unloading activity 2), 3) Prevention of water pollution caused by vessels	1) Operation of the port - Cover installation on conveyor for coal transportation to coal yard 2) Leakages of oil from oil tankers - Installation of oil fence 3) Wastewater from vessels - Prohibition of dumping any contaminated materials - Hire vessels compliant to MARPOL 73/78 treaty and BWM - Any waste will be treated by the port facility	1) - 3) - Port facility	1) - 3) - During coal unloading activity		Expenses by CPGCBL/ Vessel owners
3	Waste	- Dredging material for the maintenance of	- Waste management rules	- Prevention of inappropriate waste disposal	- Sand: To use for construction material - Silt: To dispose in ash	- Dredging area	- During the dredging activities.	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		the channel			pond (365,000m ³ /year)				
		- Waste from vessels	- Waste management rules - MALPOL 73/78 treaty (Annex I-V)	- Appropriate waste management	- Prohibition of dumping any contaminated materials - Hire vessels compliant to MARPOL 73/78 treaty - Any waste will be treated by the port facility	- Port facility	- During coal unloading activity		Expenses by CPGCBL / Vessel owners
4	Noise and Vibration	- Noise from coal handling activity at the port	- Noise standards - IFC guideline values for noise (General/2007)	- Mitigation of noise generated by the unloading activity	- Maintenance of equipment - Installation of low noise type equipment - Optimizing coal unloading schedule	- Port facility	- During coal unloading activity	CPGCBL	Expenses by CPGCBL
5	Ecosystem	1) Existence of endangered species 2) Spawning of sea turtles	1), 2) - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010)	1), 2) - Protection of endangered species	1) Existence of endangered species - Prohibit disturbance, harassment, and hunting, especially of the Spoon billed Sandpiper, by workers 2) Spawning of sea turtles - Turning off unnecessary lights during the nesting season - Using a smaller number or lower wattage of lights - Using red and yellow lights (as sea turtles are less affected by these colors) - Using low noise machinery	- Around the port facility	- During the operation of the power plant	CPGCBL	Expenses by CPGCBL
		1) Operation of the port may cause	1) ---- 2), 3)	1) Appropriate coal handling	1) Operation of the port - Cover installation on	1) - 3) - Port facility	1) - 3) - During coal		Expenses by CPGCBL/ Vessel

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		a coal spillage, and as a result, water pollution will occur 2) Leakage oil from oil tanker 3) Wastewater from vessels will cause water pollution	MALPOL 73/78 treaty (Annex I-V) 3) Wastewater from vessels International Convention for the control and management of Ships' Ballast Water and Sediments (BWM), 2004	during coal unloading activity 2). 3) Prevention of water pollution caused by vessels	conveyor for coal transportation to coal yard. 2) Leakages of oil from oil tankers - Installation of oil fence 3) Wastewater from vessels - Prohibition of dumping any contaminated materials - Hire vessels compliant to MARPOL 73/78 treaty and BWM - Any waste will be treated by the port facility		unloading activity - During oil storage activity		owners
6	Hydrology	- Potential impact to tidal currents caused by construction of the port facility	- Tidal currents	- Minimization of change of tidal currents	- Conducting tidal current simulation to assess any changes in tidal currents	- Sea area port facility	- During operation of the port facility	CPGCBL	Expenses by CPGCBL
7	Topography and Geology	- Potential impact on coastal line caused by changing tidal currents	- Coastal line	- Minimization of change of coastal line	- Conducting tidal current simulation to assess the change of drift sand movement	- Sea area around construction area for port facility	- During operation of the port facility	CPGCBL	Expenses by CPGCBL
8	Disturbance to the Existing Social Infrastructure and Social Services	- Increase in the number of vessels	- Interference to other tankers or barges	-----	- Setting water routes after consultation with related authorities	Sea area around port facility	During coal unloading activity	CPGCBL	Expenses by CPGCBL
9	Work Environment (Including	1) Labor accidents 2) Diseases	1) Labor accidents - Handling heavy	1), 2) Prevention of labor accidents	1) Labor accidents - Prepare a manual for labor accident prevention	1), 2) Port facility	1), 2) - During coal unloading	CPGCBL	Expenses by CPGCBL

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
	Work Safety)	caused by air pollutants and noise by coal unloading activity	loads - Working at heights 2) Environmental pollution - Ambient air quality standards - Noise standards - Waste management rules - IFC guideline values for ambient air quality and noise (General/ 2007)	and health problems	including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate 2) Environment pollution - Observe related standards and provide workers with appropriate equipment		activity		
10	Accidents	- Traffic accidents	- Marine traffic	- Prevention of traffic accidents	- Consulting with related authorities on vessel schedules - Determining water routes after consultation with related authorities - Setting course buoys around navigation channel area for marine safety - Informing operation schedule to local fishermen etc.	- Sea area around port facility	- During coal unloading activity	CPGCBL	Expenses by CPGCBL

(Source: JICA Study Team)

7.2 Proposed Mitigation or Management Measures for Threatened Species

Biological repercussions to nesting turtles do not always occur.

Any impact is dependent upon the level of physical disturbance caused by noise and lighting adjacent to the sand beach coast.

When the levels of physical disturbance appears to be high, effective mitigation measures described in the table below should be discussed.

Table 7.2.1 Proposed Mitigation or Management Measures on Threatened Species

	Scientific (English)	IUCN	Proposed Mitigation or Management Measures
1	<i>Eurynorhynchus pygmeus</i> (Spoon-billed Sandpiper)	CR	For the purpose of protecting the species, workers will be instructed to strictly comply with hunting and capturing restrictions prescribed by law.
2	<i>Geoclemys hamiltonii</i> (Spotted Pond Turtle)	VU	Feed on fish, invertebrates, and floating aquatic plants. There are no ponds or waterways which provide them with such foods in the project site. Prohibit disturbance, harassment, and hunting by project workers or contractors while working, traveling by vehicles or residing in the project field accommodation and encourage workers to quickly place them into nearby fresh ponds or rivers if they encounter the creatures.
3	<i>Lepidochelys olivacea</i> , (Olive Ridley Turtle)	VU	Sensitive to light and noise, so noise and use of flashlights on the coast at night can cause nesting females to halt their nesting. Measures available to mitigate these impacts should be taken: ➤ Turning off unnecessary lights during the nesting season ➤ Using a smaller number or lower wattage of lights ➤ Shielding, redirecting and repositioning lights ➤ Using red, yellow, and low-pressure sodium-vapor lights (as sea turtles are less affected by these colors) ➤ Using low-level noise heavy machinery (concrete mixing, excavation machinery, etc.) ➤ Planning construction activities to minimize adverse effects during the nesting season ➤ Avoiding tall structures creating shade on the coast to maintain nest temperatures ➤ Control the introduction of non-native plants which may lead to impenetrable root mats (The optimal use of any one of these measures depends upon the results of the current sea turtle survey)
4	<i>Caretta caretta</i> (Logger head turtle)	EN	
5	<i>Chelonia mydas</i> (Green turtle)	EN	
6	<i>Eretmochelys Imbricate</i> (Hawksbill turtle)	CR	

The protection measures outlined in Table 7.2.2 shall be considered when dealing with the 11 species indicated by the Bangladeshi scientist groups.

Table 7.2.2 Threatened Species proposed by Bangladesh Scientist Groups

Taxa	No.	Scientific Name	English Name	Available Mitigation Measures
Flora	1	<i>Calamus guruba</i> <i>Buch.-Ham.</i>	Cane	➤ Transfer to similar sites to the project area - And if impossible to transfer: ➤ Collection of seeds or adoption of cuttings
	2	<i>Trichosanthes cordata</i> Roxb.	Snake guard	
	3	<i>Lepisanthes rubiginosa</i>	Rusty sapindus	
	3			
Reptile	1	<i>Calotes versicolor</i>	Garden lizard	➤ Prohibit disturbance, harassment, killing or possession of these species by project workers or contractors while working.
	2	<i>Mabuya mabuya</i>	Skink	
	3	<i>Gekko gekko</i>	Tokay Gecko	
	4	<i>Pangshura tentoria</i>	Median Roofed Turtle	
	5	<i>Naja naja</i>	Bicled Cobra	
	5			
Bird	1	<i>Arachnothera magna</i>	Streaked Spiderhunter	(These species can easily fly away from the disturbed habitat and find other suitable habitats) ➤ Prohibit illegal hunting by project workers or contractors while working.
	2	<i>Ketupa zeylonensis</i>	Broun Fish Owl	
	3	<i>Vanellus duvaucelii</i>	River Lapwing	
	3			
Total	11			

Chapter 8

Risk Management

Chapter 8

Risk Management

Table of Contents

8.1	Identification of Risk	1
8.2	Analysis of Risk	1

8 Risk Management

8.1 Identification of Risks

The implementation of a large scale infrastructure project involves many complex and diverse risks. The identification and allocation of those risks is critical in structuring the financing facility for such a project. The project finance which is the technology widely used by internationally established financial institutions for infrastructure projects thoroughly analyzes the risks associated and constructs appropriate measures for mitigation. Unlike the project financed under a commercial basis, the project formulated under the government sector relies upon the credibility of the government in arranging financing for implementation. For the project financed by ODA assistance, in particular, the project is implemented by the Executing Agency (Project Company) with support of the government who bears the eventual and ultimate risk for debt servicing while the provider of assistance remains keen on the debt servicing with the view to the achievement and continuation of successful operations and sustainability of the project. The concern of the provider of ODA assistance centers on the smooth implementation of the project, the efficient operation and materialization of the output, and the effect and impact is achieved as has been designed. The technology used for project finance in identifying and allocating the risks and establishing the safeguarding measures, however, remains valid and reflective in enabling the government and the Executing Agency to tightly control the project. In general, a large infrastructure project is conceived to be associated with the following materially significant risks:

- ✓ Political risk,
- ✓ Capability of the executing agency for implementation,
- ✓ Natural calamities, etc.,
- ✓ Occurrence of fatal accident,
- ✓ Project completion,
- ✓ Social and environmental risk,
- ✓ Economic and financial viability,
- ✓ Availability and stable supply of fuel,
- ✓ Related infrastructure such as the transmission lines, and
- ✓ Others

8.2 Analyses of Risks

The risks listed above are reviewed and the mitigation measures to be taken are described in the following table for each of the risks mentioned;

Table 8.2.1 Identification of Risks by Causes (Prior to COD)

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
Political risk	War or civil commotions, etc.	Suspension or destruction during the implementation phase.	X (GOB)					⌚Suspension, postponement of the project and/or destruction of the plant under construction.
	Seizure by government	Seizure of the Project resulting in disruption or deterioration of the efficiency	X (GOB)			⌚Implementation Agreement (IPP)		⌚same as above
	Foreign exchange control	Change in the exchange control	X (GOB)			⌚Implementation Agreement (IPP)		⌚same as above
	Law, policy or taxation change	Changes in Power Sector Policy, Coal Policy, taxation, etc.	X (GOB)			⌚Implementation Agreement (IPP)		⌚same as above
	Socio-economic instability	Riot, strikes, social unrest, etc.	X (GOB)			⌚Implementation Agreement (IPP)		⌚same as above
	Concession or operational right	Revocation of license or changes in the business rights	X (GOB)			⌚Implementation Agreement (IPP)		⌚same as above
Capability of sponsor risk	Managerial incapability	Unsophisticated management causing delay, over-run cost		X			⌚Recruitment of capable staff and employment of capable consultants	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
	Financial incapability	Failure to attain healthy financial conditions for, timely provision of paid-up capital and funding support for covering the cost over-run.		X			⑤Recruitment of capable staff	
Natural calamities, etc.	Cyclone				X	⑤Insurance	⑤Design standard (raising the ground level by 10m) and insurance	
	Tidal wave				X	⑤Insurance	⑤Design standard (raising the ground level by 10m) and insurance	
	Earthquake				X	⑤Insurance	⑤Design standard (aseismatic structure) and insurance	
	Tsunami				X	⑤Insurance	⑤Design standard (raising the ground level by 10m) and insurance	
	Others	Lightening, Storm, Tornado, Radioactive contamination, Fire, Epidemics, etc.			X	⑤Insurance	⑤Design standard (various), insurance and other appropriate measures.	
Occurrence of fatal accident	Occurrence of accident	Disruption and delay in construction due to accident investigation and introduction of countermeasures				⑤Insurance	⑤Continuous training for safety management and insurance coverage	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHARED			
Plant Completion (incl. access road, port and coal unloading facilities, etc.)	Insufficient capability of the consultants			X		ⒺConsulting Contract	ⒺTechnical assessment and screening through prequalification	
	Insufficient capability of the EPC contractor			X		ⒺConstruction Contract	ⒺTechnical assessment and screening through prequalification	
	Poor Performance or defaults of sub-contractors			X		ⒺConstruction contracts	ⒺPerformance management by prime contractors and supervision by consultant	
	Delay in Govt approvals in planning, development and operation		X (MPEMR)			ⒺShareholder's Agreement	ⒺEffective and timely management by CPGCBL for total project	
	Delay in progress and completion	Failure to complete the project as has been planned and designed. Along with the Project, related infrastructure required for the Project needs to be completed.		X		ⒺConstruction Contract	ⒺConstruction management by sponsor, consultant and EPC contractor	
	Increase in the cost of plant and material	Insufficiency of funds due to cost increase.		X		ⒺConstruction Contract	ⒺContingency	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
	Failure in procurement of the fuel for plant testing	Discontinuation or disruption of plant testing operation due to the shortage of fuel.		X		ⓈFuel Supply Contract (Coal, Gas & Oil) ⓈGovernment Guarantee for Supply of Gas (IPP)	ⓈMobilization of trading firms for procurement [↗] to be funded by GOB or by JICA [↗]	
Social and environmental risk	Non-acceptance of the Project by the local government	Failure or delay in starting construction of the plant	X (MPEMR)			ⓈImplementation Agreement (IPP)	ⓈConsultation	
	Failure or delay in acquisition of the land	Failure or delay in starting construction of the plant	X (MPEMR)			ⓈLand Lease Agreement	ⓈConsultation	
	Failure in resettlement	Failure or delay in starting construction of the plant	X (MPEMR)			ⓈLand Lease Agreement	ⓈConsultation	
	Resistance by local inhabitants	Failure or delay in starting construction of the plant	X (MPEMR)				ⓈConsultation	
	Failure or delay to obtain dredging permit	Failure or delay in starting construction of the plant	X (MPEMR)			ⓈImplementation Agreement (IPP)		
	Congestion in surface transport	Delay in construction schedule	X (MPEMR)				ⓈConstruction of access road	
	Identification of the rare species (animals or plants)	Disruption or suspension of project implementation	X (MPEMR)				ⓈEnvironmental Impact Assessment	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
	Contamination/ pollution to the site environment			X			☑ Compliance with environmental protection guidelines	
	Deficiency financing risk	Temporary deficiency in cash flow (delay in budget execution, etc.)		X		☑ Borrowing Facilities from Banks ☑ Shareholder's Support (Agreement)	☑ Financial assistance by GOB or BPDB	
	Budgeting and financing	Purchasing of fuel for plant testing and working capital required prior to COD		X		☑ Borrowing Facilities from Banks ☑ Shareholder's Support (Agreement)	☑ Preparation of budget and fund raising for budget implementation	
	Fluctuation of exchange rate	Unexpected cost increase in construction cost, etc. and insufficiency of funds due to exchange loss.		X		☑ Borrowing Facilities from Banks ☑ Shareholder's Support (Agreement)	☑ Contingency	
	Increase in inflation	Unexpected cost increase in construction cost, etc. and insufficiency of funds due to cost increase.		X			☑ Contingency	
	Insurance risk	Availability of specific coverage and/or fluctuation of insurance premium		X		☑ Insurance contract	☑ Consultation with insurance broker or company	
	Non-compliant bids	Delay in project implementation		X		☑ Invitation for Bidding, Conditions for Pre-qualification and Specifications	☑ Quality enhancement of cost estimation	

Risk Category	Sub-category	Profile of Risk	Risk Born by			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHAR ED			
Transmission lines	Failure in acquisition of the right of way	Delay in construction of the transmission lines	X (MPEMR)			ⒺImplementation Agreement (IPP)	ⒺConsultation	
	Delay in completion of the inter- linked transmission lines	Non-readiness for trial run	X (MPEMR, PGCB)			ⒺImplementation Agreement (IPP)	ⒺFormulation of the Project without relying on the other transmission lines	

(source) JICA Study Team

Similarly, the risks listed for the phase after the commissioning date are reviewed and the measures to be taken for mitigation are described in the following table for each of the risks mentioned;

Table 8.2.2 Identification of Risks by Causes (Post COD)

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
Political risk	War or civil commotions, etc.	Suspension or destruction during the implementation phase.	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement		☒ Suspension, postponement of the project and/or destruction of the plant under operation
	Seizure by government	Seizure of the Project resulting in disruption or deterioration of the efficiency	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement		☒ same as above
	Foreign exchange control	Change in the exchange control	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement		☒ same as above
	Law, policy or taxation change	Changes in Power Sector Policy, Coal Policy, taxation, etc.	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement		☒ same as above
	Socio-economic instability	Riot, strikes, social unrest, etc.	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement ☒ Insurance		☒ same as above
	Concession or operational right	Revocation of license or changes in the business rights	X (GOB)			☒ Implementation Agreement (IPP) ☒ Power Purchase Agreement		☒ same as above

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
Capability of sponsor risk	Managerial incapability	Unsophisticated management causing operational inefficiency		X			Recruitment of capable staff and Incentive system	
	Financial incapability	Failure to attain healthy financial conditions for, timely provision of working capital.		X				
	Operational and maintenance incapability	Increase in accidents, maintenance cost, and inefficiency in operation		X			Training system for operational staffs and incentive system	
	Incapability of the outsourced company	Failure to achieve the targeted level of performance under contract		X		Ⓔ Outsourcing Contract	Enhancement of training system and employment of foreign engineers	
Natural calamities, etc.	Cyclone	Continuous non-accessibility period for berthing by the coal carriers			X	Ⓔ Insurance	Design standard (coal storage for 60 days) and insurance	
	Tidal wave				X	Ⓔ Insurance	Design standard (raising the ground level by 10m) and insurance	
	Earthquake				X	Ⓔ Insurance	Design standard (a seismically strong structure) and insurance	
	Tsunami				X	Ⓔ Insurance	Design standard (raising the ground level by 10m) and insurance	

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Others	Lightening, Storm, Tornado, Radioactive contamination, Fire, Epidemics, etc.			X	☹Insurance	Design standard (various), insurance and other appropriate measures.	
Occurrence of fatal accident	Occurrence of a major scale of accident	Long term disruption in plant operation		X		☹Insurance	Preventing maintenance and insurance	
Plant Completion (incl. access road, port and coal unloading facilities, etc.)	Failure to achieve the designed capacity performance	Less revenue due to reduction of output		X		☹Construction Contract	Extension of warranty period	
	Unexpected deterioration in operational performance	Increased consumption of fuel due to inefficiency or less revenue due to reduction of output		X		☹Construction Contract	Periodical maintenance	
Social and environmental risk	Negative impact on fishery	Suspension in plant operation or reduction in operating ratio			X	☹Insurance	Reconsideration on warm water discharge	
	Traffic congestion on surface transport				X		Construction of access road	
	Contamination/pollution to the site environment			X			☹Compliance with environmental protection guidelines	
	Malfunctioning and/or deterioration of environmental devices	Suspension in plant operation or reduction in operating ratio		X		☹Manufacturer's Warranty ☹Insurance	Periodical maintenance and insurance	
Economic and financial viability risk	Sales and collection risk	Sales price in short of cost recovery and/or slow collection		X		☹Power Purchase Agreement		

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Delay and/or insufficiency in tariff adjustment				X	☒PPA	Good operational performance, close monitoring and adjustment of tariff	
	Deficiency financing risk	Unexpected shortfall of funds for expenditure and/or debt servicing		X		☒Borrowing Facilities from Banks ☒Escrow Account ☒Shareholder's Support (Agreement)	Parental funding support by BPDB	
	Budgeting and financing	Failure in financial management for O&M, in particular, the fund shortage for periodical maintenance		X		☒Borrowing Facilities from Banks ☒Shareholder's Support (Agreement)	Incorporation of sufficient budget for periodical maintenance↗	
	Fluctuation of foreign exchange	Unexpected cost increase in fuel cost and O&M and insufficiency of funds due to exchange loss.		X		☒Power Purchase Agreement ☒Borrowing Facilities from Banks ☒Shareholder's Support (Agreement)		
	Insurance risk	Availability of specific coverage and/or fluctuation of insurance premium		X		☒Insurance contract	☒Consultation with insurance broker or company	

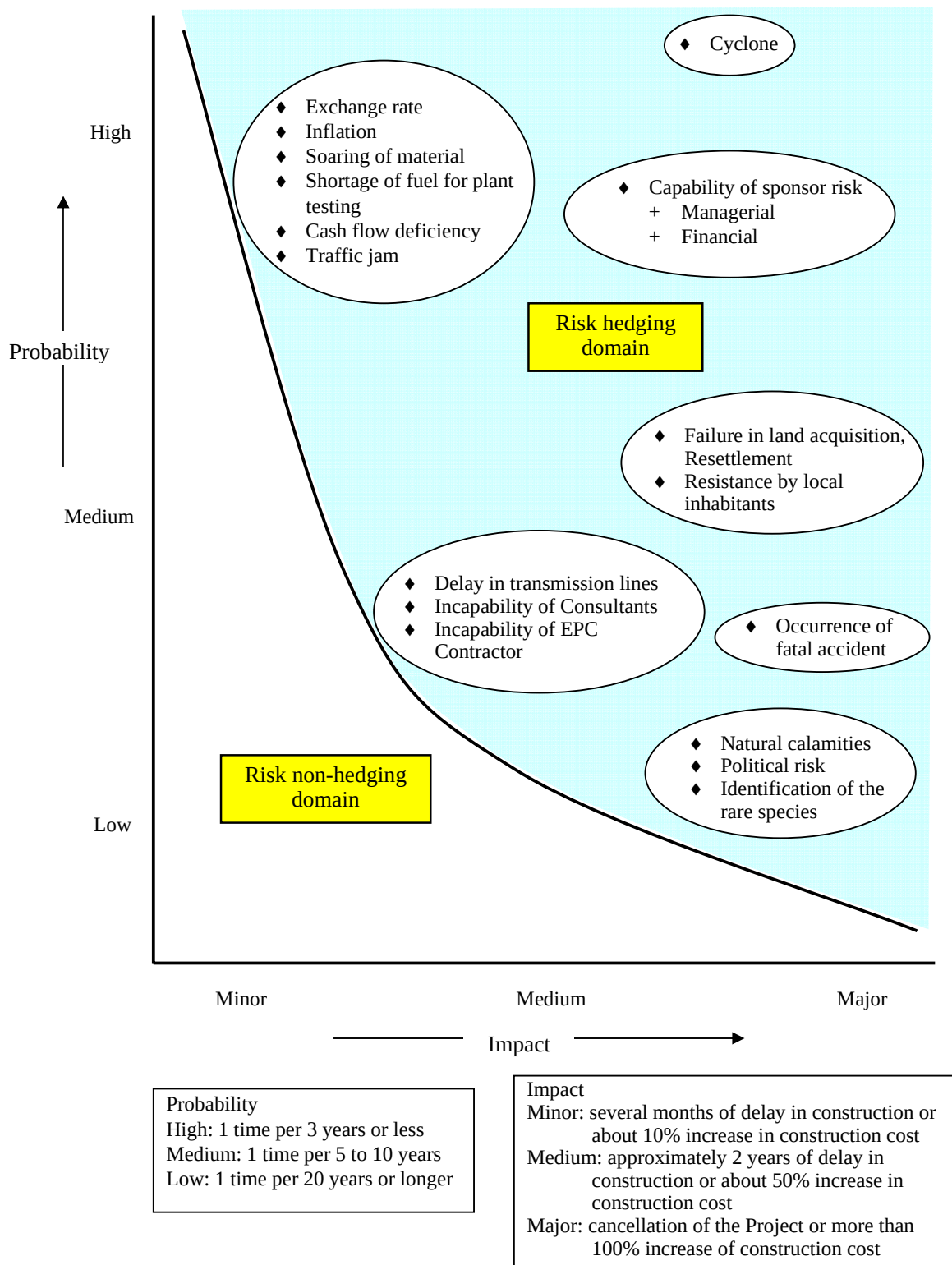
Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Aggravation of inflation	Unexpected cost increase in fuel cost and O&M and insufficiency of funds due to cost increase.		X		☹️Power Purchase Agreement ☹️Borrowing Facilities from Banks ☹️Shareholder's Support (Agreement)		
Availability and stable supply risk of fuel	Non-availability of Fuel and other materials	Occurrence of shortfall in fuel coal and/or other materials		X		☹️Coal Supply Contract	☹️Diversification of supply sources ☹️Sufficient stocks maintained	
	Non-availability of coal-carrying vessel	Occurrence of shortfall in fuel coal		X		☹️Charter-hire contract	☹️Medium term charter contract of spot hire contract diversified ☹️Sufficient stocks maintained	
	Long term contract risk	Discontinuation or disruption of stable operation due to the shortage of fuel while Binding obligation for purchase for the contract term and/or take-or-pay obligation		X		☹️Coal Supply Contract	Diversification of contract terms	
	Volatile market price	Instability in the import cost of fuel resulting in the loss of economic/financial viability		X		☹️Power Purchase Agreement		

Risk Category	Sub-category	Profile of Risk	Risk Born By			Contract for Risk Covering	Mitigating Measures	Possible Impact from Non-Mitigated Risks
			GOVT/ BPDB	CPG CBL	SHA RED			
	Unbalanced qualities of fuel coal	Inharmonious quality for mixing		X		☒Coal Supply Contract	Construction of a reserve mills for coal of low calorific value	
	Non-availability of start-up fuel	Inability to start-up the plant		X		☒Fuel Supply Contract ☒Government Guarantee for Fuel (Gas or Oil) Supply (IPP)	Sufficient storage of fuel	
Transmission lines	Troubles at transmission lines	Inability to transmit the power causing the suspension of plant operation	X (PGCB)			☒Power Purchase Agreement ☒Implementation Agreement (IPP)		
Others	Sluggish increase in power demand	No dispatch instruction to the plant	X (MPEMR)			☒Power Purchase Agreement ☒Implementation Agreement (IPP)		
	Development of low cost gas field and/or procurement of LNG (provision of lower price gas)	Dispatch instruction to the coal fired plant becomes subordinate to other fuel and the coal fired plant to be operated as the middle-load system	X (MPEMR)			☒Power Purchase Agreement ☒Implementation Agreement (IPP)		

(source) JICA Study Team

It should be noted that in the two tables given above, it shows that the risk categories as well as the sub-categories appear similar in many of the risk items but the profiles are described distinctively different as the risks surrounding the Project may appear in a different manner between the two phases of the Project.

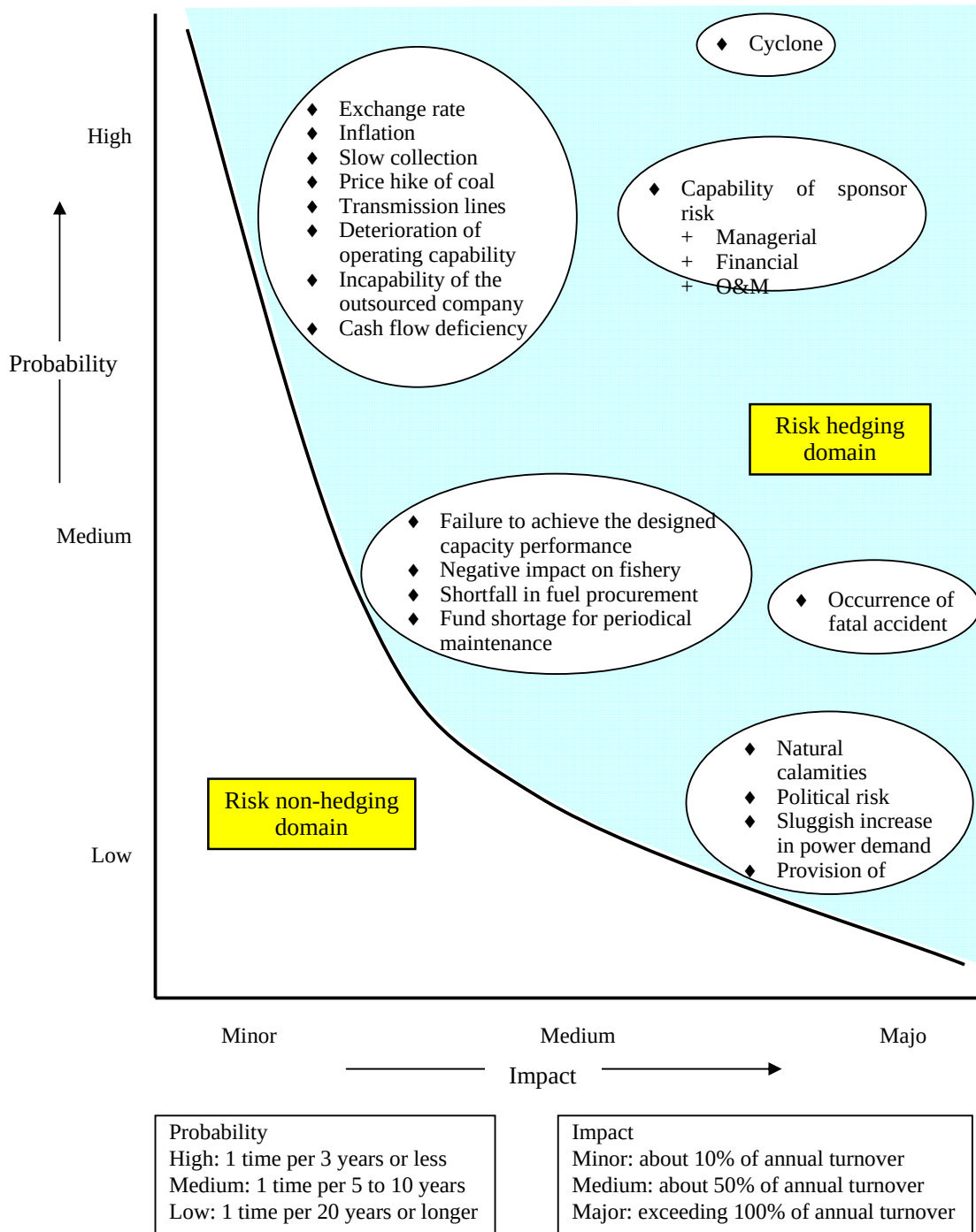
The risks are then analyzed in terms of their probability of occurrence and the impacts associated. In order to distinguish the risks that should be safeguarded or mitigated from the ones that should be left unattended, an attempt is herein made to draw a curve and plot each of the risks in a figure above or below the mitigation curve. The mitigation curve distinguishes the sphere for mitigation from the one for non-mitigation. For the risks plotted above the mitigation curve, appropriate measures for mitigation should be deliberated and introduced as their products of the probability multiplied by the impact becomes substantial. Meanwhile, the risks below the mitigation curve will be left without mitigation as the products of the probability multiplied by the impact will be less substantial. The following figure is one that describes the analysis for the phase prior to the commissioning date;



(source) JICA Study Team

Figure 8.2.1 Identification of Risks by Causes prior to COD

Similarly, the following figure depicts the risks analyzed for the period after the commissioning date;



(source) JICA Study Team

Figure 8.2.2 Identification of Risks by Causes (post COD)

Chapter 9

Environmental Monitoring Plan

Chapter 9
Environmental Monitoring Plan

Table of Contents

9.1	Power Plant and Port Facility	1

9 Monitoring plan

9.1 Power Plant and Port Facility

An Environmental Monitoring Plan will be prepared to provide guidelines for environmental management plan during the construction and operation phases of the Coal-fired Power Plant. The environmental components that will be monitored are those that will be positively or negatively affected, or expected to be affected, by construction activity. Environmental management is a sustainable way of planning, arranging, supervising, organizing, and developing the environment for the maintenance of the preservation of natural resources and the prevention or reduction of damage to the environment.

(1) Power Plant

The major environmental impact, monitoring method, responsible organization, and expense for each environmental item in the construction and operation phases for the power plant are listed in Table 9.1.

(2) Port Facility

The major environmental impacts, monitoring methods, responsible organizations, and expenses for each environmental item in the construction and operation phases for the power plant are listed in Table 9.2.

Table 9.1 Environmental Monitoring Plan (Power plant)

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Pre-Construction									
1	Land acquisition	1) Loss of private land 2) Loss of salt fields, shrimp farms and fishing sites 3) Loss of residential/ commercial structures 4) Loss of trees, home gardens, fish ponds and fruit plants	1) - 4) - The Acquisition and Requisition of Immovable Property Ordinance of 1982 - JICA Guideline (2010)	1) - 4) - Confirmation of compensation process	1) - 4) - Attendance at compensation payment - Record of compensation agreements	1) - 4) - Areas eligible for compensation	1) - 4) - During land acquisition process	- Office of the Deputy Commissioner - CPGCBL	Expenses by CPGCBL - Witness: 6,500Tk./ person/day
2	Disturbance to poor people	1) Poor households among those who are to be resettled 2) Loss of salt fields, shrimp farms and fishing sites	1), 2) - JICA Guideline (2010)	1), 2) - Same as those addressed in “Land acquisition”	1), 2) - Interviewing affected people	1), 2) - Affected people	1), 2) - Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses by CPGCBL - Interviewer: 5,500Tk./ person/day
3	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Changing peoples` thinking through interacting with local government officers, local residents and others in the land acquisition procedure	-----	- Confirmation of affected peoples` feelings	- Interviewing affected people	- Affected people	- Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses by CPGCBL
4	Misdistribution of Benefits and Compensation	- It can occur among residents, workers, government officers and	-----	- Same as those addressed in “Land acquisition”	- Same as those addressed in “Land acquisition”	- Same as those addressed in “Land	- Same as those addressed in “Land	- Implementation: Contractor/ Environmental	Expenses by CPGCBL

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		local politicians				acquisition”	acquisition”	Consultant - Supervisor: CPGCBL/ Supervision Consultant	
5	Local Conflicts of Interest	- It can occur among residents, workers, government officers and local politicians	-----	- Same as those addressed in “Land acquisition”	- Same as those addressed in “Land acquisition”	- Same as those addressed in “Land acquisition”	- Same as those addressed in “Land acquisition”	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses by CPGCBL
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) PM₁₀ - Ambient Air Quality Standard - IFC guideline values for ambient air quality (General/ 2007) - Meteorological Condition (Temperature, Moisture, Wind)	1) - 3) - Evaluation of effect of the mitigation measures towards air pollution	1) - 3) - Collecting samples and analyzing at a lab - Measuring meteorological data	1) - 3) - 3 points Residential area around the power plant	1) - 3) - Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Sampling: 50,000Tk./ sample - Analyzing: 45,000Tk./ sample

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
2	Water Quality (Soil) (Sediment)	1) Run off water from construction area 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakages of oil and chemical materials from construction activity	1) - 4) pH, BOD, TSS, Oil, Coliforms, etc. - Wastewater standards - Ambient water quality standards (inland surface water) - Ground water (Drinking water quality standards)	1) - 4) - Evaluation of effect of the mitigation measures towards water pollution	1) - 4) - Collecting samples and analyzing at a lab	1) - 4) - 1 point: Foreside of the drain outlet - 1 point: Surface water near the construction area - 1 point: Ground water from existing wells - 5 points: Sea water near the construction area	1) - 4) - Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Sampling: 50,000Tk./ sampling - Analyzing: 100,000Tk./ all sample
3	Wastes (Odor) (Sediment)	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rules	1) - 3) - Evaluation of effect of the mitigation measures for waste	1) - 3) - Record of kinds and quantity of waste, and the disposal method	1) - 3) - Construction area	1) - 4) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1), 2) Noise level - Noise level standards - IFC guideline values for noise (General/ 2007)	1), 2) - Evaluation of effect of the mitigation measures towards noise levels	1), 2) - Measurement using noise level meter	1), 2) - 3 points: On the border of the site near the residential areas	1), 2) - Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Measurement: 50,000Tk./ session

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
5	Ecosystem (Endangered Species)	1) Existence of endangered species 2) Spawning of sea turtles	1), 2) Species, Number - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010)	1) Evaluation of existence of endangered species 2) Evaluation of spawning of sea turtles	1), 2) - Observation	1) Endangered species - 1 point: Construction area 2) Sea turtle - 2 lines: Beach in front of the site and the sandbar	1) Endangered species - Bird: Once a week in migration season - Others: Twice a year in dry and rainy seasons 2) Every 3 days in spawning season	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Observation: 400,000Tk./ researcher/year
	Ecosystem (Marine Biota)	1) Potential impact due to the degradation of water quality caused by civil engineering work 2) Domestic wastewater of workers 3) Inappropriate disposal of solid waste	1) - 3) Species, Number - Phyto and Zoo Plankton - Benthos (Sea bottom)	1) - 3) - Evaluation of effect of the mitigation measures towards water pollution - Confirming the population and change in types of marine organisms	1) - 3) - Collecting samples at the site, analyzing at a lab	1) - 3) - 5 points: Sea area in front of construction area	1) - 3) - Twice a year in dry and rainy seasons		Expenses included in contract cost by Contractor - Sampling & analyzing: 200,000Tk./ season (Same as “water quality”)
	Ecosystem (Mud Flat, Fish & Nekton)	1) - 3) Ditto	1) - 3) Species, Number, Weight - Benthos (Mud flat) - Fish and Nekton	1) - 3) Ditto	1) - 3) - Collecting samples at the site, analyzing at a lab	1) - 3) - 1 point: In front of the site	1) - 3) - Twice a year in dry and rainy seasons		Expense is included in contract cost by Contractor - Sampling & analyzing: 200,000Tk./ season

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
6	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- Increase in employment and business opportunities	- Number of employment opportunities for local residents and number of businesses around the construction area	- Improvement of the local economy - Improvement of living standards of local residents - Consideration to local residents' feelings	- Information from related institutions - Interviewing residents	- Related institutions - Villages near the site	- Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Interviewer: 5,500Tk./ researcher (Same as "Poor people")
7	Land Use and Utilization of Local Resources	- Changing the traditional land use patterns and utilization of local resources	- Same as those addressed in "Local Economy"	- Same as those addressed in "Local Economy"	- Same as those addressed in "Local Economy"	- Same as those addressed in "Local Economy"	- Same as those addressed in "Local Economy"	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
8	Disturbance to Existing Social Infrastructure and Services	1) Increase in the number of vessels 2) Increase in the number of cars	1), 2) - Traffic volume by construction	1), 2) - Evaluation of effect of construction schedule	1), 2) - Record of numbers of vessels and cars being used	1), 2) - Project site	1), 2) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
9	Local Conflicts of Interest	- Conflict between local residents and external workers	- Change in local customs	- Confirmation of the attitudes of local residents to the project	- Interviewing residents	- Villages near the site	- Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision	Expenses included in contract cost by Contractor - Interviewer: 5,500Tk./ researcher (Same as "Poor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								Consultant	people")
10	Gender	1) Gender among those who are to be resettled 2) Loss of salt fields, shrimp farms and fishing sites	1), 2) -----	1), 2) - Same as those outlined in "Poor people"	1), 2) - Same as those outlined in "Poor people"	1), 2) - Same as those outlined in "Poor people"	1), 2) - Same as those outlined in "Poor people"	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
11	Children's Right	- Child labor	-----	- Evaluation of effect of banning child labor	- Checking the labor contracts between subcontractor and workers - Patrolling construction area for child labor	- Construction area	- Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
12	Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of infection	-----	- Evaluation of sanitation for labor	- Labor health records	- Related institutions	- Once a year	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
13	Work Environment (Including Work Safety)	- Labor accidents	- Handling heavy loads - Working at heights - Electric shock	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								Supervision Consultant	
14	Accidents	- Traffic accidents	- Marine traffic - Land traffic	- Evaluation of effect of traffic schedules	- Record of accidents	- Contractor's office	- Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
15	Cross-boundary Impact and Climate Change	- CO ₂ will be produced by construction work	-----	- Efforts to reduce CO ₂	- Record of machinery maintenance	- Contractor's office	- Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
Operation Stage									
1	Air Quality	1) Exhaust gas from the stacks 2) Dust from ash disposal activity 3) Exhaust gas from vehicles used for mobilization of equipment and workers 4) Dust from coal handling activity at jetty and coal yard	1) - 4) SO₂, NO₂, PM₁₀ - Emission gas standards - Ambient air quality standards - IFC guideline values for gas emission (Thermal power plant/ 2008) and ambient air quality (General/ 2007)	1) - 4) - Evaluation of effect of the mitigation measures towards air pollution	1) Exhaust gas - CEMS (Continuous Emission Monitoring System) 1) - 4) - Collecting samples at the site, analyzing at a lab - Measuring the meteorological	1) Stack outlet 1) - 4) - 3 points: Residential area around the power plant	1) Continuous measurement 1) - 4) - Once every 3 months	- CPGCBL/ Environmental Consultant	- CEMS (Expenses included in contract cost by Contractor) Expenses by CPGCBL - Sampling: 50,000Tk./ staff - Analyzing: 45,000Tk./ sample

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
			2) - 4) Meteorological Condition (Temperature, Moisture, Wind)		data				
2	Water Quality (Soil) (Sediment)	1) Thermal effluents from cooling system 2) Wastewater from plant process 3) Rainwater drainage from ash pond and coal yard 4) Leakages of oil and chemical materials	1) - 4) Water temperature, pH, DO, SS, oil, BOD, COD, Heavy metals - Wastewater standards - IFC guideline values for wastewater (Thermal power plant/ 2008) - Ground water (Drinking water quality standards)	1) - 4) - Evaluation of effect of the mitigation measure towards water pollution	1) Thermal effluents - Measuring vertical sea water temperature profile with CTD meter 2) - 4) - Collecting samples at the site, analyzing at a lab - Continuous measurement using a sensor	1), 4) - 5 points: Sea area around thermal water discharge point - 1 point: Ground water from existing well 2), 3) - 2 points: Drain outlet of the wastewater treatment facility	1), 4) - Once every 3 months 2), 3) - Sampling and analyzing: SS, Oil, BOD, Heavy metal etc.(as necessary) - Continuous measurement: pH	- CPGCBL/ Environmental Consultant	- Continuous sensor (Expenses included in contract cost by Contractor) Expenses by CPGCBL - CTD: 20,000 US\$ - Sampling: 50,000Tk./ staff - Analyzing: 100,000Tk./ sample
3	Waste (Odor) (Sediment)	1) Fly ash and bottom ash 2) Sludge from wastewater treatment and waste oil from equipment, etc. 3) Sewage and garbage from workers	1) - 3) - Waste management rules	1) - 3) - Evaluation of effect of the handling of coal ash, sludge, and garbage	1) Coal ash - Record of the amount of coal ash generation and disposal 2), 3) - Record of the amount of sludge and garbage	1) - 3) - Power plant office	1) - 3) - Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
4	Noise and Vibration	1) Noise and vibration from steam turbines, generators, and pumps, etc.	1) - 4) Noise level - Noise standards - IFC guideline values	1) - 4) - Evaluation of effect of the mitigation measures towards	1) - 4) - Measurement using noise level meter	1) - 4) - 3 points: On the border of the site near the	1) - 4) - Once every 3 months	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Measurement: 100,000Tk./

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		2) Noise from ash disposal activity 3) Noise caused by vehicles used for mobilization of equipment and workers 4) Noise from coal handling activity at jetty and coal yard	for noise (Thermal power plant/ 2008) (General/2007))	noise levels		residential areas			session
5	Ecosystem (Endangered Species)	1) Existence of endangered species (migration bird) 2) Spawning of sea turtles	1), 2) Species, Number - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010)	1) Evaluation of existence of endangered species (migration bird) 2) Evaluation of spawning of sea turtles	1), 2) - Observation	1) Endangered species (migration bird) - 1 point: Ash pond 2) Sea turtles - 2 lines: Beach in front of the site and the sandbar	1) Once a week in migration season 2) Every 3 days in spawning season	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Observation: 200,000Tk// researcher
	Ecosystem (Marine Biota)	1) Potential impact due to the degradation of water quality caused by civil engineering works 2) Domestic wastewater of workers 3) Inappropriate disposal of solid waste	1) - 3) Species, Number - Phyto and Zoo Plankton - Benthos (sea bottom)	1) - 3) - Evaluation of effect of the mitigation measure towards water pollution - Confirming the population and change in types of the marine organisms	1) - 3) - Collecting samples at the site, analyzing at a lab	1) - 3) - 5 points: Sea area in front of the site	1) - 3) - Twice a year in dry and rainy seasons		Expenses by CPGCBL - Sampling & Analyzing: 300,000Tk./ all sample
	Ecosystem (Mud Flat, Fish & Nekton)	1) - 3) Ditto	1) - 3) Species, Number, Weight	1) - 3) Ditto	1) - 3) - Collecting samples at the site,	1) - 3) - 1 point: In front of the site	1) - 3) - Twice a year in dry and		Expenses by CPGCBL - Sampling &

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
			- Benthos (mud flat) - Fish and nekton		analyzing at a lab		rainy seasons		Analyzing: 300,000Tk./ all sample
6	Disturbance to Poor People	- Improved road along with the power plant	-----	- Evaluation of access to social services	- Information from related institutions - Interviewing residents	- Related institutions - Villages near the site	Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Interviewer: 5,500Tk./ researcher
7	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- Increase in employment and business opportunities	-----	- Evaluation of increase in employment and business opportunities	Ditto	Ditto	Ditto	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
8	Land Use and Utilization of Local Resources	- Changing traditional land use patterns and utilization of local resources	-----	- Confirmation of local residents' feelings	- Interviewing residents	- Villages near the site	- Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Interviewer: 5,500Tk./ researcher (Same as "Poor people")
9	Disturbance to the Existing Social Infrastructure and Services	1) Increase in the number of vessels 2) Increase in the number of cars	1), 2) - Traffic volume	1), 2) - Evaluation of effect of traffic schedules	1), 2) - Record of numbers of vessels and cars being used	1), 2) - Project site	1), 2) Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
10	Misdistribution of Benefits and Compensation	- It can occur among residents, workers, government officers, and local politicians	-----	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
11	Local Conflicts of Interest	- Conflict between local residents and workers	-----	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- Same as those addressed in "Land use"	- CPGCBL/ Environmental	Expenses by CPGCBL

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
				use”	use”	“Land use”	“Land use”	Consultant	
12	Gender	1) Loss of salt fields, shrimp farms and fishing sites 2) Improved road along with the power plant	-----	1), 2) - Same as those addressed in “Poor people”	1), 2) - Same as those addressed in “Poor people”	1), 2) - Same as those addressed in “Poor people”	1), 2) - Same as those addressed in “Poor people”	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
13	Children’s Rights	1) Child labor 2) Improved road along with the power plant	1) Child labor 2) -----	1) Evaluation of effect of banning child labor 2) Same as those addressed in Poor people	1) Child labor - Checking labor contracts between subcontractor and workers - Patrolling construction area for child labor 2) Same as those addressed in “Poor people”	1) Working area 2) Same as those addressed in “Poor people”	1), 2) Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
14	Work Environment (Including Work Safety)	- Labor accidents	- Labor accidents - Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	-Power plant	- Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
15	Accidents	1) Traffic accidents 2) Fire	1) Traffic accidents - Land traffic - Marine traffic 2) Fire - Record	1), 2) - Evaluation of effect of the work safety plan	1), 2) - Record of accidents and fire	1), 2) - Power plant	- Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
16	Cross-boundary Impact and Climate Change	- CO ₂ emissions	- Amount of CO ₂ emissions	- Efforts to reduce CO ₂	- Calculate the CO ₂ emissions from fuel consumption	- Power plant	- Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL

(Source: JICA Study Team)

Table 9.2 Environmental Monitoring Plan (Port Facility)

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Construction Phase									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) - Same as those addressed in “Air quality” of the power plant	1) - 3) - Same as those addressed in “Air quality” of the power plant	1) - 3) - Same as those addressed in “Air quality” of the power plant	1) - 3) - Same as those addressed in “Air quality” of the power plant	1) - 3) - Same as those addressed in “Air quality” of the power plant	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
2	Water Quality (Waste)	1) Dredging 2) Landfill for land-reparation	1), 2) TSS, etc. - Wastewater standards for industrial activity	1), 2) - Evaluation of effect of the mitigation measure towards water pollution	1), 2) - Collecting samples and analyzing at a lab	1), 2) - 2 points: Sea water near the construction area	1), 2) - Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor - Sampling: 25,000Tk./ staff (Same as “Power plant”) - Analyzing: 15,000Tk./ sample
3	Noise and Vibration	- Noise and vibration caused by construction machinery	- Same as those addressed in “Noise” of the power plant	- Same as those addressed in “Noise” of the power plant	- Same as those addressed in “Noise” of the power plant	- Same as those addressed in “Noise” of the power plant	- Same as those addressed in “Noise” of the power plant	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								Consultant	
4	Ecosystem (Endangered Species)	1) Existence of endangered species 2) Spawning of sea	1), 2) - Same as those addressed in “Ecosystem (Endangered species)” of the power plant	1), 2) - Same as those addressed in “Ecosystem (Endangered species)” of the power plant	1), 2) - Same as those addressed in “Ecosystem (Endangered species)” of the power plant	1), 2) - Same as those addressed in “Ecosystem (Endangered species)” of the power plant	1), 2) - Same as those addressed in “Ecosystem (Endangered species)” of the power plant	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
	Ecosystem (Marine Biota)	1) Potential impact due to the degradation of water quality caused by civil engineering works 2) Domestic wastewater of workers 3) Inappropriate disposal of solid waste	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant		
	Ecosystem (Mud Flat, Fish & Nekton)	1) - 3) Ditto	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant		
5	Disturbance to Existing Social Infrastructure and Services	- Increase in the number of vessels	- Traffic volume from construction	- Evaluation of effect of construction schedule	- Record of numbers of vessels	- Contractor’s office	- Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor:	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								CPGCBL/ Supervision Consultant	
6	Work Environment (Including Work Safety)	- Labor accidents	- Same as those addressed in “Work environment” of the power plant	- Same as those addressed in “Work environment” of the power plant	- Same as those addressed in “Work environment” of the power plant	- Same as those addressed in “Work environment” of the power plant	- Same as those addressed in “Work environment” of the power plant	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by Contractor
7	Accidents	- Traffic accidents	- Marine traffic	- Evaluation of operation schedule of vessels	- Record of accidents	- Contractor’s office	- Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: CPGCBL/ Supervision Consultant	Expenses included in contract cost by contractor
Operation Stage									
1	Air Quality	1) Dust from coal handling activity at port 2) Exhaust gas from vessels	1) Coal handling PM₁₀ - Ambient air quality (No.41/199) - IFC guideline for ambient air quality (General/ 2007) 2) Exhaust gas from vessels- - MALPOL 73/78 treaty (Annex VI)	1), 2) - Evaluation of effect of the mitigation measure towards air pollution	1) Coal handling - Collecting samples at the site, analyzing at a lab 2) Exhaust gas from vessels - Record of vessels’ logs	1) Coal handling - Same as those addressed in “Air quality of the power plant” 2) Exhaust gas from vessels - Port office	1) Coal handling - Same as those addressed in “Air quality of the power plant” 2) Exhaust gas from vessels Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Sampling: 25,000Tk./staff - Analyzing: 20,000Tk./sample (Same as “Power plant”)

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
2	Water Quality	- Dredging material for the maintenance of the navigation channel	TSS - Wastewater standards - IFC guideline values for wastewater (Thermal power plant/ 2008)	- Evaluation of effect of the mitigation measures towards water pollution	- Collecting samples at the site, analyzing at a lab	- 2 points: Around the dredging area	- During dredging activity	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL - Sampling: 25,000Tk./ staff - Analyzing: 15,000Tk./ sample
		1) Operation of the port may cause a coal spillage and as a result, water pollution will occur 2) Leakages of oil 3) Wastewater from vessels will cause water pollution	1) ---- 2), 3) - MALPOL 73/78 treaty (Annex I-V) 3) - International Convention for the control and management of Ships' Ballast Water and Sediments (BWM), 2004	1) - 3) - Evaluation of effect of the mitigation measures towards water pollution	1), 2) - Record of coal spillages and oil leakages 3) - Record of vessels' logs	1) - 3) - Port office	1) - 3) - Once a year		
3	Waste	- Waste from vessels	- Waste management rules - MALPOL 73/78 treaty (Annex I-V)	- Evaluation of effect of waste management	- Record of the amount of waste from vessels	- Port office	- Once a year	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
4	Noise and Vibration	- Noise from coal handling activity at the port	- Same as those addressed in "Noise" of the power plant	- Same as those addressed in "Noise" of the power plant	- Same as those addressed in "Noise" of the power plant	- Same as those addressed in "Noise" of the power plant	- Same as those addressed in "Noise" of the power plant	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
5	Ecosystem (Endangered Species)	1) Existence of endangered species 2) Spawning of sea turtle	1), 2) - Same as those addressed in	1), 2) - Same as those addressed in	1), 2) - Same as those addressed in	1), 2) - Same as those addressed in	1), 2) - Same as those addressed in	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
			“Ecosystem (Endangered species)” of the power plant	“Ecosystem (Endangered species)” of the power plant	“Ecosystem (Endangered species)” of the power plant	“Ecosystem (Endangered species)” of the power plant	“Ecosystem (Endangered species)” of the power plant		
	Ecosystem (Marine Biota)	1) Operation of the port may cause a coal spillage, and as a result, water pollution will occur 2) Leakages of oil from oil tankers 3) Wastewater from vessels will cause water pollution	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Marine biota)” of the power plant		
	Ecosystem (Mud Flat, Fish & Nekton)	1) - 3) Ditto	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant	1) - 3) - Same as those addressed in “Ecosystem (Mud Flat, Fish & Nekton)” of the power plant		
6	Disturbance to Existing Social Infrastructure and Social Services	- Increase in the number of vessels	- Traffic volume	- Evaluation of effect of traffic schedule	- Record of numbers of vessels and cars being used	- Port office	- Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL
7	Work Environment (Including Work	- Labor accidents	- Labor accidents - Handling heavy loads - Working at heights	- Evaluation of effect of the work safety plan	- Record of accidents	- Port office	- Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Initiator Supervisor	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
	Safety)		- Electric shocks						
8	Accidents	- Traffic accidents	- Marine traffic	- Evaluation of vessel schedules	- Record of accidents	- Port office	- Continuous records	- CPGCBL/ Environmental Consultant	Expenses by CPGCBL

(Source: JICA Study Team)

Chapter 10

Work Plan

Chapter 10

Work Plan

Table of Contents

10.1	Project Implementation Schedule	1

10 Project Construction Plan

10.1 Project Implementation Schedule

CPGCBL is now intending to proceed with the implementation of the Matarbari CFPP Project with the financial assistance of a Japanese ODA Loan in order to meet the increasing power demand in Bangladesh.

The ultimate schedule of this project is construction of 2 x 600 MW coal fired power generating units.

CPGCBL will acquire an area of at least approximately 350 ha, which is planned for the construction of this project.

The Project Implementation Schedule that the JICA Study Team has assumed is shown in Figure 10.1 "Tentative Project Implementation for Matarbari CFPP Project and Transmission Line Project".

(1) Site Survey and Collection of Data related to site and surrounding areas

The consulting engineer for ES-I and II selected by CPGCBL will carry out a site survey and collect the necessary data for the project, and will review and study the Feasibility Study Report together with CPGCBL.

(2) Phase I (Pre-Construction Stage)

The consulting engineer will conduct the following work.

- a. Preparation of Basic Design Report
- b. Preparation of Prequalification and Bidding Documents
- c. Prequalification of Bidders
- d. Technical and Financial Evaluation of Proposals submitted by Bidders
- e. Contract Negotiations with successful Bidder

(3) Phase II (Manufacturing and Construction Stage)

After the contract has been awarded to each successful contractor, CPGCBL/Consultant will hold kick-off meetings to start the project, and indicate the project management systems and procedures. At the design stage, the Consultant will review and approve the design documents, drawings and calculation sheets submitted by the Contractor. Also, the Consultant will organize design review meetings among CPGCBL, the Consultant and each of the Contractor periodically to settle any discrepancies in design or schedules.

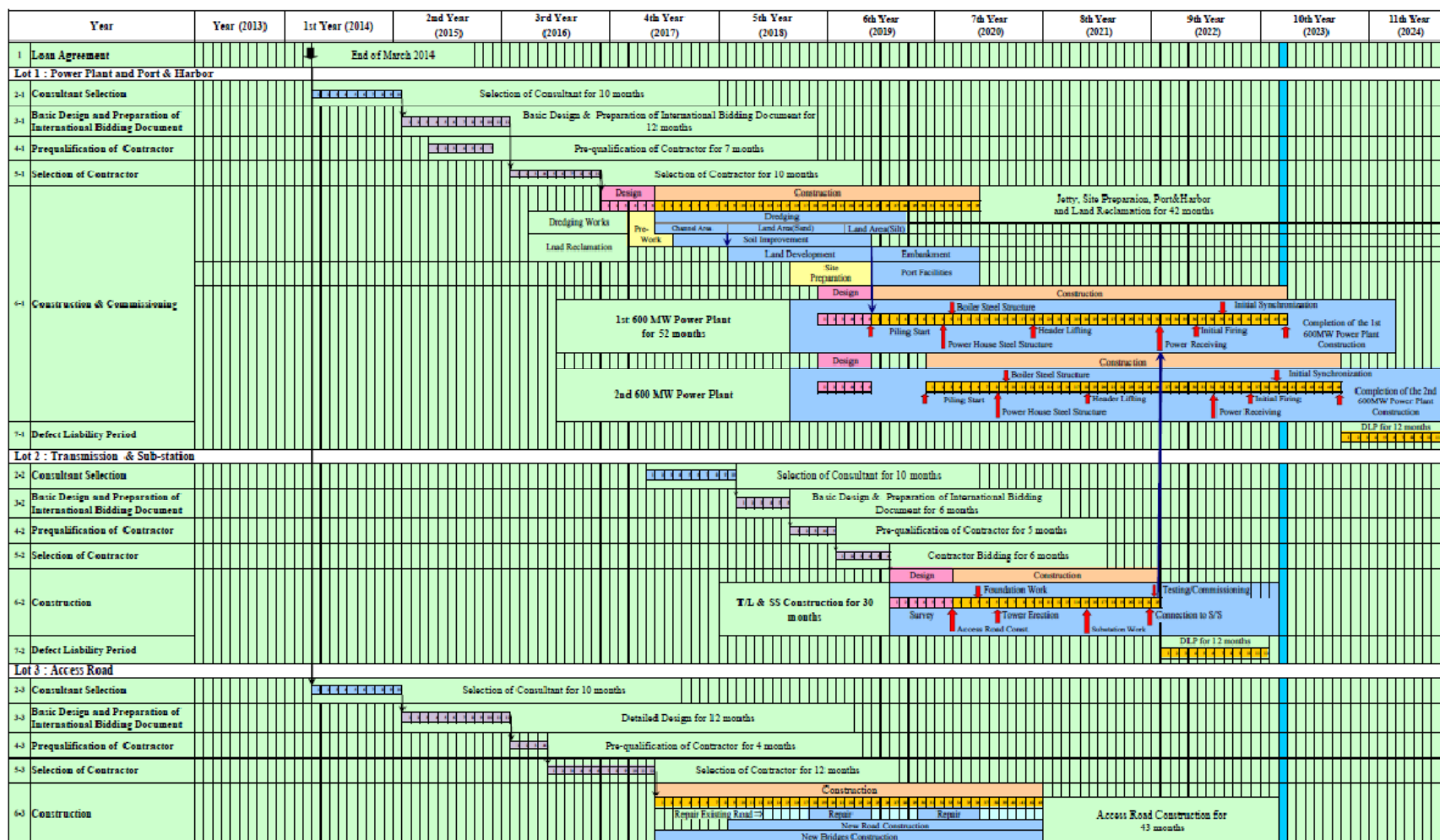


Figure 10.1 Tentative Project Implementation for Matarbari CFPP Project and Transmission Line Project

(Source: JICA Study Team)

To ensure the quality control of manufacturing, CPGCBL and the Consultant will conduct factory inspections and witness the manufacturing conditions of major equipment in accordance with the factory test schedule and approved QA/QC Inspection, and Test Plans and their related procedures, submitted by the Contractor at this stage.

At the construction stage, coordination and supervision related to all construction work, including civil work, shall be made by the Consultant. The Consultant will hold weekly construction schedule meetings to check the schedules, including the management of the labor force, and arrangements for construction equipment, tools and materials.

At the commissioning stage, the Consultant will check and approve the schedules and procedures for testing and commissioning of individual auxiliary equipment and facilities. CPGCBL and the Consultant will witness the tests of mechanical and electrical equipment and confirm important items and test results.

The performance and acceptance tests shall be carried out under the supervision of the Consultant and the Consultant will judge the results and report them to CPGCBL.

CPGCBL will issue Taking Over Certificates (TOC) for the Contractor after the results are confirmed and approved by CPGCBL.

In the warranty period, the Consultant will inspect the conditions of each equipment and facility periodically. After the warranty period, CPGCBL will issue Final Acceptance Certificates (FAC) for the Contractor.

Chapter 11

Financial and Economic Analysis

Chapter 11

Financial and Economic Analysis

Table of Contents

11.1	Project Cost	1
11.2	Financial and Economic Evaluation	2
11.3	Financial Simulation	8
11.4	Financial Evaluation	12
11.5	Economic Evaluation	22

11 Financial and Economic Analysis

The Project is to be assessed by calculating the economic internal rate of return to determine economic viability and the financial internal rate of return to determine financial viability. The following are the major areas that will be analyzed in order for the JICA Study Team to determine the final evaluation and assessment.

11.1 Project Costs

11.1.1 Basic calculation method

The total construction costs of the plant were calculated in the following way.

- 1) Total plant construction costs
Plant construction costs, consulting expenses, contingency plans, spare parts required in the initial two years, and the interest rates during the construction period are included in the total construction costs of the plant.
- 2) Plant construction costs
Concerning the plant construction costs, except for the materials which are procurable locally, materials are to be imported from overseas.
- 3) The following are not included in the total cost of construction of the plant.
 - (1) Power plant site, site preparation, and maintenance costs
 - (2) Costs of clerical work facilities related to operation management
 - (3) Costs of dwelling facilities for power plant staff and costs of related services facilities
 - (4) Costs of electric power for construction and costs for water involved in the engineering work
 - (5) Allotment costs related to power plant construction
 - (6) Removal costs of existing facilities (if any)
- 4) Base currency and exchange rates
The standard official currency is assumed to be the Japanese yen, and the exchange rates are shown below.
US\$ 1.0 = ¥ 94.8
US\$ 1.0 = TK 79.5
TK 1.0 = ¥ 1.20
- 5) Escalation rates (including Consultant)
Foreign Currency Portion: 1.3% p.a.
Local Currency Portion: 3.5% p.a.
- 6) Base year for construction costs
Construction costs are based on the prices of December 2012.
- 7) Import duties
Import duties shall be exempted.

11.2 Financial and Economic Evaluation

11.2.1 Basic assumptions

(1) Key Project Design and Assumptions

The key project design and assumptions for financial modeling are shown in the following Table 11.2.1 and Table 11.2.2;

Table 0 Essential Framework of the Project

Category	Sub-category	Dimension
Generation Plants	Rated Capacity	600 MW X 2 Units
	Plant Load Factor	80%
	Thermal Efficiency	41.29%
	Auxiliary Consumption	6.5%
	Plant Life	25 years
Start-up & Completion	Consulting Service	Start-up: Feb. 2015
	Unit 1	Construction to start: Jun. 2019 Completion: Oct. 2023
	Unit 2	Construction to start: Jun. 2019 Completion: Apr. 2024
Plant Lives of Other Components	Transmission Lines	40 years
	Port & Harbor	25 years
	Coal Unloading Facilities	25 years
	Access Road	30 years
Depreciation	Depreciation Method	Straight Line Method
	Residual Value	10% of gross fixed assets
Estimated Cost	Generation	Refer to the respective Chapters of the Report.
	Transmission	Same as above
	Port & Harbor	Same as above
	Coal Unloading	Same as above
	Access Road	Same as above

(source) JICA Study Team

Table 0 Key Assumptions

Category	Sub-category	Dimension
Financing	Financing Sources	Donor Loan: 80%, and Government funding: 20% (equity 60%: loan 40%)
	Donor Loan (subsidiary loan from GOB to executing agencies)	Interest rate: 0.01% p.a., Repayment period: 34 years, and Grace period: 10 years
	Government Loan	Interest rate: 3.0% p.a., Repayment period: 20 years, and Grace period: 10 years
	Government Equity	No written obligation and assumed to be exempt from dividend payment and redemption. (*)
Fuel Cost	Indonesian Coal	Refer to the Chapter 6 of the Report.
	Australian Coal	Same as above
	Other Coals	Same as above

Category	Sub-category	Dimension
O&M	O&M Expense	Refer to Chapter 13 of the Report
Overhead	Administrative Overhead	Refer to Chapter 13 of the Report
Taxes	Corporate Income Tax	37.5%
	VAT	5%
	VAT for EPC Contractor & Consultant	10.5%
	Custom Duties	5%
	VAT on imports	5%
Return on Equity	ROE before Tax	12% on paid-up equity
Exchange Rate		US\$ 1=Tk 79.50; US\$ 1=JPY 94.80

(note) Under the on-going practices of GOB, the outlay from the government budget is documented in the approval letter of ECNEC for the amount of equity and loan. Neither the conditions for equity redemption nor the terms and conditions of loans are committed in written documents. In the power sector, there exists no precedence of equity redemption while dividend is paid out by PGCB and DESCO based on the declaration of the companies..

(source) JICA Study Team

The assumptions listed above are prepared for the purpose of construction of the financial model only and the specific data and/or information are of preliminary nature. The succeeding analysis on financial simulation as well as the economic and financial evaluation shall be updated accordingly.

a. Project Cost

The cost of the Project has been analyzed previously, the gist of which is taken here for the sake of the financial analysis of the Project. The following table summarizes the overall cost of the Project;

Table 0 Total Cost of the Project (before tax)

Project Component	Total Cost (JPY million)	Breakdown		
		Foreign Currency (JPY million)	Local Currency (Tk million)	JPY Equivalent of local currency portion (JPY million)
Power Generation				
EPC Contract	236,668	177,513	49,609	59,155
Land cost	5,075	-	4,256	5,075
Community	624	-	523	624
Others	77	69	7	8
Consultant	4,733	3,550	992	1,183
Contingency				
Physical *1	23,904	17,929	5,010	5,975
Price	34,309	17,307 *2	14,259 *3	17,002
Sub-total	305,390	216,368	74,656	89,022
Transmission				
EPC Contract	4,033	3,064	813	969

Project Component	Total Cost (JPY million)	Breakdown		
		Foreign Currency (JPY million)	Local Currency (Tk million)	JPY Equivalent of local currency portion (JPY million)
Land cost	4	-	3	3
Others	3		3	4
Consultant	154	154	-	-
Contingency				
Physical *1	411	314	81	97
Price	538	281 *2	215 *3	257
Sub-total	5,139	3,813	1,851	1,326
Port & Harbor				
EPC Contract	37,920	15,168	19,080	22,752
Land cost				
Consultant	758	303	382	455
Contingency				
Physical *1	3,830	1,532	1,927	2,298
Price	5,527	1,055 *2	3,751 *3	4,472
Sub-total	48,035	18,058	25,140	29,977
Access Road				
Bridge	1,899	436	1,463	1,463
Road	1,498	344	1,154	1,154
Land Cost	18		15	18
Consultant	308	205	86	103
Contingency				
Physical *1	355	88	266	267
Price	563	54 *2	509 *3	509
Sub-total	4,623	1,127	3,478	3,496
E. Total	363,187	239,366	104,402	123,821
F. L/C Opening Charge	3,310	-	2,775	3,310
G. Adm. Overhead *4	6,345		5,329	6,345
H. Coal for Trial Run *5	23,834	23,834	-	-
I. HSD for Trial Run *5	770	-	646	770
J. Grand Total	397,446	263,200	107,823	134,246

Note) *1) Physical contingencies are calculated at; 10% for the plant cost and civil work; 5% for consulting services

*2) Price contingencies for foreign currency portion are calculated at 1.3% p.a.

*3) Price contingencies for local currency portion are calculated at 3.5% p.a.

! ! ! ! *4) Administrative overhead is calculated at 2% of the total eligible component.

*5) The fuel for trial run of the plants are counted for 6 months of operation. The amount spent for the procurement of the fuel for trial run will be reimbursed by the single buyer, BPDB, when the commercial run of the plants will start. The amount to be paid by BPDB will be sufficient enough for CPGCBL to purchase the fuel for future operation. For CPGCBL, the one cycle of coal purchasing will be approximately six months, i.e. two and half months for shipment and storage, half a month for generation and three months for bill collection, counting from the payment for

import till bill collection.

*6) Exchange rates applied are; US\$ 1 = BDT 79.50; US\$ 1 = JPY 94.80; BDT 1 = JPY 1.192.

b. Power Production

The Project plans to install two power generator units with a rated capacity of 600MW each. The expected annual power output will be 8,410 GWh via a plant load factor of 80%. Per the auxiliary consumption of 6.5%, the net power production, which can be available for sales, will be 7,863GWh. The parameters have been established in the following background and technological theory;

1) Plant Factor

The plant factor is the ratio of the total amount of energy (GWh) produced during a period of time to the amount of energy (GWh) the plant would have produced if the plant had been operating at the rated capacity;

$$\text{Annual plant factor (\%)} = \frac{\text{annual actual output (MWh)}}{\{\text{rated capacity (MW)} \times 8,760 \text{ (h/year)}\}} \times 100 (\%)$$

The project assumes to be operated non-stop at the rated capacity with exception of the periodical inspection and maintenance which will last approximately one and half a month every year. Under such operative condition, the plant factor is calculated theoretically as 87.5% but the plant factor may be reduced subject to the factors such as central dispatch instructions, mechanical maladjustment, etc. and in consideration of such, the Study Team has established the plant factor for the Project to be at 80%.

2) Thermal Efficiency

Thermal efficiency is the ratio of the electricity output the plant produces, to the fuel heat input the plant consumes. The difference of dimensions of heat and electricity requires a conversion factor to derive the thermal efficiency as in the following formula;

$$\eta_p = \frac{\text{MW} \times 860}{\text{F} \times \text{HHV}} \dots \dots \textcircled{D}$$

η_p : thermal efficiency of a plant (%)

MW: electricity output (kWh)

860: factor for converting kWh to kcal (kcal/kWh)

F: volume of coal consumption (kg/hr)

HHV: calorific value of coal (kcal/kg)

The thermal efficiency of the Project, 41.29%, has been established by the Study Team in consideration of the design specifics of the USC power plant which is 24.5MPa x 600°C / 600°C, the higher heating value of the fuel coal from Indonesia which is 4,700kcal/kg, the climatic conditions of Bangladesh including the ambient air temperature 30°C and the sea water temperature 30°C, etc.

3) Auxiliary Consumption

Auxiliary power consumption is the volume of electric power consumed by the auxiliary equipment and facilities in a power plant and is expressed in the percentage of the gross power output. The auxiliary power ratio of the Project, 6.5%, has been estimated by the Study Team taking the conditions of the Project into consideration and comprising the power consumption by all the unit auxiliaries as well as the common station requirement such as station lighting, air conditioning, etc.

c. Project Implementation Period

The Project implementation period, from consulting services till the commercial operation date (COD), is assumed to be nine years.

d. Depreciation

In Bangladesh, depreciation is generally treated in a flexible manner. Power entities are allowed to select the straight line or the declining balance method. In this study, it is assumed that the straight line depreciation will be adopted. Also the residual value is expected to be 10% of the gross amount of fixed assets.

e. Funding

For the total funds required, 88% of the investment cost for the Project is assumed to be financed by debt, including ODA loans and domestic loans. The ODA Yen Loan will be lent to the government of Bangladesh (GOB) from JICA and be on-lent from GOB to CPGCBL, PGCB and appropriated to RHD. The ODA Yen Loan may be granted to cover 100% of the eligible portion of the total project cost while the non-eligible portion shall not be financed. Assuming that 20% of the total project cost is comprised of the non-eligible portion, 80% of the total investment cost is to be financed by the subsidiary loan of the ODA Yen Loan, and 8% of them by domestic loans from the government of Bangladesh to CPGCBL. The remaining 12% will be financed in equity from the government of Bangladesh.

f. Debt Amortization

The repayment of loans is assumed to be made in accordance with normal financing practices. The principal of the loan elapsing the grace period shall be repaid in equal installments semi-annually at the end of June and December of each year. The interest on loans shall be calculated on the outstanding balance of the loan and be paid at the end of June and December each year. The interest accruing prior to the commissioning of the Project shall be capitalized at the time of the transfer of the asset from the capital work in progress to the fixed asset.

Table 11.2.4 Estimated Annual Debt Amortization

	Repayment Period	Grace Period
ODA loan	34 years	10 years
Government loan	20 years	10 years

(Source: JICA Study Team)

g. Revenue

The source of revenue is the electricity tariff to be fixed between CPGCBL and BPDB, the single buyer, based on the actual cost of supplying the electricity plus the ROE allowed.

In September, 2012, the Bangladesh Energy Regulatory Commission revised the bulk tariff of power supplied by the Bangladesh Power Development Board (BPDB) and the revised tariff has been used by a different Power Distribution Authority/Company/Rural Electrification Board with effect from September 1st, 2012. The average bulk tariff has been set at 4.7 Tk/kWh as of September, 2012 as mentioned in Chapter 11 (Changes in Bulk Tariff). The tariff thus revised stays at far below the unit power generation cost of the Project, which is revealed to be 6.99 Tk/kWh including the Return on Equity (ROE) of 12%. Details on the required tariff level are mentioned below (Refer to (3) Financial Simulation.) The financial analysis assumes that the actual generation cost including the ROE obtained under the Study shall be deemed as the tariff to be established in the PPA to be concluded for the sale of power output of the Project upon completion.

h. Interest Rate and Interest during Construction (IDC)

The interest rates for the ODA loan and ODA subsidiary loan are assumed to be 0.01% p.a. The prevailing practices in Bangladesh in extending the subsidiary loan to power sector generation companies are at the interest rate of 1.5% - 3.0% p.a. In order to materialize the Project with the reasonable generation cost and the wholesale price of the power within the reasonably acceptable range, the Study Team recommends that GOB allows the accommodative rate of interest in the subsidiary loan at 0.01% p.a. which should be exactly same with the rate of interest at which GOB borrows the donor funds. For the government loan, the interest rate is assumed to be 3.0% p.a., which is according to the standard interest rate of the government loan to BPDB and its subsidiaries.

i. Physical Contingency

The physical contingency is a part of the project cost for the financial and economic evaluation of the Project. The physical contingency is assumed at 10% of the total EPC including the equipment and civil work whereas 5% is appropriated for consulting services.

j. Administrative Overhead

Administrative overhead is budgeted at 2% of the total eligible component of the Project, while the administrative overhead belongs to the non-eligible component.

11.3 Financial Simulation

Base Cases and Financial Targets

Lately, MPEMR adopted the fixing of the wholesale tariff based on the total cost of generation including the return on equity (ROE) at 12%¹ in line with the tariff guidelines established by Bangladesh Energy Regulatory Commission². The analysis prepares the Base Cases with ROE at 12%. Through the consultation with Bangladesh counterpart and in view of the on-going practices in the financial world, JICA Study Team establishes the targets to be financially satisfied by the Project. The targets established for the financial indicators are;

- (i) The generation cost of power including ROE should be not more than Tk 7.00/kWh.

The target is established based on the grounds such as; (i) that the discussion the Study Team held with Bangladesh counterpart suggested the range as tolerable; (ii) that the Power Sector Master Plan 2010 gives the indicative cost of generation to stay in the range of Tk 7-8/kWh; (iii) that the comparative analysis using the levelized cost indicates the level is deemed as the least cost among various updated generation processes based on the fossil energy.

- (ii) The financial internal rate of return (FIRR) should be no less than the weighted average cost of capital (WACC).

The target is established based on the fact that the Project would not fail to earn, on the basis of present value, the financial return sufficient enough to recover the cost incurred to the investment.

- (iii) The debt/equity ratio should be not less than 30:70.

The target has been established by MPEMR's Power Sector Financial Restructuring and Recovery Plan, assisted by IDA credit for Power Sector Development Technical Assistance Project, August 2006.

- (iv) The debt service coverage ratio (DSCR) should not be less than 130%.

The ratio has also been established under the above Plan of MPEMR.

¹ Power Division, Ministry of Power, Energy and Mineral Resources, Notice dated February 20, 2013.

² The Bangladesh Energy Regulatory Commission Electric Generation Tariff Regulation 2007 prescribes that "In the case of licensees, which are wholly owned by the government, the cost of capital would equal the government's cost of capital. For the purposes of tariff rate development, the most recent treasury bill auction rate, pursuant to a central bank auction, for two-year Bangladesh treasury bills shall be utilized." (BERC, Bangladesh Energy Regulatory Commission Electric Generation Tariff Regulation 2007). 12% is the prevailing level of auction rate by the central bank whereas BPDB maintains a practice of allowing ROEs for the government owned generation companies at 5% across-the-board.

The Base Case thus established based on the above framework and assumptions produces the financial outcome of the Project as follows;

Table 11.2.5 Findings on Base Case

	Target	ROE=12%
WACC		1.60%
Generation Cost	Not more than Tk 7.0/kWh	Tk 6.99/kWh
FIRR	not less than WACC	2.52%
D/E Ratio	not less than 70:30	2024: 15.0%, 2031: 30.2%
DSCR	not less than 130%	Ave.: 128.5%
Net Present Value (NPV)	Positive	▲ 9,350 Tk million
Project Life Coverage Ratio (PLCR)	not less than DSCR +10%	121.1%
Loan Life Coverage Ratio (LLCR)	not less than DSCR + 10%	121.1%

(source) JICA Study Team

The Base Case satisfies the targets in the generation cost, FIRR and virtually meets the target in DSCR, though failing to clear other targets of Net Present Value (NPV) and Project Life Coverage Ratio (PLCR)/Loan Life Coverage Ratio (LLCR). The fact that NPV, which is the discounted value by using the discount factor of WACC, is falling in the negative territory implies that the Project is not able to generate sufficient return to cover its investment on the basis of the present value. The low earning power is also captured by PLCR/LLCR³ being stagnant in the range of low 120% level indicating that the Project might have uncertainties concerning the repayment of the total loan again on the basis of the present value. Nevertheless, the average DSCR stands at 128.5% which is close to the commonly accepted standard of 130% though the ratio is failing to clear the threshold during the early years of operation; 2028-2035 and 2038-2039. D/E ratio which is structured to be 88:12 at the start-up of operation period but is found gradually building up towards the target supported by the ROE (=12%) built in.

Power Generation Cost

The following is the table showing the summarized generation cost and ROE;

³ PLCR and LLCR results in an identical value as the Project assumes the loan life to be exactly coincide with the project life.

Table 0 Generation Cost including ROE

(Tk/kWh)

	Base Case (ROE=12%)
Generation Cost incl. ROE	Tk 6.99/kWh
Fixed Cost	
Depreciation	1.33
O&M	0.51
ROE	0.65
Sub-total	2.49
Variable Cost	
Fuel Cost	4.50
Other Variable Cost	0.00
Sub-total	4.50

(source) JICA Study Team

The average cost of generation for the Base Case turns out to be Tk 6.99/kWh being comprised of the fixed cost of Tk 2.49/kWh and the variable cost of Tk 4.50/kWh. The cost derived is found satisfying the target established.

Despite the clearance of the target for the generation cost, the cost of generation for the Project exceeds the prevailing wholesale tariff of power in Bangladesh which currently stands at Tk 4.70/kWh. Should the tariff remain below the generation cost of the Project, the high cost of generation under the Project may appear to have an adverse effect of expanding of the deficit at BPDB, but shall, without fail, contribute to save BPDB's deficit in two channels, namely, (i) to reduce the deficit at BPDB created by the purchase of electricity generated from liquid fuel based generation plants, and (ii) by the gradual revision of tariff through the materialization of the cost reflective tariff for the country.

Levelized Cost

The levelized cost is an economic assessment of the cost of generation system on a unit basis including all the costs over its life time; initial investment, operations and maintenance, cost of fuel, etc, on the basis of their present values. The analysis is of significant use in calculating the cost of generation from different sources of energy, types of generation plants and different time framework of generation projects, etc.

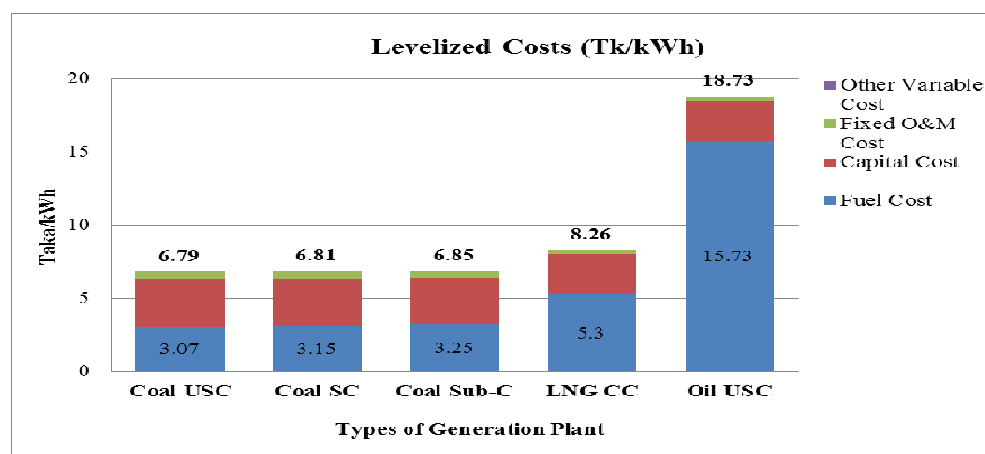
Using the methodology, the endeavor has been made to analyze the comparative costs of generation among the plants of; coal based USC plant adopted for this project, coal based SC plant, coal based Sub-C plant, LNG combined cycle plant and oil based USC plant. For the analysis, the Study has adopted a discount rate of 10% as such rate is commonly used for the similar analysis. The exchange rates applied are; US\$ 1 = Taka 79.50 = JPY 94.80. The following table and figure show the result of the comparative analysis among

the above selected generation plants;

Table 11.2.7 Levelized Generation Cost

	(Tk/kWh)				
	Coal based USC	Coal based SC	Coal based Sub-C	LNG combined cycle	Oil based USC
Fuel	3.07	3.15	3.25	5.30	15.73
Capital	3.23	3.18	3.14	2.72	2.71
O&M	0.49	0.48	0.46	0.24	0.29
Other variable	0.00	0.00	0.00	0.00	0.00
Total	6.79	6.81	6.85	8.26	18.73

(source) JICA Study Team



(source) JICA Study Team

Figure 11.2.1 Levelized Cost of Generation Plants

The assumptions used for the analysis are summarized as follows;

Table 11.2.8 Assumptions for Levelized Cost Analysis

	Coal based USC	Coal based SC	Coal based Sub-C	LNG combined cycle	Oil based USC
Rated capacity (MW)	1,200	1,200	1,200	1,200	1,200
Plant load factor (%)	80.0	80.0	80.0	80.0	80.0
Auxiliary consumption (%)	6.48	6.64	6.78	2.50	5.50
Net energy output (GWh)	7,865	7,851	7,839	8,199	7,947
Thermal efficiency (%)	41.29	40.32	39.15	51.00	41.29

	Coal based USC	Coal based SC	Coal based Sub-C	LNG combined cycle	Oil based USC
kJ/kWh	3,600	3,600	3,600	3,600	3,600

(source) JICA Study Team

The above table reveals that among the plants selected, coal based USC stands to be the least cost plant with the indicated total costs of Tk 6.79/kWh and are followed by the order of; coal SC (Tk 6.81/kWh), coal based Sub-C (Tk 6.85/kWh), LNG combined cycle (Tk 8.26/kWh) and oil based USC plants (Tk 18.73/kWh).

It is hereby proved that the coal based USC which is the technology adopted for the Project is the least cost in respect of the total life cost from the construction till the end of its life among the generally implemented generation technologies based on fossil fuels.

The above analysis implies another fact to be noted in Bangladesh which is the cost of power generation using natural gas. In Bangladesh, the tariff of natural gas is regulated by the government and the power sector as well as the fertilizer industry has been favored with the tariff established lower than the ones for other sectors. Electricity has been generated at less cost in utilization of the low price of natural gas. The analysis indicates that, should the gas be priced at the international level of price, the cost of generation based on the natural gas will be as high as at Tk 8.26/kWh which is much higher than the one by the imported coal. It endorses clearly the fact that there exists a cross subsidy practice in the power generation based on the natural gas.

11.4 Financial Evaluation

11.4.1 Methodology of Evaluation and Basic Parameters

The financial evaluation is based on an analysis of the financial viability of the Project. In other words, the financial evaluation aims to verify financial sustainability for the entity to operate and maintain the Project at a certain level of financial effectiveness for a certain period.

In general, financial viability is measured by the Financial Internal Rate of Return (FIRR), which measures and compares financial revenue (= financial benefit) on capital investment on project (= financial cost). The project can be judged as “financially viable” in the case where the calculated FIRR is higher than the weighted average capital cost (WACC) of the total capital investment of the project.

For the Project, FIRR can be separately calculated for the plant portion and the

transmission portion because the transmission portion is to be executed by the independently run PGCB who is to be financially benefited through the collection the wheeling charge over the electricity transmitted for CPGCBL's sale to BPDB's purchase.

11.4.2 Financial Cost

(1) Project Cost

For the financial analysis of the Project, all the estimated costs are converted and expressed in the constant price as of 2012. The project cost, including power generation facilities, port facilities and the access road, is estimated based on the 2012 constant price.

(2) Fuel Price

Fuel coal are planned to be imported the coal from Indonesia, Australia or the Republic of South Africa as mentioned in feasibility study. A detailed analysis of the coal prices are referred to in feasibility study.

The fuel costs for the coal-fired power plant constructed by the Project shall be the total amount of FOB (Free on Board) of coal, F&I (Freight and Insurance). Coal prices are estimated based on the actual records for 2012 and in using the indexes derived on the reference export prices projected by the U.S. Energy Information Administration⁴.

Table 11.4.1 Projections of Coal Prices (Indonesia and Australia)

	2010	2011	2012	2015	2020
Export Price Index (constant price; 2010=100)	100.00	103.40	106.80	117.00	128.80
Coal Price					
Indonesian Coal (4,200kcal/kg)	-	-	1,312	1,437	1,582
US Cents/MM kcal					
Australian Coal (5,867kcal/kg)	-	-	1,640	1,797	1,978
US Cents/MM kcal					
Freight and Insurance Cost					
Freight & Insurance for Indonesian Coal (USD/MT)	-	-	14.00	14.00	14.00
Freight & Insurance for Australian Coal (USD/MT)	-	-	22.00	22.00	22.00

(Source) JICA Study Team and The U.S. Energy Information Administration, "Annual Energy Outlook of 2012 with Projections to 2035"

(3) Operations and Maintenance Cost

The operations and maintenance (O&M) costs cover costs for operation and maintenance of all the facilities constructed by the Project, including the initial spare parts, fixed and

⁴ USDOE, US Energy Information Administration, "Annual Energy Outlook 2012", June 2012.

valuable maintenance costs, and payrolls. Details of the O&M are discussed in feasibility study.

(4) Tax and duties

The custom duties, the value added taxes and the income taxes are counted as a part of the project costs for the financial analysis. However, the taxes and fiscal levies are deemed as the domestic unrequited transfer of revenue that plays no contributory function in the project and are omitted from the project cost for the economic analysis. The tax rates to be levied on the transactions related to the Project are shown in the table below.

Table 11.4.2 Tax and Duties to be Levied

Tax and Duties	Tax Rate
Corporate Income Tax (publicly traded company)	27.5%
Corporate Income Tax (non-publicly traded company)	37.5%
Value Added Tax (VAT)	5.0%
VAT for EPC Contractor & Consultants	10.5%
Custom Duties & VAT on Imports (C&F)	5.0%

(Source: JICA Study Team)

(5) Discount Rate

A discount rate for the financial analysis is required to be equal to the minimum return on capital investment in order to make an investment decision. Namely, the Project needs a higher Financial Internal Rate of Return (FIRR) than the financial costs derived by the Weighted Average of the Capital Cost (WACC). The WACC of the Project is calculated using the following formula:

$$\text{WACC before tax} = [r_E \times E/(D + E)] + [r_{D \text{ for ODA}} \times (1-T) \times D \text{ for ODA}/(D + E)] + [r_{D \text{ for G loan}} \times (1-T) \times D \text{ for G loan}/(D + E)]$$

r_E : Cost of equity = 12% p.a.

$r_{D \text{ for ODA subsidiary loan}}$: Cost of ODA loan = 0.01% p.a.

$r_{D \text{ for Government loan}}$: Cost of domestic loan (government) = 3.0% p.a.

$E/(D + E)$: Equity/(Equity + Debt) = 12%

$D \text{ for ODA subsidiary loan}/(D + E)$: ODA subsidiary loan/(Debt + Equity) = 80%

$D \text{ for government loan}/(D + E)$: government loan/ (Debt + Equity) =8%

Corporate Income Tax Rate in Bangladesh: 37.5%

The estimated WACC of the Project is calculated to be as follows:

WACC after income tax= 1.60%

11.4.3 Financial Benefit

Financial Benefit for the Plant Portion

The financial benefit of the plant portion is the electricity sales revenue and the salvage value of the plant at the end of the project life.

The tariff of the electricity to be sold by CPGCBL to BPDB shall be fixed in PPA before starting its commercial operations at the rate analyzed above; Tk 6.99/kWh. For the purpose of the financial evaluation of the Project, we do adopt the rate obtained, Tk 6.99/kWh including ROE, as the yardstick to measure the financial benefits of the Project.

Financial Benefit for the Transmission Portion

The financial benefits of the transmission portion is the wheeling charge of 0.2291 Tk/kWh and the salvage value of the transmission line at the end of the project life.

11.4.4 FIRR

(1) Financial Internal Rate of Return (FIRR) for the Plant Portion

The FIRR of the plant portion is calculated by a financial model based on the assumptions mentioned above.

The provisional estimation of FIRR is 2.52%, which is higher than WACC for the Project and the Project is deemed financially viable.

(2) FIRR for the Transmission Portion

The estimated FIRR for the transmission portion based on the assumptions is 20.09%. The transmission portion can be expected to gain significant financial return, which is much higher than WACC.

Table 11.4.3 FIRR for the Power Plant

							(million TK)
Fiscal Year	Financial Cost (A)			Financial Benefit (B)			Balance (B)-(A)
	Capital Cost	Operating Cost	Total	Sales Revenue	Salvage Value	Total	
2015	465	0	465	0	0	0	-465
2016	960	0	960	0	0	0	-960
2017	17,401	0	17,401	0	0	0	-17,401
2018	14,996	0	14,996	0	0	0	-14,996
2019	26,798	0	26,798	0	0	0	-26,798
2020	53,711	0	53,711	0	0	0	-53,711
2021	49,222	0	49,222	0	0	0	-49,222
2022	49,339	0	49,339	0	0	0	-49,339
2023	49,455	0	49,455	0	0	0	-49,455
2024	35,562	17,774	53,336	27,495	0	27,495	-25,841
2025	0	34,592	34,592	54,990	0	54,990	20,398
2026	0	35,792	35,792	54,990	0	54,990	19,199
2027	0	36,086	36,086	54,990	0	54,990	18,905
2028	0	35,474	35,474	54,990	0	54,990	19,516
2029	0	35,768	35,768	54,990	0	54,990	19,222
2030	0	39,690	39,690	54,990	0	54,990	15,301
2031	0	39,984	39,984	54,990	0	54,990	15,007
2032	0	36,650	36,650	54,990	0	54,990	18,340
2033	0	36,723	36,723	54,990	0	54,990	18,267
2034	0	37,922	37,922	54,990	0	54,990	17,068
2035	0	38,216	38,216	54,990	0	54,990	16,774
2036	0	37,605	37,605	54,990	0	54,990	17,385
2037	0	37,899	37,899	54,990	0	54,990	17,091
2038	0	44,632	44,632	54,990	0	54,990	10,358
2039	0	44,926	44,926	54,990	0	54,990	10,064
2040	0	38,781	38,781	54,990	0	54,990	16,209
2041	0	39,075	39,075	54,990	0	54,990	15,915
2042	0	40,274	40,274	54,990	0	54,990	14,716
2043	0	40,568	40,568	54,990	0	54,990	14,422
2044	0	39,957	39,957	54,990	0	54,990	15,034
2045	0	40,251	40,251	54,990	0	54,990	14,740
2046	0	44,172	44,172	54,990	0	54,990	10,818
2047	0	44,466	44,466	54,990	0	54,990	10,524
2048	0	40,453	40,453	54,990	0	54,990	14,537
2049	0	20,712	20,712	27,495	34,010	61,505	40,793
Total	297,909	978,444	1,276,353	1,374,761	34,010	1,408,770	132,417
FIRR	2.52%						

(Source: JICA Study Team)

Table 11.4.4 FIRR for the Transmission Lines

(million TK)

Fiscal Year	Financial Cost (A)			Financial Benefit (B)			Balance (B)-(A)
	Capital Cost	Operating Cost	Total	Sales Revenue	Salvage Value	Total	
2015	0	7	7	0	0	0	-7
2016	0	7	7	0	0	0	-7
2017	0	7	7	0	0	0	-7
2018	65	7	72	0	0	0	-72
2019	1,715	7	1,721	0	0	0	-1,721
2020	1,719	7	1,725	0	0	0	-1,725
2021	855	7	862	0	0	0	-862
2022	10	7	17	0	0	0	-17
2023	10	7	17	0	0	0	-17
2024	3	7	9	901	0	901	891
2025	0	7	7	1,801	0	1,801	1,795
2026	0	7	7	1,801	0	1,801	1,795
2027	0	7	7	1,801	0	1,801	1,795
2028	0	7	7	1,801	0	1,801	1,795
2029	0	7	7	1,801	0	1,801	1,795
2030	0	7	7	1,801	0	1,801	1,795
2031	0	7	7	1,801	0	1,801	1,795
2032	0	7	7	1,801	0	1,801	1,795
2033	0	7	7	1,801	0	1,801	1,795
2034	0	7	7	1,801	0	1,801	1,795
2035	0	7	7	1,801	0	1,801	1,795
2036	0	7	7	1,801	0	1,801	1,795
2037	0	7	7	1,801	0	1,801	1,795
2038	0	7	7	1,801	0	1,801	1,795
2039	0	7	7	1,801	0	1,801	1,795
2040	0	7	7	1,801	0	1,801	1,795
2041	0	7	7	1,801	0	1,801	1,795
2042	0	7	7	1,801	0	1,801	1,795
2043	0	7	7	1,801	0	1,801	1,795
2044	0	7	7	1,801	0	1,801	1,795
2045	0	7	7	1,801	0	1,801	1,795
2046	0	7	7	1,801	0	1,801	1,795
2047	0	7	7	1,801	0	1,801	1,795
2048	0	7	7	1,801	0	1,801	1,795
2049	0	7	7	901	1,896	2,797	2,790
Total	4,377	234	4,611	45,035	1,896	46,931	42,321
FIRR	20.09%						

(source) JICA Study Team

(3) Internal Rate of Return on Equity (IRR-E) for the Project

Internal Rate of Return on Equity (IRR-E) indicates profitability of the Project on equity to be invested. IRR-E assumes that the inflows are the cash flows required minus any debt to be raised for the Project and the outflows are cash flows from the Project minus any

interest and debt repayments. In the case that annual net profit after tax is considered as cash inflows, the amount of annual depreciation should be added up.

Based on the assumptions above, IRR-E for the total project is revealed to be 9.64%. Taking into consideration of the prevailing consensus on the ROE of IPP generation projects at around 15-20%, the gap between such ROE and the government bond rate of 12.48% (20 years T Bond) is understood to be the risk premium for the investor. In taking the risk premium as such, the hurdle rate of IRR-E for equity investment at CPGCBL is calculated to be 9.20% after Corporate Income Tax. The IRR-E calculated is found to be higher than the hurdle rate.

* Hurdle rate = ROE [12% x (100- tax rate of 37.5%)] + risk premium [the difference between the interest rate of Government Bond and ROE for IPP (15% - 12.48%) x (100 – tax rate of 37.5%)]

Table 11.4.5 Internal Rate of Return on Equity (IRR-E) for the Power Plant

(million TK)

Fiscal Year	Financial Cost (A)			Financial Benefit (B)				Balance (B)-(A)
	Equity Investment	Repayment of Loan	Total	Profit after Tax	Depreciation	Salvage Value	Total	
2015	261	0	261	0	0	0	0	-261
2016	128	0	128	0	0	0	0	-128
2017	4,105	0	4,105	0	0	0	0	-4,105
2018	1,992	0	1,992	0	0	0	0	-1,992
2019	3,591	0	3,591	0	0	0	0	-3,591
2020	7,230	0	7,230	0	0	0	0	-7,230
2021	6,698	0	6,698	0	0	0	0	-6,698
2022	6,768	0	6,768	0	0	0	0	-6,768
2023	6,838	0	6,838	0	0	0	0	-6,838
2024	4,862	0	4,862	2,157	5,897	0	8,053	3,191
2025	0	0	0	5,801	10,441	0	16,242	16,242
2026	0	11,586	11,586	5,117	10,441	0	15,559	3,973
2027	0	11,586	11,586	5,038	10,441	0	15,479	3,893
2028	0	11,586	11,586	5,521	10,441	0	15,962	4,376
2029	0	11,586	11,586	5,439	10,441	0	15,881	4,295
2030	0	11,586	11,586	3,094	10,441	0	13,535	1,949
2031	0	11,586	11,586	3,001	10,441	0	13,442	1,856
2032	0	11,586	11,586	5,162	10,441	0	15,603	4,017
2033	0	11,586	11,586	5,206	10,441	0	15,647	4,061
2034	0	11,586	11,586	4,558	10,441	0	14,999	3,413
2035	0	11,586	11,586	4,477	10,441	0	14,918	3,332
2036	0	9,344	9,344	4,928	10,441	0	15,369	6,026
2037	0	9,344	9,344	4,799	10,441	0	15,240	5,897
2038	0	9,344	9,344	647	10,441	0	11,088	1,745
2039	0	9,344	9,344	496	10,441	0	10,937	1,593
2040	0	9,344	9,344	4,345	10,441	0	14,786	5,442
2041	0	9,344	9,344	4,190	10,441	0	14,631	5,287
2042	0	9,344	9,344	3,490	10,441	0	13,931	4,588
2043	0	9,344	9,344	3,352	10,441	0	13,793	4,449
2044	0	9,344	9,344	3,774	10,441	0	14,215	4,872
2045	0	9,344	9,344	3,633	10,441	0	14,074	4,730
2046	0	9,344	9,344	1,226	10,441	0	11,667	2,323
2047	0	9,344	9,344	1,071	10,441	0	11,512	2,169
2048	0	9,344	9,344	3,588	10,441	0	14,029	4,685
2049	0	9,344	9,344	2,427	4,545	34,010	6,972	-2,372
Total	42,475	246,672	289,147	96,536	261,029	34,010	357,565	68,418
IRR-E	9.64%							

(source) JICA Study Team

11.4.5 Sensitivity Analysis

The sensitivity analysis is to assess the effects of the changes on the financial return of the Project. Per the sensitivity analysis, changes in selected variables can be assessed in terms of the extent that they result in changes in FIRR. In the Study, the following eight variables are selected for analysis;

Fuel mix

Foreign exchange rate

Interest rate of subsidiary loan

Share of donor loan in total fund raising

Government funding in equity

Plant cost

Plant load factor

Coal Price

Following table presents the result of the sensitivity tests conducted when the assumptions and/or the parameters of the Project change;

Table 11.4.6 Sensitivity Test on FIRR

Category	Variance	Generation Cost (Tk/kWh)	WACC (%)	FIRR (%)	DSCR (Ave.: %)
Base Case		6.99	1.60	2.52	128.5
Fuel Mix with Australian Coal	Indonesian 100%	6.70	1.60	2.51	128.7
Foreign Exchange Rate	Appreciation by 20%	5.71	1.60	2.55	130.2
	Depreciation by 20%	8.28	1.60	2.50	127.4
Interest Rate of Subsidiary Loan	1.0% p.a.	7.23	2.09	3.14	126.3
	2.0% p.a.	7.47	2.59	3.71	124.6
	3.0% p.a.	7.71	3.09	4.23	123.3
Share of Donor Loan in Total Fund Raising	85%	6.85	1.20	2.05	120.6
	75%	7.13	1.99	2.97	136.8
Government funding in equity	100%	7.37	2.41	3.74	159.4
	80%	7.18	2.00	3.19	143.1
Plant Cost	Increase by 20%	7.40	1.60	2.48	128.2
	Decrease by 20%	6.59	1.60	2.58	129.2
Plant Load Factor	90%	6.71	1.60	2.54	128.1
	70%	7.35	1.60	2.50	128.9
Coal Price	Increase by 20%	7.76	1.60	2.55	127.9
	Decrease by 20%	6.23	1.60	2.49	129.1

(source) JICA Study Team

It is to be noted that there exist two types of variables; controllable and uncontrollable. The controllable variables mean the ones whose changes can be managed by the Project sponsor and other parties concerned while the uncontrollable variables mean the ones that cannot be managed by the Project sponsor and the parties concerned individually or collectively as such belong to the outside environment such as the technological

limitations, international market condition, or financial environment, etc. Out of the variables listed above, the categories of the fuel mix, the interest rate of the subsidiary loan, share of donor loan and government funding belong to the controllable and the remaining ones belong to the uncontrollable.

The above table indicates mixed results of the sensitivity tests for different categories of variables. Among the controllable, the increases in the interest rate of subsidiary loan and the government funding in equity bring the cases to stay out of the target range in terms of the generation cost. The uncontrollable categories of foreign exchange, plant cost, plant load factor and coal price, if they change for deterioration, will push the generation cost above the target level. For FIRR, all of the variant cases, controllable and uncontrollable are found satisfying the targets. For DSCR, limited number of cases are clearing the targets, though almost all of other cases are found to be staying close to the targets established with exception of a few cases of low values.

While there exists only one case in which all of the three targets are perfectly cleared simultaneously, i.e. the case where foreign exchange rate against US Dollar appreciates by 20%, no other cases satisfy all of the three targets simultaneously. Among those that are close to satisfy the three targets, the following cases are worth while taking close look; (i) Base Case, (ii) fuel mix to concentrate 100% in Indonesian, (iii) increase in the donor funding up to 85%, (iv) decrease in the plant cost, (v) increase in the PLF, and (vi) decrease in coal price. A half of the cases picked up are those of the uncontrollable variables and the Project may not able to obtain. The obtainable cases are found in (i), (ii) and (iii). It can be concluded that the Project can optimally adopt the Base Case for the financing structure. By adding the complementary measures of weighting the fuel mix to the Indonesian coal may help the Project to improve the generation cost and financial health of the Project.

A particular attention is invited into the changes in interest rate on the subsidiary loan from GOB to CPGCBL. The Base Case assumes the interest rate to be 0.01% p.a. and produces the output of the generation cost to be Tk 6.99/kWh. When the interest rate changes to 1.0% p.a., 2% p.a., and 3% p.a., the generation cost moves up to Tk 7.23/kWh, Tk 7.47/kWh and Tk 7.71/kWh with the result that the Project moves out of the acceptable range in respect of the targets established. The result indicates the indispensable nature of adopting the Base Case envisaging the interest rate on subsidiary loan at 0.01% p.a. Besides, it should be noted that GOB transfers all the cost and expenses to accrue on the donor loan to CPGCBL by virtue of the subsidiary loan agreement and bears no cost with exception of the risk inherent to the failure of CPGCBL in its debt servicing.

11.4.6 Conclusion and Recommendation

The analysis above reveals that the Base Case meets the target generation cost, financial conditions of FIRR and DSCR. The Study Team recommends CPGCBL to adopt the Base Case as the financing structure for the company

There remains some weakness in the Base Case in particular respect to the NPV and PLCR/LLCR. The NPV staying in the negative territory provides a caution that the Project may fail to produce sufficient value on the basis of present value for justifying the profitability. Such weakness of the Project stems from the basic structure of setting the revenue at the generation cost plus the ROE assigned with a limited amount of equity while all the other cost items are passed through to the generation cost which will be the tariff rate for the generated electricity. While the average DSCR is staying close to 130%, the company is understood to maintain sufficient strength for making the debt service in nominal terms. In fact, the company will be in a financially stable condition as it will neither be subject to the volatile fluctuation of the interest rate as the subsidiary loan provides virtually zero rate of interest nor the fluctuation in the sales revenue. The subdued conditions of low NPV, PLCR and LLCR of the case should be remedied by the strict execution of the tariff in reflection of the actual cost and ROE assigned together with the rigid observance of the contracted terms for collection of the invoice from the single buyer.

The Base Case is made of structure and practices that have not been seen before but to be adopted for the Project including;

- (i) The concessionary terms and conditions should be adopted in the subsidiary loan agreement with the rate of interest at 0.01% p.a. and the repayment term in 34 years including the 10 years of grace; and
- (ii) The longer terms for grace period should also be allowed for 10 years in the government lending in order to coordinate the repayment schedule with the longer term of construction.

The Study Team hereby recommends to GOB to adopt and accommodate above conditions in establishing the financial structure for the Project.

11.5 Economic Evaluation

11.5.1 Methodology of Evaluation and Basic Parameters

The economic analysis also appraises the benefit of an investment, but the concept of the economic benefit is different from the financial benefit. The economic analysis measures the effects on the national economy whereas the financial analysis assesses the financial profitability of the Project operating entity. The effect of the Project on the national

economy is indicated by the Economic Internal Rate of Return (EIRR).

In order to calculate the EIRR, it is essential to identify the economic costs and the benefits. In particular, a comparison of the without-project and with-project situations is at the heart of the estimation of the net economic benefits of the Project. Then, those costs and benefits are quantified as much as possible, and are valued. In the case that EIRR is higher than the social discount rate which can be derived from the long-term treasury bond, the economic viability of the Project can be ensured.

11.5.2 Economic Costs

(1) Project Costs

The economic analysis is based on the Project costs which are used for the financial analysis but excluding the taxes and fiscal levies.

(2) Fuel Cost

The fuel costs for the financial analysis are also used for the economic analysis.

(3) Operation and Maintenance Costs

The O&M costs for the financial analysis excluding the taxes and fiscal levies are used for the economic analysis.

11.5.3 Economic Benefits

The economic benefits can be derived by the positive difference between the “with-project” situation and the “without-project” situation.

The Least Cost Alternative method is conventionally used for the economic analysis of power projects whereas the Willingness-to-Pay method is recently used to measure the economic benefits. Per the Least Cost Alternative method, “the avoidable cost” will be considered as the economic benefits of the Project. Avoidable costs can be estimated by the difference between the power generation cost, including capital and the O&M cost of the Project and the ones of alternative power generation, such as the existing power plants based on the liquid fuel energy, in order to increase the same volume of power production.

In the case of this Project, BPDB has been purchasing electricity from the power generation companies who operate the generation plants based on the liquid fuel energy,

such as high speed diesel oil (HSD) and/or heavy fuel oil (HFO), etc. It is expected that the Project can replace the expensive electricity supplied by those costly generation. In cases where the Project can produce electricity at lower cost, the difference between the two costs can be assumed as the economic return of the Project as a result of cost saving. The details of generation based on the liquid energy are typically found at Quick Rental Power Producers as shown below;

Table 11.5.1 Capacity and Tariff of QRPPs

Fuel	No. of QRPPs	Capacity	Current Average Tariff
HSD	5	350MW	18.92Tk/kWh
HFO	10	857MW	15.61Tk/kWh
Total	15	1,207MW	16.57Tk/kWh

(Source: JICA Study Team)

In addition to the saving the purchasing cost of power from such liquid fuel based generation companies, the salvage values of the plant and the transmission line at the end of the Project life are added for the economic benefit of the Project.

11.5.4 Economic Analysis

In utilization of the basic assumptions above, the EIRR will be computed using the economic analysis model with economic cash inflow and outflow.

The estimated EIRR is 20.12%. It is higher than the social discount rate for Bangladesh of 12.48%, which can be derived from the yield of the 20-year treasury bond issued by the Government of Bangladesh in April, 2013 and the Project is deemed as economically viable.

Table 11.5.2 Economic Internal Rate of Return (EIRR)

Fiscal Year	Economic Cost (A)			Economic Benefit (B)			(million TK)
	Capital Cost	Operating Cost	Total	Saving cost of GRPPs	Salvage Value	Total	Balance (B)-(A)
2015	441	0	441	0	0	0	-441
2016	870	0	870	0	0	0	-870
2017	16,324	0	16,324	0	0	0	-16,324
2018	13,820	0	13,820	0	0	0	-13,820
2019	26,474	0	26,474	0	0	0	-26,474
2020	51,828	0	51,828	0	0	0	-51,828
2021	46,762	0	46,762	0	0	0	-46,762
2022	45,967	0	45,967	0	0	0	-45,967
2023	45,967	0	45,967	0	0	0	-45,967
2024	33,161	16,933	50,094	65,145	0	65,145	15,051
2025	0	32,947	32,947	130,290	0	130,290	97,342
2026	0	34,073	34,073	130,290	0	130,290	96,216
2027	0	34,353	34,353	130,290	0	130,290	95,936
2028	0	33,787	33,787	130,290	0	130,290	96,502
2029	0	34,067	34,067	130,290	0	130,290	96,222
2030	0	37,737	37,737	130,290	0	130,290	92,552
2031	0	38,017	38,017	130,290	0	130,290	92,272
2032	0	34,907	34,907	130,290	0	130,290	95,383
2033	0	34,987	34,987	130,290	0	130,290	95,303
2034	0	36,113	36,113	130,290	0	130,290	94,177
2035	0	36,393	36,393	130,290	0	130,290	93,897
2036	0	35,827	35,827	130,290	0	130,290	94,463
2037	0	36,107	36,107	130,290	0	130,290	94,183
2038	0	42,405	42,405	130,290	0	130,290	87,885
2039	0	42,685	42,685	130,290	0	130,290	87,605
2040	0	36,947	36,947	130,290	0	130,290	93,343
2041	0	37,227	37,227	130,290	0	130,290	93,063
2042	0	38,353	38,353	130,290	0	130,290	91,937
2043	0	38,633	38,633	130,290	0	130,290	91,657
2044	0	38,067	38,067	130,290	0	130,290	92,223
2045	0	38,347	38,347	130,290	0	130,290	91,943
2046	0	42,017	42,017	130,290	0	130,290	88,273
2047	0	42,297	42,297	130,290	0	130,290	87,993
2048	0	38,551	38,551	130,290	0	130,290	91,738
2049	0	19,722	19,722	65,145	33,669	98,814	79,092
Total	281,614	931,497	1,213,111	3,257,238	33,669	3,290,907	2,077,796
FIRR	20.12%						

(Source: JICA Study Team)

11.5.5 Sensitivity Analysis

The objective of the sensitivity analysis is to assess the effects of the changes on EIRR. Per the sensitivity analysis, changes in selected variables can be assessed in terms of the extent that they result in changes in the EIRR. In the Study, the following six variables

are selected for analysis:

- Ⓒ! Plant Cost
- Ⓒ! Plant load factor
- Ⓒ! Coal price
- Ⓒ! Cost of purchasing electricity from QRPPs
- Ⓒ! Exchange rate
- Ⓒ! Fuel mix

The Table 11.5.3 shows the results of sensitivity analysis on EIRR by the selected variables.

Table 11.5.3 Sensitivity Test on EIRR

Variables	Variance	EIRR
Base Case	-	20.12%
Plant Cost	+20%	17.71%
	-20%	23.29%
Plant Load Factor	90%	21.82%
	70%	18.27%
Coal Price	+20%	19.34%
	-20%	20.86%
Cost of purchasing power from liquid fuel plants	+20%	23.56%
	-20%	15.99%
Exchange Rate	+20% (appreciation of Tk)	24.05%
	-20% (depreciation of Tk)	16.93%
Fuel Mix (Indonesian 100%)	100%	20.41%

(source) JICA Study Team

In the benefit side, the increase in the cost of purchasing power from liquid fuel plants enhances EIRR to 23.56%. In the cost side, two variables can expand EIRR to more than 23%: the reduction of plant cost, and the appreciation of Taka against US Dollar. However, overall, the Project can generate sufficient level of EIRR staying above 16% and in excess of the social discount rate prevailing in Bangladesh at 12.48% regardless of the changes in any of the parameters. It can be judged that the economic viability of the Project can be endorsed.

Chapter 12

Public Consultation

Chapter 12

Public Consultation

Table of Contents

12.1	Meeting Minutes	1
12.2	List of Participants	16

12.1 Meeting Minutes

Construction of 2x600MW Coal Fired Power Plant at Matarbari, Cox's Bazar **Minutes of 1st Stakeholder Meeting (Power Plant)**

Venue : Yunus Khali Govt. Primary School, Kalarmarchhara, Moheshkhali :
Date : November 12, 2012
Time : 10:00 AM to 2:00 PM
Participants : List of Participants is enclosed.

The meeting was presided over by Mr. Alope Kimar Sarker, Managing Director of Coal Power Generation Company Bangladesh Ltd. (CPGCBL). Mr. Alope Kumar Sarker welcomed all participants. He thanked Japan International cooperation Agency (JICA) for their cooperation to conduct the feasibility study for construction of 2x600MW Coal Fired Power Plant at Matarbari, Cox's Bazar. He also thanked the JICA Study team for carrying out the study. He requested all participants to give their valuable comments on implementation of the project.

Mr. Saito, Team Leader of JICA Study Team and Mr. Abdul Latif Khan of BPDB also spoke on the occasion followed by the power point presentation on the feasibility study for construction of 2x600MW Coal Fired Power Plant at Matarbari, Cox's Bazar presented by Mr. Rama Nath Roy of Engineers Associates Limited (EAL).

After presentation, the following discussions were held:

1. Mr. Badiul Alam, Unuskhali, Kalarmarchhora, Moheshkhali wanted to know the exact requirement of land for the power project in Matarbari and Dhalghata union. Secondly, salt and shrimp cultivation are done in Matarbari area, which meets the requirement of salt and shrimp throughout the country. He wanted to know whether the power plant will affect the salt and shrimp cultivation. In reply, Mr. A.Latif Khan, Superintendent Engineer of BPDB informed that about 1000 acres of land will be required for the plant. No adverse effect will take place on shrimp and salt cultivation in the surrounding area of the plant as the latest ultra super critical (USC) technology will be applied in the plant to make it environment friendly.
2. Mr. Hasan Bashir, Business man and local politician thanked JICA for their great initiative. He also thanked Japan government for their friendly attitude towards Bangladesh. People of Matarbari are very proud and happy about it. He requested the authority to ensure maximum protection for the nature and environment so that salt, shrimp and battle leaf cultivation are not affected. Moreover, he wanted to know whether this plant will affect the human being by any means. In reply, Mr. A.Latif Khan, Superintendent Engineer of BPDB informed that this power plant will be constructed using the most advanced technology. So, human being will not be affected.
3. Md.Gias Uddin, Business man and local politician raised that they will lose their livelihood if the 1000 acres of land of Matarbari is acquired for the project. So, he requested the project authority to provide employment to the local people in the project. In reply, Mr. A.Latif

Khan, Superintendent Engineer of BPDB assured that priority will be given to the local people for employment in the project. Moreover, JICA Study Team is working on it to develop a rehabilitation plan as well. So, there are no worries for the local people in this regard.

4. Mr. Nurun Nobi, UP member, Kalarmarchhora is very hopeful that the present shortage of power supply will be improved to some extent if this power plant is implemented. So, he is very much eager to know when this power plant will start functioning. In reply, Mr. A.Latif Khan, Superintendent Engineer of BPDB informed that feasibility study is being now carried out. This will be completed by June 2013. If the project is found viable, JICA will give a primary report to the Government of Japan. After that the Government of Bangladesh will execute a loan agreement with the Government of Bangladesh, which may take another one year at least. Then EPC contractors will be engaged to construct the plant. This may take few years to complete the construction and then the plant will be commissioned. So, it is a long process.
5. Mr. Muhibullah, School teacher, Matarbari reminded that few months ago in Japan due to an earthquake there was a huge damage to nuclear power plant, which causes pollution to the atmosphere. So, he wanted to know any consequences if this project in Matarbari faces the similar natural disaster in future.

Secondly, he wanted to know the amount of vibration and sound caused by this power plant.

Thirdly, he is very annoyed with the fly ash which may cause respiratory problems to the people in the surrounding area of the project.

In reply, Mr. A.Latif Khan, Superintendent Engineer of BPDB informed that the proposed power plant is not nuclear power plant. It is a coal based power plant and well protected. So, it will not be affected by any natural disaster unless it is devastating.

As this is a high tech power plant, there would not be much of sound outside power plant.

In this power plant no fly ash will be produced as ultra super critical technology will be applied. Flue gas will contain only 0.02% ash and moreover the flue gas will be discharged to the atmosphere through a stack of about 275m high. So it will not affect the human being around the power plant

6. Mr Fazlul Karim, Businessman, Sariat Dail, Matarbari thinks that the power plant to be established in Matarbari is not only a pride to matarbari but Cox's Bazar also. The people of Matarbari are very happy but the communication system in Matarbari with other parts of Bangladesh is very bad. So, he hoped that the authority will construct road also apart from the power plant. In reply, Mr. A.Latif Khan, Superintendent Engineer of BPDB informed that there is a plan also to construct a road in Matarbari which will be extended to Chittagong-Cox's Bazar highway.
7. Md. Jomir Uddin, Businessman, Matarbari, a local resident of Matarbari is in favour of the construction of power plant in Matarbari. He also informed that people of Matarbari are very optimistic to see this project being implemented. However, he raised some points to take into consideration for wellbeing of the people of Matarbari.

The points are as follows:

- a. Priority will be given to the local people for employment in the project.
- b. All roads, school, college, madrasahs, health centers, bazars and fisheries ghats etc. shall be developed. All roads of Matarbari island and roads along the east and west side of the island shall be made pucca.
- c. The protective dams along the west coast of Matarbari Island shall be made very strong and permanent to save the island from cyclone, tidal waves and erosion.
- d. The compensation for land shall be provided three times of registered rate.
- e. Proper compensation shall be provided to the affected fishermen, salt farmers and others. They shall be rehabilitated with appropriate employment opportunities.
- f. Road to Chittagong from Matarbari shall be improved.
- g. The electricity shall be supplied to Matarbari area at reduced rate (tariff).
- h. The plant must be environment friendly so that the environment is not affected.

In reply, Mr. Alope Kumar Sarker, MD, CPGC and Mr. A Latif Khan, SE, BPDB assured them to take the above points into consideration. Both of them emphasized that the plant will be constructed using the latest technology, which has very negligible impacts on the environment. So, there is nothing to worry in this regard. They also mentioned that there are some points subject to government policy. These points will be raised to government level for consideration.

Finally, Mr. Alope kumar Sarker, MD, CPGC thanked all participants for giving their valuable comments and assured the people to take all points raised by them into consideration for implementation of the power plant project in Matarbari.

Then he concluded the stakeholder meeting giving thanks to all participants.





Photographs taken during Stakeholder Meeting

**Preparatory Study on Chittagong area Coal Fired Thermal Power Plant
Development Project**

Minutes of 2nd Stakeholder Meeting (Power Plant)

Venue : Moheshkhali Upazila Parishad Auditorium, Cox's Bazar

Date : 16/04/2013

Time : 11:30 AM

Participants : List of Participants is enclosed in **Annex-1**

Photographs : Some pictures taken during the meeting are given in **Annex-2**.

The meeting was presided over by Md. Anwarul Naser, Upazila Nirbahi Officer (UNO) of Moheshkhali Upazila. Mr Abul Quasem, Managing Director of Coal Power Generation Company Bangladesh Limited (CPGCBL) welcomed all participants. He thanked Japan International cooperation Agency (JICA) for their cooperation to conduct the feasibility study for construction of 2x600MW Coal Fired Power Plant at Matarbari, Cox's Bazar. He also thanked the JICA Study team for carrying out the study. He requested all participants to give their valuable comments on implementation of the project.

Then Mr. Saito, Team Leader of JICA Study Team spoke on the occasion followed by the power point presentation on the feasibility study for construction of 2x600MW Coal Fired Power Plant at Matarbari, Cox's Bazar presented by Mr. Rama Nath Roy of Engineers Associates Limited (EAL).

After presentation, the following discussions were held in the question & Answer session:

1. **Mr. Master Nur Baksh of Majidia Alim Madrasa, Matarbari** raised that the first stake holder meeting was held back in November at Matarbari. In that meeting it was decided to hold the second stake holder meeting at Shariar Dail. But the second stakeholder meeting was being held at Moheshkhali Upazila Complex blaming that Shariar dail is not safe place. So, he became very upset and felt insulted. Apart from this, he raised that nothing has been specifically mentioned about the female workers in regard to the employment of local people. So, he requested to hold another stakeholder meeting at Matarbari site in the future to enable more local people to participate in the meeting. He mentioned that he would be in favour of establishing

power plant at Matarbari if the local people are in favour of the power plant at Matarbari.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** said that there are not enough people moving at night causing Matarbari site an unsafe place at night. However, he thinks that next stakeholder meeting would be held at Matarbari. In regard to the employment of female workers, he mentioned that there will be no discrimination with female workers. Workers of all genders will have equal opportunity.

2. One of the participants raised whether JICA has decided to finance this project or not. He asked how the compensation will be provided to the affected people. He also requested to hold another stakeholder meeting at Matarbari site.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** mentioned that JICA will take the decision for funding this project based on the discussions of these meetings and also from the results of social and environmental studies. JICA has not yet taken any decision. But, it is understood that JICA is interested to finance this project. Normal compensation will be provided to the affected people as per Government law. However, additional compensation may be provided to the affected people as per JICA's guidelines if the project is financed by JICA. He also assured to hold another stakeholder meeting at Matarbari if possible.

3. **Mrs. Shamim Ara Dulali, Upazilla Women Vice Chairman** also reiterated that no power plant shall be constructed unless the local people are fully motivated in terms of their compensation, equal rights for both genders and assurance of no negative impacts on environment. So, she requested to hold a meeting at a much larger scale at Matarbari and Dholghata and gather the opinions of the people living in these areas.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** told that it is not possible to take opinions from each and every people. The outcome of any stakeholder meeting is disseminated to concerned people to develop awareness among them. He also assured that people of both genders will enjoy equal opportunity in terms of employment and compensation etc.

4. **Md. Saleh Ahmed, Upazilla Freedom Fighter Commander, Moheshkhali, Cox's Bazar** was very overwhelmed with the decision of the Bangladesh Government for

the establishment of this power plant at Matarbari by the end of the year of 2021. He welcomed this project on behalf of local people and also welcome the organizations associated with this project. He would also like to add that the main vision after the independence was urbanization of villages. For this foreign aid is required for rapid urbanization. However, he mentioned that the local workers, both men and women will take part equally for this project. He also demanded that electricity must be provided to the people of Moheshkhali on priority basis if the power plant is established.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** told that the local workers will be always privileged to work first. But, since this project is very big, workers from outside also have to be employed even after employing all the local workers. The main purpose of this power plant is to quench the necessity of electricity for the people; certainly the local people will get their necessary supply of electricity.

5. **Mr. Merul Aksar (Moni) of Dholghata** mentioned that the embankment is very necessary to protect the proposed power plant from cyclonic storms and tidal surge. He understood that the existing embankment will be further developed to protect the power plant. Dhalghata union may be protected from the cyclonic storms and tidal surge if the embankment is further extended upto Dhalghata. So, He requested to develop the existing embankment along Dhalghata Union.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** assured to develop the existing embankment to protect the power plant and Dhalghata union as well.

6. **Mr. Aminul Haq, Teacher and Journalist** was very optimistic to see this power plant being implemented very soon for development of Dhalghata union. So, he requested to start construction work before the forthcoming rainy season.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** informed that the project is a large one. So, it is not possible to start construction of this project so early. If JICA finds that this project is feasible, a loan agreement will be signed between JICA and GOB by March, 2014. Then consultants will be employed for this project. EPC Contractor will be engaged subsequently. It will take 6 months for design of the plant. Then construction may be started by the year of 2016-2017 and the plant will be commissioned in 2022-2013.

7. **Md. Gias Uddin Shaheen, Kalarmar Chora Union, Leader of Krishok League and Businessman** mentioned that If a power plant is established at the boundary of Matarbari and Dholghata unions, surrounding areas e.g Kalarmar Chora union will also be affected as effluents and other chemicals will be discharged within a three mile radius from the power plant. It was learnt that smog due to flue gas will cover up the sky around a radius of 3 mile and the sun won't be visible for at least 4 hours starting from the morning sunrise. The people of Moheshkhali rely highly on the sun since they are farmers of shrimp, betel leaves and salt. As a result, they will lose their source of income. So, he requested to use such technology that will not affect the project site and the surroundings as well.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** told that there won't be any smog to block sunshine. Similar coal based power plant is now in operation at Boropukuria in Dinajpur, where no smog is produced. He invited the interested people to see the situation in Boropukuria for themselves.

8. **A political leader and teacher**, one of the participants asked why imported coal will be used for this proposed power plant in spite of the availability of domestic coal..

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** informed that there is a huge reserve of coal at the northern region of Bangladesh. But, due to lack of coal policy, extraction of domestic coal is stopped. In addition, coal need to be transported to the project site. In order to generate 1200 MW electricity, 10,000 metric tone of coal will be required each day. It is quite difficult to transport this huge amount of coal from Dinajpur to the project site by poor roads and highways. So, it will be best to import coal from other countries.

9. **Md. Akhtaruzzaman, Member: Dholghata Union Parishad** informed that there are at least one thousand families in total at Matarbari and Dholghata union, whose land will be acquired for the project. Moreover they will also lose their means of livelihood. It was found in other project that the affected people don't get proper compensation for land and proper resettlement. So, he urged JICA to take necessary steps for proper compensation to the affected people and their proper resettlement with adequate means of livelihood.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** informed that only twenty one houses will be affected. He mentioned that the proposed site has been

selected in the area where very few houses will be affected. The affected people will be properly resettled and as far as their income is concerned, they will be supervised in finding their means of livelihood before/ after their resettlement.

10. **Mr. Amir Gaffur Parvez, Secretary, Moheshkhali, Press club** mentioned that it is necessary to construct new power plants for development of Bangladesh. A land of 455hactare will be required for this proposed power plant. Most of the cases it was found that compensation for the land goes to the wrong hands. So, he wanted proper compensation to the actual owners of the lands. He also wanted proper resettlement of the people who will lose their houses. He wanted the equal opportunity for both male and female workers at the project site.

In reply, **Mr. Abul Quasem. Managing Director of CPGCBL** informed that only the affected people will be compensated, and they will get it easily. The equality of male and female workers at the power plant site will be taken care.

At the end of question & answer session, **Mr. Mir Kashem Chowdhury, Chairman, Kalarmar Chora UP** spoke on the occasion. He gave greetings to all the people present at the meeting. There are many arguments and counter-arguments regarding the coal based power plant. The people of Moheshkhali are dependent on three very important things- fish, salt and water. If these three things are protected, there is no problem in establishing the power plant. He welcomed JICA study team members and requested them to keep in mind that there is no air pollution. Three unions over here will be affected the most. The local people and the environment will be highly affected. If the water temperature increases by a small margin of 2%, there will be negative impact on the fishes. So, he wanted assurance that the people of these 3 particular unions (Matarbari, Dhalghata & Kalar Marchora) won't be victims of any health related **hazards**.

Then **Mr. Ekramul Haq Chowdhuri Ruhul, Chairman Matarbari Union** spoke on the occasion. He raised few issues about the construction power plant at Matarbari. The lands which are required for the establishment of the power plant in Matarbari, the owners of these particular lands and the affected people due to this project, were not called on the stakeholder meeting. Only few of the people were called. If a power plant is established in Matarbari, then opinions of all the people living on this area have to be taken. If only the people are in favour of this project, only then a power plant can be established on this area. So, for the people of Matarbari and Dholghata, two stakeholders meeting have to be held on these two particular areas in a much larger scale and all of

their opinions have to be taken, these steps are highly encouraged for JICA. If the above steps are followed accordingly, only then the establishment of this power plant is welcomed by him.

Then **Mr. Abu Bakar Siddique , Upazila Chairman of Moheshkhali Upazila** spoke on the occasion. He is also in favour of the project in Matarbari area if the plant is environment friendly.

Then **Mr. Ahmanullah Bacchu, Chairman, Dholghata Union** told that If a coal based power plant is established in Dholghata Union, then the people of this area will be deprived from the daily source of income. So, few alternative ways of income have to be introduced to these people. They have to be rehabilitated in a proper way. He requested JICA to pay a closer attention on the negative environmental impacts that are likely to occur in this area due to the establishment of this power plant. Each and every year, the people of Dholghata union suffer from floods. There is an embankment, but it is not enough to protect the people from the flood. So by taking this information into account, he requested JICA to build a state of the art embankment for the people of Dholghata Union and also for the proposed power plant.

Finally, **Mr. Anwarul Naser, UNO Moheshkhali** gave greetings to all the people present in the meeting.. Matarbari and Dholghata need some development. These areas are always a hot spot for natural disasters. As a result, if a power plant is established here, the government has to take proper initiatives to protect this power plant as well. One of them would be to build an embankment and protect the people of this area first; this is nothing but a matter of common sense. He wanted these much needed developments.

And one or two speeches here today have been really great. He demanded to show the videos of other coal based power plants in the next meeting. To conclude, He would like to thank the people who are an integral part of their respected lands; managed their times and came here to be a part of this important meeting.

Then the meeting was concluded with thanks to all present in the meeting.









12.2 List of Participants

(1) 1st Stakeholder meeting

Sl. No.	Name of Participant	Designation & Organization	Contract Phone No.
1	Tadashi NAKAMURA	JICA Study Team	
2	Tadashi Miyagi	JICA Study Team	
3	Shigeki WADA	JICA Study Team	
4	Junko Fujiwara	JICA Study Team	
5	Biplob Kumar Sarker	DGM, Cox's PBS	01769400127
6	Shafi Uddin Ahmed	AGM, Cox's PBS	01817385367
7	Md. Iddris	Assistant Teacher	01815152415
8	Zainal Abedin	Assistant Teacher	01839081196
9	Abdul Quddus	Unit Manager, BGS	01819633081
10	Anjoy Paul	Asst. Teacher, Unishkali G.P. School	01836108329
11	Badiul Alam	Business	01838140576
12	Maniksha Hero	Doctor	01811672507
13	Engr. Md. A. Latifkha P.Eng	S.E, BPDB	01730705077
14	Hazi Mohammad Hossain	Business	01719324464
15	Mohammad Ledu		
16	Nurul Islam	Non Resident Bangladeshi	
17	Abdur Rahim	Businessman	01738430540
18	Jemsan Burua	Teacher	01735038206
19	Abdur Rahim	In Charge, BGS	01818521493
20	Hazi Monirul	Retired	01845670148
21	Sahnewaj	Sub Inspector of Police	01811811650
22	Iqbal Bahar Coung	Secretary Union Council (SUP)	01838142347
23	Badal Kanti Sheel	Service	01823910624
24	Amin Ullah		
25	Shamsul Alam	Business	01834011915
26	S.M Didarul Islam	Sub Assistant Agriculture	01824898929
27	Shahida Akhter	Member Union Council (MUP)	01713967391
28	S.M. Iqbal Bahar Choudhury		01813142433
29	Abdul Halim	Social Welfare Worker	01825251995
30	M. Rahman	Resource Expert, JICA, EAL	01917278455
31	Nasrin Akter (Poly)	JICA Study Team, EAL	01749450099
32	Sharmin Akter (Mita)	JICA Study Team, EAL	01710081362
33	Bipasha	JICA Study Team, EAL	01836740448
34	Md. Sahabuddin	Journalist & Councillor	01820538942
35	Rahul Bagum	Journalist	01713645923
36	Rejaul Karim	Asst. Teacher, Younus Khali G.P School	01813950200
37	Najim Uddin	Head Teacher, Younus Khali G.P School	01828423508
38	Mofaida Begum	Asst. Teacher	01723295355
39	Monowar Hossain	B.M	01716858318
40	A.M.M.K. Bashar	Director, CMD	01819221016
41	Shigeru SAITO	JICA Study Team	

42	Sachio KOSAKA	JICA Study Team	
43	Aloke Kumar Sarkar	C.E. Services & MD. CPGC, BPDB	
44	Aqrumul Amin	Business	
45	Sadrul Amin	Business	01837015401
46	Gias Uddin	Business	01834136960
47	Mohammad Hossain	Business	01811815176
48	Zamil Uddin	Business	01740806253
49	Mohammad Sayed	Agriculture	
50	Khalil		01839229593
51	Fazlur Rahman	Business	
52	Faizul Karim		01814330897
53	Hasan Bashir	Business	01727239280
54	Eman Ali	Retirement	01734976392
55	Noor Nobil	Member Union Council (MUP)	01713619965
56	Saidul Ali		
57	Jafor		
58	Abdul Mannan		
59	Rafique Uddin		
60	Md. Mujibul Haque	Agri Officer, SAO	
61	Belal Uddin	Business	01823911546
62	Amirul Bahai	UAO, Agri Officer	01715235590
63	Mosaddek Faruk	Business	01710388213
64	Mohammad Golam Ali	Asst. Teacher, Younus Khali G.P School	01814702525
65	Monjur Alam	Member Union Council (MUP)	01826309697
66	Bodiullah	Member Union Council (MUP)	01827228910

(2) 2nd Stakeholder meeting

Sl. No.	Name of Participant	Organization & Designation	Contact Phone No.
1	Md. Didarul Islam	Matarbari, Sariardail	01725540997
2	Md. Sibbir Ahmed	Matarbari, Sariardail	01740806250
3	Amina Begum	Matarbari, Sariardail	01845680214
4	Md. Alamgir	Health Asst. Kalarmarchara	01829254714
5	Gopal Krisna Das	U.S.S.O @, Maheshkhali	01825709693
6	Mahmudul Karim	Imam, Matarbari	01740817215
7	Mohammad Zakaria	Imam, Matarbari	01733744574
8	Mohammad Helal	Imam, Matarbari	01732987322
9	Sahida Akter	Member, Kalarmarchara UP	01713967391
10	Dr. Mansur Ahmed	Ex. Member, Kalarmarchara	01710303036
11	Md. Gias Uddin Sahin	Unuskhali, Kalarmarchara UP	01834136960
12	Md. Saleh Ahmed	Maheshkhali	01823381104
13	Md. Kala Mia	Maheshkhali	01834507543
14	Md. Sadekullah Siddique	Maheshkhali	01816863776
15	Md. Aman Ullah	Head Master, Kalarmarchara High School	01815576603
16	Rabi Chandra Chakma	Office Assistant, SAFO	01855679681
17	Samar Chandra Day	Statistical Officer	01816059970
18	Abdur Rahim	BGS APC	01818521493
19	Abdul Hamid	Head Teacher, Matarbari Govt. Primary School	01718468339
20	Mr. Mahbub	Journalist, Dainik Himchari	01819330675
21	Md. Mokshod	Maheshkhali	01815540669
22	Md. Altas	Maheshkhali	01825253810
23	Mohammad Rashid	Secretary, Dhalghata UP	01553754037
24	Md. Sahbuddin	Maheshkhali	01826141932
25	Md. Ataullah	Member, Dholghata UP	01824827566
26	Md. Kauser	Matarbari	01726283390
27	Nur Mohammad	Matarbari	01812586855
28	Md. Ismail	Matarbari	01740806258
29	Mr. Hamed Hossain	Social Worker, Matarbari	01740817275
30	Mr. Nur Box	Senior Teacher, Matarbari Alim Madrasha	01740974088
31	Md. Ishaque	President, Fisheries Co-operative Society, Matarbari	01928870893
32	Md. Abdul Malek	Department of Women Affairs Office	01942912550
33	Md. Abul Bashir Parvez	Press Club	01815356294
34	Mr. Zamir Uddin	Matarbari	01740806253
35	Md. Abu Taher	Daily Amader Cox's bazaar	01815099700
36	Shamim Ara Dulaly	Women Vice Chairman	01813060583
37	Sirazul Alam	Member Dhalghata UP	01815941395
38	Shakirullah Khokon	Maheshkhali	01831511907
39	Nurul Absar Chowdhury	Secretary, Nobojagoron Club, Dhalghata	01828586244

Sl. No.	Name of Participant	Organization & Designation	Contact Phone No.
40	Jiarul Absar Zia	Secretary, Nobojagoron Club, Dhalghata	01825311644
41	Farij Ullah	Maheshkhali	01818715541
42	Nabir Hossain Ajad	Member, Dholghata UP	01824910207
43	Rahul Borman	The Daily Prothom-alo	01713645923
44	Mr. Anamul Haque Rahul	Chairman, Matarbari UP	01713620023
45	Aminul Haque	Moheshkhali, Press Club	01712112726
46	Sokuntaj Begum	Member, Matarbari UP	01821819940
47	Mahbub Rokon	Moheshkhali, Press Club	01832077961
48	Meer Kashim Choudhuri	Chairman, Kalarmarchara UP	01743524552
49	Ahasan Ullah Bacchu	Chairman, Dhalghata UP	01813622118
50	Norihiko FUKAZAWA	JICA Study Team	
51	Shigeru SAITO	JICA Study Team	
52	Tadashi NAKAMURA	JICA Study Team	
53	Shigeki WADA	JICA Study Team	
54	Tadashi MIYAGI	JICA Study Team	
55	Md. Mozammel Hossain	JICA Study Team	
56	Katsuya Kasai	JICA	
57	Kazuhiro YOSHIDA	JICA Study Team	01775486867
58	Osamu NAKAZAWA	JICA Study Team	01775486866
59	Abdur Rahman	Access Road IDEA	01911010714
60	Engr. Md. Asid Masud	Access Road Project, JICA Study Team	
61	Md. Aktaruzzaman	MUP of Dhalghata	01812750143
62	Yoichiro KUBOTA	JICA Study Team / TEPCO	01726360353
63	A.K.M Anisur Rahman	Executive Director, EAL	01711687327
64	Junko FUJIWARA	JICA Study Team	
65	Rama Nath Roy	JICA Study Team	01712619317
66	Md. Anwarul Haque	UNO, Moheshkhali	01731592321
67	Md. Abdul Quasem	MD, Coal Power Generation Co.	01716442098
68	Abu Bakar Siddique	Chairman, Moheshkhali UP	01817222851
69	Md. Habibur Rahman	Officer-in-Charge Moheshkhali PS	01713773669
70	Mostak Ahmed	Vice Chairman	01819628668
71	Shamim Ara Dulari	Vice Chairman	01813060583
72	Moksud Miah	Mayor, Moheshkhali Municipality	01815861832
73	M. Rahman	JICA Study Team	01917278455
74	Nasrin Akter (Poly)	JICA Study Team	01749450099
75	Md. Sumon	JICA Study Team	01726789008
76	Naznin Akter	JICA Study Team	01717757087
77	M. Ilyeas Rahman	BPEB	01711168468
78	Md. Tofazzal Hossain	JICA Study Team	01914464114
79	Waresur Rahman	JICA Study Team	01754175330
80	Md. Sahab Uddin	Journalist, Daily Samokal	01820538942
81	Engr. Biplob Kumar Sarker	DGM, Pally Bidyut Samity	01769400127
82	M. Ramjan Ali	Journalist, Purbodesh	01840226071
83	Md. Anwarul Azim	ULAO, Matarbari	01818246445

Sl. No.	Name of Participant	Organization & Designation	Contact Phone No.
	Chowdury		
84	Mr. Nurul Absar	Political Leader, Dhalghata	
85	Mr. Abu Taleb	Member, Dhalghata	
86	Shamima Akter	Head Teacher,	01824875985
87	Md. Shakir Ullah	Moheshkhali	01831511907
88	Md. Anisul Haque	Forest Range Officer	01716535337
89	Gowranga Ch. Biswas	UAE, LGED	01712092958
90	Md. Jahangir Iqbal	Range Officer	01714404441
91	Md. Solayman	Beat Officer	01714868720
92	Sarder Shariful Islam	AD, Department of Environment	01556340776
93	Jahangir Alam	MLSS, LGED, Moheshkhali	01818850644
94	Mafizur Rahman	Affected People	01815943357
95	Bodoruddin Md. Ali	Affected People	0184507943
96	Dalilur Rahman	Affected People	
97	Abdul Salam	Affected People	
98	Younus Ali	Affected People	
99	Md. Alam	Affected People	
100	Bodor Uddin	Affected People	
101	Saidul Haque	Affected People	
102	Zahed Hossain	Affected People	
103	Arof Ali	Affected People	
104	Mohiuddin (Son of Md. Ali)	Affected People	
105	Ayat Ullah	Affected People	
106	Abdul Razzak	Affected People	
107	Obaidul Haque	Shirar Dail	
108	Sura Khatun (Md. Nacher)	Affected People	
109	Chinu Ara Begum (Kamal Hossain)	Affected People	
110	Zubaida Khatun (W/O Hasan Ali)	Affected People	
111	Rahima Khatun (W/O Abdul Hakim)	Affected People	
112	Shamim Ara (D/O Md. Ismail)	Affected People	
113	Shahadat Ullah (Relatives of Ayatullah)	Affected People	
114	Mr. Sultan	Member, Bazar Committee	
115	Dr. Wadud	Secretary, Bazar Committee	
116	Nazim Uddin	Majee, Matarbari	
117	Hasan Ali	Affected People	
118	Abdus Sattar	Businessman, Santi Bazar	
119	Maolana Abu Naser	Imam	
120	Moulana Hamed Ullah	Imam, Matarbari	
121	Shaokat (S/O Nasir Uddin)	Affected People	
122	Mr. Supon	Worker, BGS NGO	01812809655
123	Md. Alam	Shairar dail	01822858007
124	Zamir Uddin	Shairar dail	
125	Riazul Islam	Shairar dail	

Sl. No.	Name of Participant	Organization & Designation	Contact Phone No.
126	Mr. Munnah	Officer, ASA NGO, Matarbari	01826142004
127	Mr. Saleh Ahmed	Head Teacher, Dhalghata High School	01813727367
128	Mr. Moksedul Karim	President, Managing Committee, Dhalghata High School	01812604844
129	Md. Shihab Uddin	Secretary, Matarbari UP	01819647948
130	Ansarul Karim	Member	01826503992
131	Sirajul Haque	Journalist, Moheshkhali	01727628295
132	Ahmed Ullah	Head Teacher, Matarbari Govt. Primary School	01818401797
133	Md. Shafiqul Islam	JICA Study Team	01711984984

6.3 Presentation Materials (Annexure-6)